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Determinations of Some Selected Heavy Metals and Elements in Baobab Tree Leaves (*Adonsonia digitata*) Grown in College of Agriculture, Maiduguri, North – Eastern Nigeria

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Abstract: This research study was carried out on the appraisal of some selected heavy metals and elements in Baobab tree leaves (*Adonsonia digitata*) grown in College of Agriculture, Maiduguri, north – eastern Nigeria. The samples were collected, authenticated and prepared as described by Gwana, *et al.* [1]. Plant part materials were analysed in triplicate and the techniques applied were that of the methods as described by AOAC (Association of Official Analytical Chemists) [2] and Ashiq, *et al.* [5]. The results obtained revealed that the presence of the seven selected metals and elements with their mean concentration levels were ranged from 0.3 to 81.0 mg / l; 81 mg / l, 0.84 mg / l, 0.04 mg / l, 0.61 mg / l, 0.68 mg / l, 0.3 mg / l, and 0.3 mg / l for Ca, Cd, Cr, K, Mn, Pb and Zn. While with regard to the mean percentage of their concentration were ranged from 0.4 % to 97.0 %; Ca had 97.0 %, Cd (1.0 %), Cr (0.05 %), K (0.73 %), Mn (0.81 %), Pb and Zn both had 0.4 % each. The magnitude of concentration levels of the elements detected in *Adonsonia digitata* leaves in sequential order was Ca > Cd > Mn > K > Pb and Zn > Cr, the highest mean concentration was calcium (Ca), the least was chromium. *Adonsonia digitata* leaves grown in this area were rich in minerals, both macro and micro elements. The study also revealed that amongst the seven elements being determined, Ca, Cd and Cr had exceeded the standard recommended values for heavy metals and elements, both rest (Mn, K, Pb and Zn) were found not health risks free, wholesome for consumption (in terms of the minerals determined) by human beings and animals. The results obtained were similar to the works of Ibrahim and Jimoh [7], Qais, *et al.* [9]; Okoronko, *et al.* [15] amongst others.

Keywords: *Adonsonia digitata*; Concentration; Elements; Health risks; Metals.

1. Introduction

Baobab tree (*Adonsonia digitata*), known as "*Kuka*" in Hausa language, "*Karkara*" in Kanuri language, and "*Bakko*" in Fulfulde (Fulani) language. In Nigeria and its neighboring countries, the leaves are locally used to make soup especially in the northern part of Nigeria. The baobab tree leaves are stable source of food for rural population in many part of Africa. Every part of the baobab tree is reported to be useful for mankind as well as livestock, used as food and medicinal purposes.

Adonsonia digitata belongs to the family Meliaceae; it is a deciduous tree native arid central Africa and it is a largely spread across large area of sub – Saharan, semi-arid and sub-humid regions of African countries [3, 4]. The leaves of baobab tree are good source of vitamins and minerals, e.g. calcium and vitamin C., and are also important source of protein in complementing the amino acids profile and thereby improving the protein quality of the diet [6].

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The African baobab tree (*Adonsonia digitata*) is among the eight species of baobab and it is only native to mainland Africa. Like other baobabs, the African is a massive deciduous fruits tree reach up to 20 – 30 metres high, with a lifespan of several hundred years. It's swollen and hollow bottle and can be as broad as 3 – 7 metres broad [8]. It bears short, stout and tortuous branches and has thin canopy. It's strongly anchored in the soil by an extensive and strong root system that grows 100 metres deep and whose diameter may be higher than the tree height. The leaves are simple or digitally compound, dark green on top and borne at the end of a 16 cm and 1.5 – 7 cm broad. It shed its leaves during the early dry season and new leaves appear after flowering. The penta - memerous flowers are white, large and were 20 cm in diameter and 25 cm long, hang from stalks on pedicels up to 90 cm long. The fruit is a voluminous, 35 cm long and 17 cm in diameter, ovoid capsule with a hard woody envelope containing a pulp and black seeds. Once ripe, the fruit enveloped, becomes brittle and the pulp takes on a chalky consistency. The tree starts producing fruit from 8 – 10 years after planting but consistent production occurs only after 30 years [4, 8, 10, 11].

