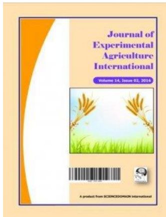

Journal of Experimental Agriculture International

25(5): 1-8, 2018; Article no.JEAI.35900
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Heavy Metal Levels in Beans (*Vigna unguiculata*) in Selected Markets in Ibadan, Nigeria

F. A. Adepoju[1*], A. F. Adepoju[2] and O. O. Fadina[2]

[1]Crop Protection and Environmental Biology, University of Ibadan, Nigeria.
[2]Cocoa Research Institute of Ibadan, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author FAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AFA and OOF managed the analyses of the study. Author AFA managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2018/35900
Editor(s):
(1) Dr. Lanzhuang Chen, Professor, Laboratory of Plant Biotechnology, Faculty of Environment and Horticulture, Minami Kyushu University, Miyazaki, Japan.
Reviewers:
(1) João Paulo Siqueira da Silva, Federal University of Pernambuco, Brazil.
(2) Zoran S. Ilić, Serbia.
(3) Birsa Mihail Lucian, Alexandru Ioan Cuza University of Iasi, Romania.
(4) Hocine Benabid, Algeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/26151

Short Research Article

Received 01 August 2017
Accepted 12 October 2017
Published 08 September 2018

ABSTRACT

Aim: Beans play a significant role in human diet especially in developing nations like Nigeria which happens to be the largest producer and consumer of beans in the world. To ensure food safety, heavy metal levels need to be monitored on regular basis to control human exposure through dietary intake.

Methodology: 72 Samples of brown beans (Oloyin and Drum) were obtained from three different markets in Ibadan, Nigeria. The markets were Ayeye Market, Bodija Market and Oja-Oba Market. Powdered samples were digested with nitric acid. Extract from the digest were analyzed for Lead (Pb) and Cadmium (Cd) using Buck Scientific Atomic Absorption Spectrometer.

Results: Concentration of Cd and Pb ranged from 0.00 to 0.01 mg/kg and 0.00 to 1.52 mk/kg respectively. The results of this research indicated levels of Cadmium and Lead within safe limit, hence human health is not at danger.

Conclusion: Efforts need to be made in total elimination of heavy metal in the beans because human health is at risk due to the effects of their bioaccumulation in the body.

**Corresponding author: E-mail: francis4great@yahoo.com;*

Keywords: Beans; cadmium; lead; dietary exposure; health implication.

1. INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] is an important crop in many tropical continents like Africa, Asia and South America [1] Cowpea belongs to the class *Dicotyledonea,* order Leguminosae (*Fabales)*, family Papilionaceae (*Fabaceae)*, subfamily *Faboideae*, tribe *Phaseoleae*, sub tribe *Phaseolinae*, and genus *Vigna* [2]. This crop provides food, animal feed and cash for the rural populace in addition to benefits to farmlands via *in situ* decay of roots residues and ground cover from cowpea's spreading habits.

In Africa, Cowpea is a popular leguminous crop which is known as 'beans' in Nigeria and 'niebe' in the francophone countries. The largest production is in the moist and dry savannas of sub-saharan Africa, where it is intensively grown as an intercrop with other cereal crops like millet, sorghum and maize as well as rice fallow [3].

Beans are one of the most economically and nutritionally important indigenous African grain legumes produced throughout the tropical and subtropical areas of the world. Grains legumes or pulses are rich and low-cost sources of dietary proteins and other nutrients for a large part of world's population [4]. They supplement to the lower quality cereal or root and tuber protein commonly consumed in tropical Africa [5]. On average, cowpea grains contain 23-25% protein and 50-67% starch in dry bases [1].

Beans play a key role in the agriculture and food supply of Nigeria which happens to be the largest producer and consumer of beans in the world. Cowpea grain is consumed directly after cooking, or as a component of meals made from cereals or root crops [6]. Cowpea cakes (made from mashed and fried seed) are also sold as a fast food along roadsides in humid forest of South-western Nigeria.

It has been estimated that about 3.3 million tonnes of cowpea dry grains were produced worldwide in year 2000. Nigeria produced 2.1 million tonnes of this, making it the world's largest producer, followed by Niger (650,000 tonnes) and Mali (110,000 tonnes) [7].

