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EVALUATION OF HEAVY METAL CONTENTS AND THEIR ESTIMATED DAILY INTAKES FROM BEANS CAKE (AKARA) COMMONLY CONSUMED WITHIN AFIKPO METROPOLIS, NIGERIA

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ABSTRACT

This study examined the contents of some heavy metals and their estimated daily intakes from beans cake (popularly called akara) commonly consumed within Afikpo Metropolis, Nigeria using the Atomic Absorption Spectrophotometry (AAS). The results indicate that the concentration of the heavy metals (mg/Kg) varied across the various samples. The samples (labelled A1, A2, A3, A4 and A5) were purchased from five different outdoor vendors within Afikpo Metropolis; was ground into powdered, sun-dried for 12 hours, subjected to acid digestion and then analysed for the selected trace metal (Ni, Cu, Pb, Fe, Al and Zn) contents using calibrated atomic absorption spectrophotometer following standard analytical procedures. Results of the analysis revealed that the metal concentrations of Ni in mg/kg has the least value of 0.06±0.04 in sample A2 and the highest value of 0.27±0.06 in sample A4 the Cu has the least value of 0.31±0.10 in sample A4 and the highest value of 1.28±0.28 in sample A1; Pb has the lowest value of 0.04±0.01 in sample A4 and Pb has the highest value of 0.49±0.04 sample A3; Fe has the least value of 2.00±0.10 in sample A5 and with the highest value of 6.23±0.21 in sample A4; Al has the least value of 0.92±0.08 in sample A2 and the highest value of 3.23±0.29 in sample A5 and Zn recorded the least value of 2.06±0.06) and the highest value of 5.16±0.19 in sample A1. Similarly, the estimated daily dietary intake (mg/kg body weight) from the respective in sample A1 to A5 for a 70 kg body weight were in the range 3.9E-4 to 9E-5; 1.83E-3 to 4.4E-4; 7.0E-4 to 6E-5; 8.90E-3 to 2.86E-3; 4.61E-3 to 1.31E-3 and 7.37E-3 to 2.94E-3 for Ni, Cu, Pb, Fe, Al and Zn respectively. The results thus showed that only Pb, Al and Ni were above WHO permissible limits and consequently, estimated daily intake risk factor increased as Fe < Zn < Cu < Al < Ni < Pb. The presence of some of these metals can be attributed to the various human activities, vehicular emission storage containers, methods and ingredients used in the preparation. That notwithstanding, the results indicate that consumption of these roadside bean cake may not pose and serious health threat.

Key words: Trace metal, beans cake, contamination, daily intake, Afikpo.

Introduction

Beans cake, popularly known as ‘akara’ in Nigeria, is a high consumption food that is considered as an essential rich source of protein, minerals and energy supply to the body. In 2018, Adepoju *et al*. had reported that beans is one of the most nutritional and yet economically important indigenous African grain legumes commonly cultivated throughout the tropical and subtropical regions of the world, with the largest production recorded in the moist and dry savannas of sub-Saharan Africa. Interestingly, beans have also been recently reported as Nigeria's fourth-most popular food after rice, yam, and cassava (LIN, 2023) with Nigeria being the largest producer and consumer of beans

in the world, thus playing a key role in the agriculture and food supply of the nation (Adepoju *et al*., 2018). Incidentally, beans are frequently and unarguably a favourite food in Nigeria due to their flavour and nutritional value and can be consumed or eaten alone (whole) or frequently paired with other dishes such as bread, rice, pap, and garri (Ovonramwen *et al*., 2023). It is also believed that some people consume beans in processed forms such as bean pudding (Moi Moi), bean cake (Akara), and bean flour soup (Gbegiri) (Ovonramwen *et al*., 2023).