However, the biological system need to be absorbed the nutrient available in the leaves of baobab tree but unfortunately, it associated with some harmful elements such as heavy metals which may lead to intoxication and with prolong accumulation may be found in the leaves [12-14]. Such metals are important for proper functioning of the biological system and their deficiency or excess could lead to a number of disorders, and are biodegradable elements, have prolong biological half-life and have the potential accumulation in different body organs, leading to health risk [14, 16, 17].

Consumption of food crops contaminated with heavy metals is a major food chain route for human exposure [4, 6, 26, 28]. The distribution of heavy metals in plant body depends upon availability and concentration of heavy metals as well as particular plant species and its population [5, 18-20]. Many researchers have shown that some common vegetables are capable of accumulating high levels of metals from the soil [21, 22]. Certain species of these vegetables (e.g. cabbage) are hyper-accumulators of heavy metals into the edible tissues of plants [23].

Out of the one hundred and twelve (112) elements in nature, about eighty (80) are metals, most of which are found only in trace amounts in the biosphere and biological materials. Some metals or metal like elements which do give rise to well organize toxic effects in man and his ecological associates [5, 24, 25]. These elements include; arsenic, antimony, beryllium, cobalt, chromium, lead, manganese, nickel, e.t.c, [26, 27].

Protection of environment is the most vital issue today; explosive population growth, rapid progress in science and technology, massive industrial organization and use of various chemicals in agriculture and most important, human activities are the factors threatening the very quality of life [28-30]. Macro and micro element compounds found in plants such as vegetables and grains in small amounts, these compounds are not established nutrients, but significantly protect the development of lots of degenerative diseases [31-33].

High levels in the body can be immediately poisonous, or can result in long-term health problems similar to those caused by pesticides and herbicides [22, 34]. For example, cadmium in fertilizer derived from sewage sludge can be absorbed by crops. If these crops are eaten by humans in sufficient amounts, the metal can cause diarrhoea and, over time, liver and kidney damage [27, 32, 35, 36]. The objectives study are to determine some selected heavy metals and elements in baobab tree leave (*Adonsonia digitata*) grown in College of Agriculture, Maiduguri. The highly desired need of food security, and ecosystem environmental condition, when *Adonsonia digitata* is been cultivated in farm (as source of food for both human and animal, especially ruminants) and medicinal plant, a lot of products would be obtained from it, every part of the plant materials are useful and lot of income would be generated, which will increase the Gross Domestic Products and income at large.

2. Methodology

The method applied in the determinations of heavy metal in each plant materials samples after the Ashing and the digestion was by using the Atomic Absorption Spectrophptometric techniques as described by AOAC (Association of Official Analytical Chemists) [2]; Ashiq, *et al.* [5]; Gwana, *et al.* [1].

2.1 Materials

Materials and reagents used in this research study were of high grade, AOAC standard reagents and the determinations of minerals in the plant part materials was by using the Atomic Absorption Spectrophotometer of the 210 VGP - Buck model. SOP was strictly being observed.

2.2. Sampling

2.2.1. Samples Collection

The site of the farm is located at College farm centre premises, Maiduguri, Nigeria. At early hours (07:30 AM) in the morning, fresh sample of the plant material (*Adonsonia digitata* tree leaves) were obtained directly and randomly through carefully hand plugging from the farm centre. These plant materials were pooled together and packed in black polythene bags, labeled and transported to the Laboratory, College of Agriculture, Maiduguri, Nigeria.

2.2.2. Plant Sample Identification

The plant was identified as *Adonsonia digitata* tree plant by Botanist, Shetima, U. K. of the department of Forestry Technology, Mohamet Lawan College of Agriculture, Maiduguri, Borno State of Nigeria. The age of the plants were estimated at about 42 years old and authenticated with reference to the herbarium sheets (Voucher number 10), kept at the Herbarium of the said Department of the same University.

2.2.3 Preparation of Sample Plant Materials

The plant parts materials obtained were prepared, standard operation procures (SOP) are absolutely being observed as described by Gwana, *et al.* [1].