Food safety simply means absence or presence of safe levels of contaminants, adulterants, naturally occurring toxins or any other substance that may make food injurious to health on an acute or chronic basis. The increasing demand for food safety stimulated researches regarding the risk associated with consumption of foodstuff contaminated by heavy metals [8]. Heavy metals are placed conspicuously on the list of contaminants contributing injuries to the heath of human being. These greatly influence the safety of beans consumption because they have been excessively released into the environment due to rapid industrialization and have created major global concern with attendant negative roles in human life [9,10,11].

Heavy metals are environmental contaminants capable of causing human health problems if excess amount is ingested through food [12], heavy metals are non-biodegradable and persistent, have a long half-lives and can be bio-accumulated through biological chains [12]. Heavy metal toxicity can result from contamination of irrigation water, the application of fertilizer and metal based pesticides, industrial and vehicular emission, harvesting process, transportation, storage or sale [13]. Crops and vegetables grown in soils contaminated with heavy metals have greater accumulation than those grown in uncontaminated soils. Deposition of heavy metals from industrial and vehicular emissions on crops foliar surfaces may occur during production, transportation and marketing [14]. When heavy metals are absorbed by plants which may be used as food and medicine to man and as forage to animals, they find their ways into the body system causing cancer and even heart disease [15].

Food is an important source of lead and cadmium and determination of lead and cadmium in food can be used for the estimation of their exposure [16]. Lead and cadmium can be very harmful even at low concentrations when ingested over a long time [17]. After ingestion, the absorption rate of lead ranges from 3% to 80%, whereas the typical absorption rates of dietary lead in adults and infants are 10% and 50%, respectively. After absorption, lead is initially distributed to soft tissues throughout the body via blood, and then deposited in bone [18,17].

Lead and Cadmium are classical chronic toxic chemicals. Mercury, Lead and Cadmium had been categorized as highly toxic among heavy metals [19]. They may cause damages to kidneys, the cardiovascular, immune, hematopoietic, central nervous and reproductive systems. It was reported by [20] that the main sources of exposure for an adult are food (ranging from 0.4 µg/kg bw/week to 10.1 µg/kg bw/week) and water (ranging from 0.23 µg/kg bw/week to 0.35 µg/kg bw/week). Heavy metals are found in a diversity of food materials, including beans [21].

Metals such as lead, mercury, cadmium and copper are cumulative poisons, cause environmental hazards and are reported to be exceptionally toxic [22]. These metals are major sources of oxidative stress in the cell and play an important role in the etiology of diverse human pathologies such as carcinogenesis [23,24,25, 26]. Exposure to heavy metal toxicity leads to brain damage, mental retardation, cerebral palsy, lung cancer, gastrointestinal abnormalities, and dermatitis, and death of the unborn foetus [27]. Many metals have been shown to directly modify and/or damage DNA by forming DNA adducts that induce chromosomal breaks [28].

Excessive content of Pb and Cd in food is associated with etiology of a number of diseases especially with cardiovascular, kidney, nervous as well as bone diseases [29,30,31]. Since the dietary intake of food may constitute a major source of long-term low-level body accumulation of heavy metals, the detrimental impact becomes apparent only after several years of exposure. Regular monitoring of these heavy metals in food materials is essential for preventing excessive buildup of the metals in the food chain.

The two common varieties of bean popularly eaten in South-western Nigeria included drum, and Oloyin [32]. Ibadan is the most populous city in this region with about 4 million people according to Census, 2006. The city is characterized with heavy anthropogenic, industrial and vehicular activities which are major contributor to the release of heavy metals to the environment as reported by [13]. Apart from concentration of heavy metal in the environment, [33] had also reported that the species of crop determines amount of heavy metals that any crop will bio-accumulate.