In Nigeria in particular, there has been an increasing proliferation of food vendors to meet the increasing demand for food supply for the majority of the populace. Research has shown that most of the ready-made food items sold in the Nigerian outdoor markets are often not adequately processed or packaged, with a great majority of these foods such as local snacks, staple foods (cassava foods, rice, beans and beans cake, grains, oil, fish, vegetable and meat) been displayed close to roadsides (Lanre-Iyanda & Adekunle, 2012). The resultant effect usually being excessive contamination with particulate matter including heavy metals such as cadmium, chromium, arsenic, mercury, lead, nickel, copper, and zinc among others capable of inducing carcinogenicity (Ovonramwen *et al*., 2023; Ali *et al.*, 2021). In view of the increasing demand for food and food safety therefore the concern of many researchers to the risk associated with the consumption of contaminated food materials has been drawn (Eneji *et al*., 2015). Among the major food contaminants are metals due to their biocumulative tendencies, non-biodegradable nature and particularly toxicity (Yashim & Suleiman, 2016). Interestingly, the report of Akaninwor *et al*. (2006) revealed that essential elements such as iron, zinc, copper, nickel and magnesium have been associated with enzyme systems particularly those involved in oxidation process and other important biochemical processes. However, the main threats to human health from metals are associated with exposure to lead, cadmium, mercury and arsenic (Yashim & Suleiman, 2016).

Meanwhile, Incidents of metallic poisoning arising from contamination of foods and feeding stuffs without regards to the amount of daily intakes have been documented in literature (Akaninwor *et al*., 2006; Osabor & Ntinya, 2018; Eneji *et al*., 2015). Most of these metals that could be present in beans cake, can be introduced during milling process and if present even in very low concentrations, can pose several human health implications including miscarriage, asthma, cough, shortness of breath or wheezing, vomiting, abdominal cramps, diarrhoea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, muscle weakness and cognitive impairment (Martin & Griswold, 2009; Ovonramwen *et al*., 2023). Elevated dietary intake of the metal may result in increased thyroid problems, cancer, damages to the kidneys and brain and ultimately cause death (Lanre-Iyanda & Adekunle, 2012; WHO, 1982; Martin & Griswold, 2009). Consequently, monitoring of food toxicity due to toxic metals contamination is essential to food security as well as sustainable human and environmental resource management. Hence, with the current emphasis on eating more healthy diets which should not contain toxic metals, it is therefore very important to examine trace metal contents and their estimated daily intakes from beans cake (akara) commonly consumed within Afikpo Metropolis, Nigeria.

Materials and Methods

Study Area

Afikpo community is the second largest town and the Headquarter of Afikpo North Local Government Area of Ebonyi State, in South East Nigeria. The community is a hilly area that lies on Latitude 5.8931° north and Longitude 7.9374° east and at an elevation of 83 metres (272 feet). The community span over an area of approximately 164 square kilometres. It is essentially a transitional area between open grassland and tropical rain forest with an average annual rainfall of

198 cm^3. The people of Afikpo occupationally engage in farming and trading. Akara vendors are sometimes stationary within the parks, specific junctions, and streets or hawking.

Sample Collection

The sample was randomly selected from five different vendors labelled A1, A2, A3, A4 and A5 within Afikpo Metropolis. From each vendor, a total of ten (10) pieces of the akara was randomly picked and purchased. The sample was packaged in an air-tight polyethylene bag and transported to the Chemistry unit laboratory in Akanu Ibiam Federal Polytechnic, Unwana for the analysis.

Sample Pretreatment

After collection of the sample, they were brought into the laboratory and processed further prior to the analysis. Dark particles including pieces of onions were removed. Other foreign matters such as grains not completely milled, pebbles and tiny stones were manually removed from the beans cake sample.

Analytical Precision and Quality Assurance

For quality assurance of the analytical data, all the reagents used were of analytical grade purity. Double distilled water was used for dilution and preparation of reagents and standards. All glassware and plastic containers used were washed with liquid soap and rinse with tap water before soaking in 10% nitric acid for 24hours, cleaned thoroughly with double distilled water and dried to ensure that there is no contamination.