The leaves were destalked and cut into pieces, washed with acidic water, running tap water for several minutes, deionised water for few minutes and air - dried for three weeks at an average room temperature of 30 – 34^{o}C. Continuous turning of the plants materials were done to avert fungal growth for several days until the treated leaves dried, then in hot air oven at 60 ± 5^{O}C for 48 hours completely and were kept away from high temperatures and direct sunlight to avoid denaturalizing the treated plant part material.

2.2.4. Pulverization of the Treated and Dried Plant Part Material

The reduced chopped leaves materials were pulverized reduced to fine powder using an electronic blender (Homogenizer). This was done in order to increase the surface area so that the to hasten the process. The fine powdered plant material was then transferred in to sterilized brown plastic bottles, labeled, screwed - capped and stored in a dry – cool, and away from damp and direct sunlight, this is in order to avoid the denaturalizing the prepared plant material sample and its components, until when ready for Ashing.

2.2.5. Ashing the Samples

The washed, air dried plant parts materials were pulverized in to powder, transferred in to crucible dish and put to muffle furnace, heated at 500^{o}C for 3 hours. It was then removed and allowed in a desiccator to cooled and dried, as described by Ashiq, *et al.* [5].

2.2.6. Digestion of the Samples

0.5g of the ashed samples was transferred into 250 ml beaker each. 10 ml of 6M Hydrochloric acid were also added to each and covered the beaker with watch glass and heated for 15 minutes, removed and cooled. 1ml of concentrated Nitric acid was added and heated to evaporate to dryness and dehydrated the Sillica. 1ml of 6M of Hydrochloric acid was added again. 10 ml of distilled water was added and heated to redissolved, cooled and filtered with filter paper Whatman No 541 into 100 ml volumetric flask up to the mark leveled. It was then transferred in to polythene bottle for elements analysis, as described by AOAC (Association of Official Analytical Chemists) [2].

2.3. Method of Elements Analysis

The method used in the determinations of some selected mineral composition of the sampled plant materials, after the Ashing and the digestion of the sample was by using the Atomic Absorption Spectrophptometric techniques as described by AOAC (Association of Official Analytical Chemists) [2].

2.4. Data Analysis

Data obtained from this research study were subjected to statistical tools of analysis using percentage, mean for the measurement of central tendency, and standard deviations for measurement of dispersion and or discrepancy within the variables being obtained and its' significance, as described by Stroud and Booth [37].

3. Results

The results obtained revealed that, mean concentration levels some heavy metals and other elements were determined in some plant parts materials (leaves) of *A. digitata* that grown in the premises of the farm centre, College of Agriculture, Maiduguri. Seven (7) elements were selected, screened and evaluated. The mean concentration levels of seven (7) elements Ca, K, Cd, Cr, Mn, Pb and Zn in milligram per gram (mg/g) were presented in mean and standard deviations of each element in the plant part material concerned as been presented in the tables below as follows:

Table 1 showed the mean concentration levels of some heavy metal elements determined in *A. digitata* leaves. The results revealed that the mean concentration levels of the elements which were expressed in microgram per litre were ranged from 0.04 to 81 mg / l; Ca had 81 mg / l which was the highest, Cd (0.84 mg / l), Cr (0.04 mg / l), K (0.68 mg / l), Mn (0.61 mg / l), Pb (0.31 mg / l) and Zn had the lowest value of 0.3o mg / l respectively.

Table 2 showed the mean percentage of selected elements detected in *A. digitata* leaves. The results obtained revealed that the percentage concentration of each heavy metal and elements, were ranged from 0.1 to 97 %; Ca had the highest value of 97 %, Cd (1 %), Cr (0.1 %), K (0.8 %), Mn (0.7 %), Pb and Zn were with 0.4 % each and the in mean percentage was chromium that respects.

Table-1. Mean Concentration Levels of Some Heavy Metals and Elements Determined in *A. digitata* Leaves.

Plant part (*M. oleifera*)	Mean Concentration of Metal in microgram per gram (mg / l)						
	Ca	Cd	Cr	K	Mn	Pb	Zn
Leaves	81.0 ± 0.5	0.84 ± 0.01	0.04 ± 0.01	0.68 ± 0	0.61 ± 0.01	0.31±0.02	0.3 ± 0
*Safe limit (mg / l)	75.0	0.003	0.40	10.0	-	0.10	5.0

Keys: - = no known, nd = not detected.
***SOURCE**: WHO / AOAC, safe limit, revision 2, section 973 – 42B (b).