Despite these array of negative impacts of the consumption of heavy metal contaminated beans by large populace, and based on persistent nature and cumulative behavior as well as the probability of potential toxicity effects of heavy metals as a result of consumption of beans, there is need to assess this food items to ensure that the levels of these heavy metals meet the agreed international requirements to ensure that maximum levels allowed are not exceeded. This study therefore, presents data on the levels of Pb and Cd in cowpea (Bean) in Ibadan, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

Ibadan is located in the south-west part of Nigeria. It is located approximately on longitude 3°5' to 4°36'East of the Greenwich Meridian, and latitude 7°23' to 7°55' North of the Equator. Ibadan is located at a distance of 145 km north of Lagos [34]. The 2006 census put the total population of Ibadan to 2,550,593 while the average population density was 828 persons per km^2 [35]. The three markets where samples were collected are the major raw food markets. They are located within the Ibadan city and are along main roads.

2.2 Collection of Samples

Three samples of each of two varieties of brown beans (cowpea) were randomly collected from four vendors each from three major food stuff markets in Ibadan, Nigeria during 2016. The total samples obtained were 72 samples.

The three markets considered for this study were Oja-Oba Market, Ayeye market and Bodija international market, all located at Ibadan. The two varieties of brown bean samples collected were 'Oloyin' and 'Drum'

2.3 Pretreatment of Samples

After collection of the samples, they were brought into the laboratory and processed further for analysis. Healthy seeds of the samples were used for analysis while bruised and insect infested samples were removed. Foreign matters such as grains, pebbles and pod remnants were manually removed from the cowpeas.

2.4 Preparation of Laboratory Samples for Analysis

Dried samples (dried in an oven at 40°C) of the cowpea were ground into fine powder using a laboratory grounder, sieved using 0.500 mm mesh size sieve and stored in polyethylene bags, until used for acid digestion.

2.5 Reagents

All the reagents used were of analytical grade. 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 water before soaking in 10% nitric acid for 24hours, cleaned thoroughly with double distilled water and dried to ensure that there is no contamination.

2.6 Acid Digestion

Heavy metals in cowpea (beans) samples were extracted following acid digestion procedure. It followed method described by Kakulu and Jacob [36] with little amendment. 0.5 g each of the powdered samples were weighed into a digestion tube and 10 ml of 98% nitric acid was added. This was then placed in a water bath and allowed to boil for about 72 hours. This was covered with a lid and transferred to digestion block in a fume cupboard for digestion. The temperature was steadily increase (to prevent fuming) until it reached 105°C. This was left and allow to undergo digestion for 30 minutes, after which digestion was completed, the resulting pale yellow solution was allowed to cool and transferred into a 25 ml volumetric flask and made up to 25 ml mark with de-ionized water and was filtered into clean sample bottles.

Reagent blank was prepared in similar manner. Spiking of the sample was done using standards of concentration of each studied metals (Cadmium and Lead), and blank samples were extracted as above.

2.7 Heavy Metals Analysis

The acid digest of beans sample solutions were analyzed for Lead (Pb), and Cadmium (Cd) using a Buck scientific atomic absorption spectrophotometer (model 210/211 VGP) with Air-acetylene flame. A certified standard reference materials was used to ensure accuracy and the analytical values were within the range of certified value. Blank and standards were run after five determinations to calibrate the instrument.

Statistical Analysis: Means and standard deviation were calculated using analysis of variance (ANOVA).

3. RESULTS AND DISCUSSION

Tables 1 and 2 show the concentration of heavy metals investigated in beans commonly consumed in Ibadan, Nigeria. The values are given as mean ± Standard Deviation. The heavy metal levels determined were based on grain dry weight.

Table 1 reveals the mean concentrations of Cadmium and Lead in Drum beans in the three markets under study and their standard deviations. The average concentration of Cadmium in Drum beans in Ayeye market was 0.00125 mg/kg. No Cadmium concentration was present in drum beans sampled in Bodija market, while on the average 0.00125 mg/kg Cadmium was present in sampled Drum beans in Oja-Oba market. In Ayeye market, the mean Lead concentration in Drum beans was 0.0039 mg/kg. The mean Lead concentration in Drum beans in Bodija market was 0.057 mg/kg and the mean Lead concentration in Drum beans in Oja-oba market was 0.0125 mg/kg. In Drum Beans samples analyzed, concentration of Cd ranged from 0.000 to 0.010 mg/kg in the Ayeye and Oja-oba markets but no sample indicated Cd contamination in Bodija market while it was 0.000 to 0.108 mg/kg, 0.000 to 0.850 mg/kg and 0.000 to 1.520 mg/kg in Ayeye, Bodija and Oja-oba markets respectively.