Sample preparation and Digestion

Sample preparation and digestion was conducted in accordance with the method adopted by Lanre-Iyanda & Adekunle (2012) with some adjustment. Pre-treated sample was sun-dried for 12 hours, ground into fine powdered followed by acid digestion. Exactly 1.0 g of the ground sample was quantitatively transferred into a well-glazed porcelain crucible, placed in a muffle furnace and ashed at 450^oC for 12 hours. The resultant ash was cooled to room temperature and digested to a clear solution with 5 ml of 5M HNO_3. The residue was then filtered into a calibrated 50 ml volumetric flask using Whatman filter paper No. 41, and the solution was made up to mark with deionised water.

Metal Analysis

The total concentrations of the metals in the digests were determined by aspirating the solution into Varian Spectra AA 55B Model atomic absorption spectrophotometer after the necessary standardization procedures and the respective spectral lines (nm) were 232.0, 324.7, 283.3, 210.5, 165.6, 213.9 for Ni, Cu, Pb, Fe, Al and Zn respectively from hollow cathode lamps.

Estimation of Daily Dietary Intake

Field Survey for Estimation of Average Consumption of beans cake (akara) in Afikpo

To estimate the daily dietary intakes, field survey was carried out following the procedures described in Adekunle *et al.* (2009). The weight of products consumed by adult on daily basis was evaluated and the value obtained was 100g on the average. The daily dietary intake of each metal was calculated using the expression below:

$$EDI = \frac{Cs \times W \times 10^{-3}}{BW}$$

Where Cs = concentration of each metal in the sample
W = average food weight consumed daily. A default value of 100 g was obtained
BW = the body weight of a typical adult of 70kg body weight was used.

Statistical Analysis

Results of the analysis were generally expressed as mean of triplicate determinations ± standard deviation. Using Statistical Package for Social Science (SPSS) for Windows version 23, statistical analysis was performed in order to ascertain if there were significant variations at $p \leq 0.05$ for a particular metal content within the labelled sample. Data were subjected to Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) was employed to separate the means.

Results

The results obtained from the study are presented in Tables. Table 1 and Table 2 show the concentrations (mg/Kg) of the trace metals studied in the beans cake samples collected and the estimated daily dietary intakes of the metals respectively. The trace metal concentrations were expressed as mean of triplicate determinations ± standard deviation of the data obtained. The results revealed varying contents of the metals.

Table 1: Trace metal concentrations (mg/Kg) in the studied beans cake (akara)

Parameter	Sample Concentration (mg/Kg)				
	A1	A2	A3	A4	A5
Ni	0.07 ± 0.03^{a}	0.06 ± 0.04^{a}	0.24 ± 0.14^{b}	0.27 ± 0.06^{b}	0.12 ± 0.11^{a}
Cu	1.28 ± 0.28^{c}	0.77 ± 0.22^{b}	0.54 ± 0.07^{b}	0.31 ± 0.10^{a}	1.15 ± 0.18^{c}
Pb	0.16 ± 0.05^{a}	0.14 ± 0.05^{a}	0.49 ± 0.04^{b}	0.04 ± 0.01^{a}	0.10 ± 0.03^{b}
Fe	3.26 ± 0.17^{b}	4.30 ± 0.26^{b}	2.02 ± 0.11^{a}	6.23 ± 0.21^{c}	2.00 ± 0.10^{a}
Al	2.08 ± 0.06^{b}	0.92 ± 0.08^{a}	1.48 ± 0.04^{b}	1.59 ± 0.04^{b}	3.23 ± 0.29^{c}
Zn	5.16 ± 0.19^{c}	3.41 ± 0.10^{b}	2.06 ± 0.06^{a}	4.50 ± 0.33^{b}	3.48 ± 0.05^{b}

Data represents mean of triplicate determinations ± standard deviation, and mean values followed by different letters within a row are significantly different at $P\leq0.05$ from one another. Significant difference was analysed using ANOVA.