Table-2. Percentage Concentration of Some Heavy Metals and Elements Determined in *A. digitata* Leaves.

Plant part (*M. oleifera*)	Mean Percentage Concentration of Metals and elements (%)						
	Ca	Cd	Cr	K	Mn	Pb	Zn
Leaves	81.0	0.84	0.04	0.68	0.61	0.31	0.30
Percentage	97	1.0	0.1	0.8	0.7	0.4	0.4

Keys: % =percentage, - = no known, nd = not detected.

4. Discussion

Most plants are of economics values to the ecosystem environment. The plant of baobab tree (*A. digitata*) will not be left behind due to its economics contribution to human and animals, known as "*Kuka*" in Hausa language, "*Karkara*" in Kanuri language, and "*Bokko*" in Fulfulde (Fulani) language. In Nigeria and its neighboring countries, the leaves are locally used to make soup especially in the northern part of Nigeria. The baobab tree leaves are stable source of food for the rural population in many part of Africa. Every part of the baobab tree is reported to be useful for mankind as well as livestock, used as food and medicinal purposes. The baobab tree is mainly used for; as vegetable, seasoning additives and herbal concoctions, the roots of seedlings, leaves, flowers, fruits, shoots, and the roots, are edible which may mostly when undergo certain processing before been consumed. The fruits and the seeds are used as yoghurt and seasoning ingredient. The leaves can be used either fresh as vegetable or dried and powdered used as soup or used as a functional thickening ingredient of the soup and sauces in Nigeria and other part of Africa countries. It is been used as vegetable and for medicinal purposes traditionally. The plant has been widely grown in the semi – arid zones, tropical (including Nigeria) and subtropical areas where leaves are used as vegetables, which for centuries has been advocated for traditional food and medical uses. It could be used as leafy vegetable, root vegetable, seed and fruit vegetable when undergone process. Vegetables are source of minerals, vitamins, proteins, oil, carbohydrates, phytonutrients, etc, which serves as nutrition and source of medicinal materials.

Within the recent years, changes in climate have caused some impacts on human system and natural – the ecosystem environments, which causes rise of the eyebrows to the scientific researchers, which led to the environmental analyses in order to ascertain the impacts and make statements on the impacts. Some the human activities, not natural, such as the global warming and contaminations by industrial wastes materials to the ecosystem environments may lead to excessive release of some metals to the soils and waters, e.g. rivers, streams, etc, and as a result this may lead to bioaccumulation in edible plants. Plants absorb these metals through their root tissues, depending on of type of varieties of the plants, and some are specific to these metals. The elements play an important role in the metabolic pathways during the growth and development of plants, when available in required concentration, distribution of the metals in plant body is been depending upon availability, pH and the concentration of heavy metals as well as particular plant species and its population, which was proved in this study that, the *A. digitata* plant parts (leaves) materials determined that was grown and sampled in the college farm was found to contained Ca, Cd, Cr, K, Mn, Pb and Zn of which was detected and this was also reported by Ibrahim and Jimoh [7], Qais, *et al.* [9]; among others.

According to National Institution Occupational Safety and Health [38] and FAO (Food and Agricultural Organization) [10] who stated that the consumption of food crops contaminated with heavy metals is a major food chain route for human and animals exposure, and may result to various health risk hazard. Many researchers have shown that some common vegetables are capable of accumulating high levels of metals from the soil. Certain species of these vegetables were said to be hyper-accumulators of heavy metals into the edible tissues of plants. When eaten by human and animals, are then transferred into their body systems, thereby, causing health risks or may cause unsafe and insecurity for foods.

The determinations of some heavy metals and elements in baobab tree (*A. digitata*) plant parts (leaves) material was been studied, grown in the College farm and the results that were obtained from the analysis revealed that mean concentration levels of the sampled leaves, which were ranged from 0.04 to 81 mg / l;

Calcium (Ca) had a concentration level of 81 mg / l, which was the highest in value of concentration. This value obtained exceeds the recommended standard value of 75 mg / g that was reported by FAO/WHO [39]. Potassium (K) was with mean concentration level of 0.68 mg / l was the least in concentration amongst the elements determined in this study, and found both not exceeding the recommended standard value of 10.0 mg / g for potassium by AOAC (Association of Official Analytical Chemists) [2]; European Union [40]; FAO/WHO [39].