Table 2 reveals the mean concentrations of Cadmium and Lead in Oloyin beans in the three markets under study and their standard

Table 1. Mean levels (mg/kg) of cadmium and lead in drum beans in the three markets from Ibadan, Nigeria

Markets	Mean concentration of cadmium	Range of cadmium	Mean concentration of lead	Range of lead
Ayeye market	0.00123±0.0034	0.000 - 0.010	0.0039±0.052	0.005 – 0.122
Bodija Market	0.00000±0.00000	0.000 - 0.000	0.057±0.034	0.015 – 0.100
Oja-Oba Market	0.00125±0.0034	0.000 - 0.010	0.0125±0.035	0.000 – 0.010

Table 2. mean levels (mg/kg) of cadmium and lead in oloyin beans in the three markets from ibadan, Nigeria

Markets	Mean concentration of cadmium	Range of cadmium	Mean concentration of lead	Range of lead
Ayeye market	0.00125±0.0034	0.000 – 0.010	0.028±0.038	0.000 – 0.108
Bodija Market	0.00125±0.0034	0.000 – 0.010	0.159±0.288	0.000 – 0.850
Oja-Oba Market	0.0025±0.0046	0.000 – 0.010	0.234±0.521	0.000 – 1.52

deviations. The average concentration of Cadmium in Oloyin beans in Ayeye market was 0.00125 mg/kg. It was 0.00125 mg/kg in Bodija market and 0.0025 mg/kg in Oja-Oba market. In Ayeye market, the mean Lead concentration in Oloyin beans was 0.028 mg/kg. The mean Lead concentration in Oloyin beans from Bodija market was 0.159 mg/kg and the mean Lead concentration in Oloyin beans from Oja-Oba market was 0.234 mg/kg. In the Oloyin beans samples analyzed, concentration of Cd ranged from 0.000 to 0.010 mg/kg in the three markets while that of Pb was 0.000 to 0.108 mg/kg, 0.000 to 0.850 mg/kg and 0.000 to 1.520 mg/kg in Ayeye, Bodija and Oja-oba markets respectively.

Table 1 shows the average Cadmium concentrations in drum beans in the three markets studied. The highest Cadmium concentrations were found in Market 1 and Market 3, with average concentrations of 0.00125 mg/kg and 0.00125 mg/kg respectively. This shows that on the average, Cadmium concentrations across the three markets are still within safe limit, as it is below FAO/WHO's 0.2 mg/kg recommended safe limit for cowpea. This result agreed with the report of Sulyman, et al. [37] but disagreed with Iweala et al. [38] which reported higher concentration of Cd in beans, though at safe levels

Also in Table 1 the average Lead concentrations in drum beans in the three markets under study was indicated. The highest average Lead concentration was found in Market 2 with average concentrations of 0.057 mg/kg. This shows that on the average, Lead concentrations across the three markets are still within safe limit, as it is below FAO/WHO of 0.2 mg/kg recommended safe limit for Lead FAO/WHO [39]. This result though at safe level, was against Iweala et al. [38] report, who recorded no result of Pb concentration in Beans.

Table 2 shows the average Cadmium concentrations in Oloyin beans in the three markets under study. The highest average Cadmium concentration was found in Market 3 with average concentrations of 0.0025 mg/kg. This shows that on the average, Cadmium concentrations across the three markets are still within safe limit, as it is below FAO/WHO's 0.2 mg/kg recommended safe limit.

Table 2 shows the average Lead concentrations in Oloyin beans in the three markets under study. The highest average Lead concentration was found in Market 3 with average concentrations of 0.234 mg/kg. This shows that on the average, Cadmium concentrations across the three markets are still within safe limit, as it is below FAO/WHO recommended safe limit [39]. Iweala et al. [38] report a zero concentration level of Pb in beans which contradict results in this study. The values of Cd in cereals reported by Edem, et al. [40] were within range of values obtained in this research work, but far below what were reported by Okoye et al. [41] and Dahiru et al. [42]. These differences could be due to differences in the concentration of the metal in the soil where the crops were grown. Also Okoye et al. [41] reported Pb values in cereals that fell within range obtained in this research work.

