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Full Length Research Paper

Analysis of Elemental Content in *Solanum macrocarpum (L.)* and Associated Soil from Alau, Borno State, Nigeria

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The fresh fruit of *Solanum macrocarpum* (Solanaceae) and the soil in which the plant was grown were obtained from Alau in Konduga Local Government, Borno state. The concentration of elements which included Fe, Mg, Zn, Cu, Mn, As, Cr, Cd, Se and Pb were determined using Atomic Absorption Spectrometer (AAS). Flame Emission Spectrophotometer (FS), Gallenkamp (FGA 330), was used to determine Na, K and Ca while S and P was determined using UV/V spectrophotometer. The results obtained from this analysis revealed that S, Na and K were in high concentrations; Fe, Zn, Mg, Cu and P in moderate concentrations while Pb, Cd and Se were not detected in the fruit. In the soil sample however, Fe, Na and K were in high concentrations, S, Zn, Mg, Ca and P in moderate concentrations, while Pb, Cd and Se were not detected. The fruit contained much higher elemental concentrations than the soil generally except in the soil where the concentrations of Fe, P, Cr and As were higher, but the concentration of Mn was the same in both the soil and the fruit. Generally, the concentration of trace elements, Zn, Cu, Fe, Mn, Cr and heavy metals like in fruit are within safety limits as reported by WHO. However, the concentration of some essential elements (K, Na and S) is much higher than reported levels. Thus, the values of these elements in the fruit could probably be due to the topography, soil-water-plant exchange complex and evapo-transpiration of the environment. Also, the values of the elements show that the use of this fruit would not pose a health risk.

Keywords: Elemental Content, *Solanum macrocarpum* Linn; soil, fruit, Borno State.

INTRODUCTION

Solanum macrocarpum Linn. otherwise called garden egg or *Solanum macrocarpum* L. senso stricto or *Solanum daysphyllum* Schumach and Thon belongs to the family Solanaceae. It is extensively cultivated in the North East Arid Zone of Nigeria, Sierra Leone, Kenya and Uganda (Grubben and Denton, 2004). Tradico medical uses of the plant include the young fruits and flowers as laxatives, for cleaning the teeth and in the treatment of cardiac diseases and hyperlipidaemia in Nigeria. The heated leaves are chewed to treat throat troubles in Sierra Leone. The juice of boiled roots is drunk in Kenya to get rid of hook worm while crushed leaves are taken to treat stomach troubles (Grubben and Denton, 2004). The young leaves and young fruits are cooked and consumed as a vegetable. The fruit is a depressed glabrose berry, 2 – 6 cm x 3 – 10 cm, green, ivory or purplish – white with dark stripes when young, yellow to brownish when ripe, partly covered by the enlarged calyx lobes; fruit stalk is erect or decurved, 1 – 4 cm long (Grubben and Denton, 2004), in contrast to that of *S.melongena* whose fruit is a large, egg – shaped berry, varying in colour from dark purple to red, yellow or white (ANON, 2007; Sodipo, 2009).

Solanum macrocapum Linn aqueous fruit extract has been reported to exhibit laxative and hypotensive effects (Sodipo *et al.,* 2008). The aqueous fruit extract has also been shown to possess lipid lowering activities (Sodipo *et al.,* 2009c; 2011a; 2012a) and at the same time has renal and hepatoprotective effects (Sodipo *et al.,* 2009a,b; 2012c).The aqueous fruit extract also demonstrated antianaemic properties (Sodipo *et al*., 2009d; 2011b;

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2012b).