Amongst the selected heavy metals determined, it results revealed that Cadmium (Cd) was the highest and had the mean concentration level of 0.84 mg / l, and this value obtained, it is highly greater than the recommended standard value of 0.003 mg / g for Cd reported by FAO/WHO [39]. Chromium (Cr) was the least and the mean concentration level of 0. 04 mg / l which did not exceeds the recommend standard value of 0.4 mg / g for Cr by

FAO/WHO [39]. Manganese (Mn) was detected and had the highest concentration value of 0.61 mg / l. Lead had the mean concentration level of 0.31 mg / l which exceeds the recommended standard value of 0.10 gm / g for Pb. Also zinc was detected in the leaves of baobab with a mean concentration value of 0.30 mg / l, and this value did not exceed the recommended standard value of 5.0 mg / g for Zn respectively.

With regard to their mean percentage of concentration values were; Ca had the highest percentage of 97 %, and then followed by Cd with 1 %, K had 0.8%, Mn had 0.7%, Pb and Zn had 0.4 % each, and least was Cr had 0.1 % in descending order of percentage. The magnitude of concentration levels of the heavy metals and elements detected in *A. digitata* leaf in the sequential order was Ca > Cd > K > Mn > Pd > Zn > Cr, the highest was calcium and the least was Cr respectively.

With the consideration to the analysed *A. digitata* leaves and the recommended standard values, that amongst the heavy metals determined only cadmium and lead exceed the recommended values, while chromium and zinc did not exceeds the recommended values. Among the elements determined, only Ca exceeds the recommended value and K not exceeds the recommended standard value. But for the Mn is yet to be known. To these results, Ca, Cd and Pb exceeded recommended values, while Cr, K and Zn did not exceeds the recommended standard values. The analysed sampled represent the whole baobab tree leaves that was grown in the college farm or premises, and the results revealed that the leaves of the baobab tree was found not fit for consumption due to the elements determined in it exceeds the recommended standard values, it's alarming, it is not health risk free for consumption. The consumption of food crops that were contaminated with heavy metals is the food chain route for human and animal's exposure and is the major bioaccumulation of these metals, which may exceed the standard safe limit. To control the bioaccumulation and free from health risks of these metals is through evaluations of our ecosystem environment and its biodiversity.

5. Conclusion

The cultivation and growing of economic plants is necessity in our surroundings ecosystem environment for the control, protection, provision food security and shelter. Plant such as Baobab tree (*Adonsonia digitata*), known as "*Kuka*" in Hausa language, need to be grown in farms. In Nigeria and its neighboring countries, the leaves are locally used to make soup especially in the northern part of Nigeria. The leaves are stable source of food for rural population in many part of Africa. Every part of the baobab tree is reported to be useful for mankind as well as livestock, used as food and medicinal purposes. Vegetables are source of minerals (essential elements), vitamins, proteins, oil, carbohydrates, phytochemicals which serves as nutrition and source of medicinal materials, e.g. antioxidants, and foods production contributes many, it helps socially to community, educational and skill development benefits for the society. Planting economical plants are helping to nature cultural, horticultural skill and knowledge of food production, storage and usage.

The analysed sampled represent the whole baobab tree leaves that was grown in the college farm or premises, and the results revealed that the leaves of the baobab tree was found not fit for consumption due to some of the selected elements determined in it exceeds the recommended standard values, it is not health risk free for consumption. The consumption of food crops that were contaminated with heavy metals is the food chain route for human and animal's exposure and is the major bioaccumulation of these metals, which may exceed the standard safe limit. To control the bioaccumulation and free from health risks of these metals is through evaluations of our ecosystem and its biodiversity.

6. Recommendation

Studies need to be carried out on both the studied plant and the soil in order to determine the heavy metals and e lements concentration levels and to ascertain the ecosystem environment condition of the this area.

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