In this study the result indicated that safe levels of CD and Pb were recorded in all samples analysed (except in one sample of Oloyin beans Obtained from Oja-Oba market which indicated Pb concentration of 1.52 mg/kg) when compared to the FAO/WHO permissible limits for grain crops. This was in agreement with the result of Sulyman, et al. [37] with Cd levels in cereal studied found below safe limit. Nonetheless, one should not overlook the fact that both metals (Cd and Pb) accumulate in the body with time due to the frequency of consumption of beans containing them in small quantities. If these metals are not eliminated at the rate at which they bioaccumulate they pose serious health risk to their consumers.

Due to the low levels of Cd and Pb in the bean samples analyzed there is an indication that vehicular emission of the adjourning roads to the markets might contribute to the heavy metals. The levels of heavy metal measured must have been contributed by plant uptake at the place where the beans were grown and/or emission from vehicle when transporting them since most of beans sold in Ibadan are from the Northern part of Nigeria.

4. CONCLUSION

The results of this study did not indicate absence of the toxic heavy metals (Lead and Cadmium) on the average but they were at safe levels compare with the FAO/WHO standard. Nonetheless, one should not overlook the fact that these toxic elements accumulate in the body with time due to frequency of their exposure. If these metals are not eliminated at the rate which they bioaccumulate, they pose serious health risk to their consumers. So it is essential for agricultural activities and other human activities that increase heavy metal contamination of food stuffs be controlled. Therefore, the opinion of Otitoju et al. [43] that monitoring and systematic gathering of information on heavy metal levels in the environment are essential components of any pollution control system is well supported [42].

As reported by Zoran et al. [44] seed coat accumulate significant amounts of Pb and due to large surface area to volume ratio in beans grain, large amount of Pb and other toxic metals are accumulated. Also, Zoran, et al. [45] reported that two-to-four-times higher Pb are in the seed coat than in the seed embryo because the seed coat constitute the effective barrier against penetrating of toxic ions. Hence less exposure to Pb and Cd would be achieved if seed coats are removed before consumption by human being.

It is necessary to undergo studies that will cover larger consuming public and also conduct extensive population exposure risk assessment of the heavy metals in beans being sold in these three markets studied. Routine assessment of Cd and Pb concentration in this beans sold in these three market is inevitable to ensure the metals do not exceed the global standard for safety. Also due to the sensitivity of food safety in human health appropriate regulation of industrial wastes disposal activities should be ensured to reduce environmental contamination because industrial waste are major sources pollution by heavy metals. Routine monitoring of soils on which crop especially cowpea are planted is essential to safeguard uptake by plant, and untreated sewage water should be avoided when irrigating cowpea farms.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kabulu MS. Cowpea (*Vigna unguiculata*) variety mixtures for stable and optimal leaf and seed yields when intercropped with maize in Central Tanzania. MSc thesis at Georg-August-Universität, Göttingen, Germany. 2008;75.
2. Oyewale RO, Bamaiyi LJ, Oparaeke AM, Adamu, RS. Evaluation of four insecticide formulations for the management of insect pests of cowpea. Afican Journal of Food Science and Technology. 2014;5(8):180-188.
3. Ishiyaku MF, Higgins TJ, Umar ML, Misari SM, Mignouna HJ, Nang'yo F, Stein J, Murdock LM, Obokoh M, Huesing JE. Field evaluation of some transgenic Maruca resistant Bt cowpea for agronomic traits under confinement in Zaria, Nigeria; 2010.
4. Egounlety MA, Aworh OC. Effect of soaking, dehauling, cooking and Fermentation with *Rhizopus oligosporus* on Oligosaccharides, trypsin inhibitor, phytic acid and tannins of soybean (Glycine *max* Merr.), cowpea (*Vigna unguiculata* L. Walp) and groundbean (*Macrotyloma geocarpa* Harms). J. Food Eng. 2003;56:249-254.
5. Karikari SK, Molatakgosi G. Response of cowpea (*Vigna unguiculata* (L.) Walp.) varieties to leaf harvesting in Botswana. UNISWA Journal of Agriculture. 1999;8:5-11.
6. Latunde-Dada GO. Iron contents and some physical components of twelve cowpea varieties, Int. J. Food Sci. Nutr. 1993;43:193-197.
7. International Institute of Tropical Agriculture (IITA). IITA Crops and Farming Systems; 2004.
Available:www.ita.org/crop/cowpea.html
8. Wodaje Addis Tegegne. Assessment of some heavy metals concentration in selected cereals collected from Local markets of Ambo city, Ethopia. Journal of Cereals and Oil Seeds; 2015;6(2):8-13.
9. Divrikli U, Saracogly S, Soylak M, Elci L. Determination of trace heavy metal