Mineral elements (most of which are present in medicinal plants) serve not only as sources of nutrition to plants and animals, but also play other functions fundamental to the environment. Research has shown that inorganic elements are essential in nutrition and play important roles as structural components in cellular processes (Hakeem, 1987). Also, there is a growing recognition of the adverse effect of the cumulative exposure to heavy metals in small quantity and essential elements in large concentrations (WHO, 1973, U.S. Food and Drug Administration 1999; Abdulrahman, 2004; Sodipo, 2010; Akan *et al* 2010a,b). These adverse effects of elements are of major concern. Plants are sensitive to environmental conductors and their elemental contents respond to changes in the condition of the environment (Vtorova, 1987; Kabata and Pendias, 1984). The uptake of trace elements by plants depends on the reserves of the nutrients in the soil and its availability (Koke *et al.*, 1984). Furthermore, the soil pH, soil organic matter content and plant genotype have a marked effect on nutrient availability (Kloke *et al*., 1984). In view of the various uses of this plant, there is therefore a need to investigate the elemental contents of the fruit and the soil from which the plant was obtained in order to ascertain the levels of the elements in the fruit so as to avoid toxic concentrations and also to know if the concentration in the fruit are due to the level in the soil and its availability or otherwise.

EXPERIMENTAL

Sample collection and identification

The plant material and the soil sample used in this study were obtained from Alau in Konduga Local Government Area, Borno State between October and November, 2007. The plant was identified and authenticated by Prof S. S. Sanusi of Biological Sciences Department, University of Maiduguri, Maiduguri, Nigeria. Specimen voucher (No. 548A) was deposited at the Research Laboratory of the Department of Chemistry.

Sample Preparation

The air-dried powdered fruit (5g) was placed in an evaporating dish in an oven at 80^{O}C and dried to a constant weight. The sample was placed in a weighed porcelain crucible and ashed at 500^{O}C in a hot spot furnace for 3h. The ashed material was then digested and prepared for determination of elements. The cooled, ashed sample (0.5g) was digested by heating for 3h with a mixture of 10ml each of c.HNO_3, HCl and $HClO_4$ in a 500ml flask.

This material (aliquot) together with the residue was mixed with 100 ml 2M HNO_3 and 30ml distilled water in 100 ml volumetric flask. The volume was made up to the mark with distilled water (Radojevic and Bashkin, 1999). Blank sample (using the same procedure but omitting the plant material) and standard for the various elements were similarly prepared.

Some air-dried soil sample was ground and sieved (<2mm). 1.0 g was then weighed and placed in a 100 ml tall-form beaker. 30 ml 1:1 HNO_3 acid (10 ml H_2O and 10 ml. c. HNO_3) was added and boiled gently on a hot plate until the volume reduced to approximately 5 ml while stirring. A further 10 ml of 1:1 HNO_3 acid was added and the procedure was repeated. It was cooled and the extract was filtered through a Whatman No. 541 filter paper into a 100 ml volumetric flask. The volume was made up to the mark with distilled water (Radojevic and Bashkin, 1999). Blank sample using the same procedure but omitting the soil) and standard dilutions for the various elements were similarly prepared.

All samples were stored in plastic containers in a refrigerator maintained at 4^{O}C prior to analysis

Elemental analysis

The resulting solutions from the perchloric acid and nitric acid digestion for the fruit and soil respectively were used for elemental analysis using Atomic Absorption Spectrometry (AAS) with SP/Cr Unicam Model Solar 32 Data station V7.10 System at the appropriate wavelength, temperature and lamp current for each element under study for the determination of Fe, Mg, Zn, Ca, Cu, Mn, As, Cr, Cd, Se and Pb, Flame Emission spectrophotometry (FES), Gallenkamp (FGA 330) for determination of Na, K and Ca while S and P were determined using uv/v spectrophotometry (Ogugbuaja, 2000).

Statistical Analysis

The results of the elemental analysis were expressed as the mean value ± standard deviation (S.D). The result obtained was subjected to analysis of variance (ANOVA) using SPSS/PC 4 package and differences between means were compared using Ozdamar's (1991) multiple range test.

RESULTS

Tables 1 and 2 show the mean concentration of elements in the fruit of *Solanum macrocarpum* and the soil on which the plant was grown. From the result of the study, the elemental concentration ranged between 13.02 ± 1.44µg/g to 12,536.00±85.60µg/g) in the fruit (Table 1).