Table 2: Estimated daily dietary intakes of metals from the studied beans cake (akara)

Parameter	Sample EDI (mg/Kg body weight)				
	A1	A2	A3	A4	A5
Ni	1.0×10^{-4}	9.0×10^{-5}	3.4×10^{-4}	3.9×10^{-4}	1.7×10^{-4}
Cu	1.83×10^{-3}	1.10×10^{-3}	7.7×10^{-4}	4.4×10^{-4}	1.64×10^{-3}
Pb	2.3×10^{-4}	2.0×10^{-4}	7.0×10^{-4}	6.0×10^{-5}	1.4×10^{-4}
Fe	4.66×10^{-3}	6.14×10^{-3}	2.89×10^{-3}	8.9×10^{-3}	2.86×10^{-3}
Al	2.97×10^{-3}	1.31×10^{-3}	2.11×10^{-3}	2.27×10^{-3}	4.61×10^{-3}
Zn	7.37×10^{-3}	4.87×10^{-3}	2.94×10^{-3}	6.43×10^{-3}	4.97×10^{-3}

Discussion

The results in Table 1 reveals that all the samples studied had some amount of the trace metals selected for the study. Ni content was in the range of 0.06±0.04 - 0.27±0.06 g/Kg. Similarly, the

contents of Cu, Pb, Fe, Al and Zn were found in the following ranges: 0.31±0.10 - 1.28±0.28; 0.04±0.01 - 0.49±0.04; 2.00±0.10 - 6.23±0.21; 0.92±0.08 - 3.23±0.29 and 2.06±0.06 - 5.16±0.19 mg/Kg respectively. The results show that within sample A1, maximum and minimum metal contents were recorded for Zn (5.16±0.19 mg/Kg) and Ni (0.07±0.03 mg/Kg), while maximum and minimum metal values obtained for sample A2, A3, A4, and A5 were Fe (4.30±0.26 mg/Kg) and Ni (0.06±0.04 mg/Kg); Zn (2.06±0.06 mg/Kg) and Ni (0.24±0.14 mg/Kg); Fe (6.23±0.21 mg/Kg) and Pb (0.04±0.01 mg/Kg), and Zn (3.48±0.05 mg/Kg) and Pb (0.10±0.03 mg/Kg) respectively. The Pb found in the bean cake could have been introduced by the spices used in the preparation of the cake and other anthropogenic factors; spices have been widely reported to contain high concentrations of Pb (Dariyan *et al*, 2025). In all the samples selected, highest metal content was recorded for Fe (6.23±0.21 mg/Kg) in sample A4. Thus, the relative abundance of the metals decreased in the order Fe > Zn > Al > Cu > Pb >Ni. The results in Table 1 also reveal that except for Pb, Al and Ni, all other metal investigated were within the WHO permissible limits and mean values followed by different letters within a row as shown in Table 1 are significantly different at $P \leq 0.05$ from one another. Significant difference was analysed using ANOVA and Duncan Multiple Range Test (DMRT). Table 2 shows the estimated daily dietary intakes of metals from the studied beans cake (akara) for a 70 kg body weight. This results reveal that the overall contribution of beans cake (akara) to consumer metal intake were found in the range 3.9E-4 to 9E-5; 1.83E-3 to 4.4E-4; 7.0E-4 to 6E-5; 8.90E-3 to 2.86E-3; 4.61E-3 to 1.31E-3 and 7.37E-3 to 2.94E-3 for Ni, Cu, Pb, Fe, Al and Zn respectively. Results of the study indicated that risk of trace metal intake from the selected food type base on the acceptable daily dose increased in the order Fe < Zn < Cu < Al < Ni < Pb.

Conclusion

Varied contents of trace metals were obtained across the five different beans cake samples studied with Ni showing the least level in all the studied samples while Fe appeared the highest. The levels of trace metals abundance in the five selected samples appeared in a decreasing trend Fe > Zn > Al > Cu > Pb >Ni. The results thus showed that only Pb, Al and Ni were slightly above WHO permissible limits and consequently, estimated daily intake risk factor increased as Fe < Zn < Cu < Al < Ni < Pb The results thus showed that only Pb, Al and Ni were slightly above WHO permissible limits and consequently, estimated daily intake risk factor increased as Fe < Zn < Cu < Al < Ni < Pb.

Recommendations

This study therefore recommended that regular monitoring of this foodstuff and other categories of outdoor foodstuffs be conducted, to avoid metal build up in the body of consumers, whose detrimental impact becomes apparent only after several years of exposure.

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