contents of green vegetables samples from Kayseri-Turkey by flame atomic absorption spectrometry. Fresenius Environ. Bull. 2003;12:1123-1125.
10. Dundar MS, Saglam HB. Determination of cadmium and vanadium in tea varieties and their infusions in comparison with 2 infusion processes. Trace Ele. Elect. 2004; 21:60-63.
11. Colak H, Soylak M, Turkoglu O. Determination of trace metal content of herbal and fruit teas produced and marketed from Turkey. Trace Elem. Elec. 2005;22:192-195.
12. Haware DJ, Pramond HP. Determination of specific heavy metals in fruit juices using atomic absorption spectrophotometer (AAS). Int. J. Res. Chem. Environ. 2011; 4(3):163-168.
13. Ladigbolul A, Balogun KJ. Distribution of heavy metals in sediments of selected streams in Ibadan metropolis, Nigeria. Int. J. Environ. Sci. 2011;1:1186-1191.
14. Jassir MS, Shaker A, Khalip MA. Deposition of heavy metals on green leafy vegetable sold on roadsides of Riyadh city, Saudi Arabia. Bull. Envir. Cont. Toxicol. 2005;75:1020-1027
15. Corey RB, King LD, Lue-Hing C, Faming DS, Steward JJ, Cunnigham SDM, Anderson TA, Schwas AR. Phytoremediation of soild contaminated with pollutants. Adv. Agro. 1996;56:55-114.
16. Mary EF, Kimberly AG, Helen JB. Lead levels of edibles grown in contaminated residential soils: A field survey. Sci. Total Environ. 2004;2(3):245-257.
17. Tuzen M. Determination of heavy metals in fish samples of the middle Black Sea (Turkey) by graphite furnace atomic absorption spectrometry. Food Chem. 2003;80:119-123.
18. Celik U, Oehlenschlager J. Determination of zinc and copper in fish samples collected from Northeast Atlantic by DPSAV. Food Chem. 2004;87:343-347.
19. Hezbullah M, Sultana S, Chakroborty SR, Patwary MI. Heavy metal contamination of food in a developing country like Bangladesh: An Emerging threat to food safety. Journal of Toxicology and Environmental Health Science. 2016;8(1).
20. Food Standard Agency (FSA) of UK. Total Diet Study of 12 Elements-Aluminium, Arsenic, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, Nickel, Selenium, Tin and Zinc; Food; 2007.
21. Iwegbue CMA, Nwozo SO, Overah CH, Bassey FI, Nwajei GE. Concentrations of selected metals in some ready-to-eat-foods consumed in southern Nigeria: Estimation of dietary intakes and target hazard quotient. Turk. J. Agric. Food Sci. Technol. 2013;1:1-7.
22. Yargholi B, Azimi AA. Investigation of Cadmium absorption and accumulation in different parts of some vegetables. American Eurasian Journal of Agriculture and Environmental Science. 2008;3:357-364.
23. Frenkel K. Carcinogen-mediated oxidant formation and oxidative DNA damage. Pharmacolology and Therapeutics. 1992; 53(1):127-166.
24. Wang Y, Fang J, Leonard SS, Rao KM. Cadmium inhibits the electron transfer chain and induces reactive oxygen species. Free Radical Biology and Medicine. 2004;36:1434-1443.
25. Leonard SS, Bower JJ, Shi X. Metal-induced toxicity, carcinogenesis, mechanisms and cellular responses. Molecular Cell Biochemistry. 2004;255:(1-2):3-10.
26. Hei TK, Filipic M. Role of oxidative damage in the genotoxicity of arsenic. Free Radical Biology and Medicine. 2004;37:574-581.
27. U.S.EPA. Draft action plan. Development of a framework for metals assessment and guidance for characterizing metals. EPA/630/P-02/003A. Washington, DC.; 2002.
28. Chakrabarti SK, Bai C, Subramanian KS. DNA-Protein cross links induced by nickel compounds in isolated rat lymphocytes role of reactive oxygen species and specific amino acid. Toxicology and applied and pharmacology. 2001;170(3): 153-165.
29. WHO. Lead. Environmental Health Criteria, Geneva. 1995;165.
30. Steenland K, Boffeta P. Lead and cancer in humans: Where are we now? Am. J. Ind. Med. 2000;38:295-299.
31. Jarup L. Hazards of heavy metals contamination. Br. Med. Bull. 2003;68: 167-182.
32. Olayiwola OA, Shittu SA, Adebayo OR. Evaluation of heavy metals in three common Nigerian Cowpea (*Vigna unguiculata*) paste end product (''Moinmoin'') using different packaging materials. International Journal of Environmental Sciences. 2012;3(2).

33. Kiende J, Kwara F, Orinda G, Okemo P. Assessment of heavy metal concentrations in urban grown vegetables in Thika Town, Kenya. Afr. J. Food Sci. 2012;6:41-46.
34. Bankole MO, Bakare HO. Dynamics of urban land use changes with remote sensing: Case of Ibadan, Nigeria. Journal of Geography and Regional Planning. 2011;4(11):632-643.
35. National Population Commission, Nigeria. Census Report; 2006.
36. Kakulu SE, Jacob JO. Comparison of digestion methods for trace metal determination in moss samples. Proceeding of the 1st National Conference of the Faculty of Science, University of Abuja. 2006;77-81.
37. Sulyman Y, Abdulrazak S, Oniwapele YA, Ahmad Ahmad. Concentration of heavy metals in some selected cereals sourced within Kaduna state, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT). 2015;9: 17-19.
38. Iweala EEJ, Olugbuyiro JAO, Durodola BM, Fubara_Manuel DR, Okoli AO. Metal contamination of foods and drinks consumed in Ota, Nigeria. Reseach Journal of Environmental Toxicology. 2014;8(2):92-97.
39. FAO/WHO Codex alimentarius- general standards for contaminants and toxins in food. Schedule 1 maximum and guideline levels for contaminants and toxins in food. Joint FAO/WHO food standards programme, Codex committee, Rotterdam. Reference CX/FAC 02/16; 2002.
40. Edem CA, Grace I, Vincent O, Rebecca E, Matilda O. A comparative evaluation of heavy metals in commercial wheat flours sold in Calabar-Nigeria. Pakistan Journal of Nutrition. 2009;8:685-587.
41. Okoye COB, OdoIS, Odika IM. Heavy metals content of grain commonly sold in markets in South-east Nigeria. Plant product Research Journal. 2009;13:1119-2283.
42. Dahiru MF, Umar AB, Sani MD. Cadmium, copper, lead and zinc levels in sorghum and millet grown in the city of kano and its environ. Global Advanced Research Journal of Environmental Science and Toxicology. 2013;2(3):082-085.
43. Otitoju O, Akpanabiatu MI, Otitoju GTO, Ndem JI, Uwah AF, Akpanyung EO, Ekanem JT. Heavy metal contamination of green leafy vegetable Gardens in Itam Road Construction site in Uyo, Nigeria. Research Journal of Environmental and Earth Sciences. 2011; 4(4):371-375.
44. Zoran SI, Natasa M, Radmila T, Nikolaos K, Lidija M, Ljubomir S. Effect of Pb on germination of different seed and his translocation in bean seed tissues during sprouting. Fresenius Environmental Bulleting. 2015;24(2a).
45. Muszynska E, Habus-Fajeriska E, Ciarkowska K. Evaluation of seed germination ability of native calamine plant species on different substrate. Polish Journal of Environmental Studies. 2013;22:1775-170.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26151