Table 1: Elemental concentration of the fruit of *Solanum macrocarpum*

S/N	Elements	Concentration (µg/g)
1	Potassium (K)	4,234±51.56
2	Sodium (Na)	6,238.50±215.08
3	Calcium (Ca)	254.31±9.87
4	Magnesium (Mg)	543.75±30.86
5	Lead (Pb)	ND
6	Zinc (Zn)	505.71±5.21
7	Copper (Cu)	151.75±2.69
8	Cadmium (Cd)	ND
9	Iron (Fe)	552.45±7.38
10	Manganese (Mn)	80.00±2.83
11	Arsenic (As)	13.02±1.41
12	Sulphur (S)	12,536.00±85.60
13	Phosphorus (P)	63.00±4.24
14	Selenium (Se)	ND
15	Chromium (Cr)	33.00±4.24

ND = Not detected
The values given in the table above are means of replicate values (n=25)

Table 2: Elemental Concentration of the Soil from which *Solanum macrocarpum* fruit was grown

S/N	Element	Concentration (µg/g)
1	Potassium (K)	1,435±24.60
2	Sodium (Na)	1,224±11.23
3	Calcium (Ca)	123.40±2.65
4	Magnesium (Mg)	469.17±5.24
5	Lead (Pb)	ND
6	Zinc (Zn)	84.06±2.81
7	Copper (Cu)	10.21±1.23
8	Cadmium (Cd)	ND
9	Iron (Fe)	1,780.40±8.60
10	Manganese (Mn)	80.00±1.53
11	Arsenic (As)	15.01±2.63
12	Sulphur (S)	853.20±30.82
13	Phosphorus (P)	80.00±5.42
14	Selenium (Se)	ND
15	Chromium (Cr)	51.00±1.53

ND = Not detected
The values given in the table above are means of replicate values (n=25)

and 10.21±1.23µg/g to1,780.40±8.60µg/g in the soil (Table 2). From the results of the study, the elemental concentration in the fruit sample showed high concentration of sulphur, S (12,536.00±85.60µg/g), Sodium, Na (6,238.50±215.08µg/g), potassium, K (4,234±51.56µg/g), whilst arsenic, As (13.02±1.44µg/g) and chromium, Cr (33.00±4.24µg/g) occurred in low quantities. The following elements occurred in moderate concentrations, iron, Fe (552.45±7.38µg/g), magnesium, Mg (543.71±30.86µg/g), Calcium, Ca (254.30±9.87µg/g) copper Cu (151.75±2.69µg/g), manganese, Mn (80.00±2.83µg/g), zinc, Zn (505.71±5.21µg/g) and phosphorus, P (63.00±4.24µg/g). In the soil sample however, Fe, Na and K were in high concentrations (1,780.40±8.60µg/g, 1,224.00±11.23µg/g and 1,435.00±24.60µg/g) respectively S, Zn, Mg, Ca and P in moderate concentrations (853.20±30.82µg/g), 84.04±2.81µg/g, 469.17±5.24µg/g, 123.40±2.60µg/g, 80.00±1.56µg/g respectively) while As and Cr occurred in low quantities (15.01±2.63µg/g and 51.00±1.53µg/g respectively). In both the fruit and soil, lead, Pb, cadmium, Cd and selenium, Se were not detected with the method adopted for the analysis. In the fruit, S showed the highest concentration whilst in the soil; it was

Fe that showed the highest concentration. In both the fruit and soil, As recorded the lowest concentration. The concentration of Mn was the same (80.00±2.83μg/g) in both the fruit and soil.

Results of analysis of variance (ANOVA) showed that variation between the elements in the fruit and soil were statistically significant ($P<0.05$).

DISCUSSION

The concentration of the essential elements (Zn, Cu, Fe, Mn), and the non-essential elements (Cr and As) detected in the fruit were within safety limits that has been reported by Alloway (1995); WHO (1996); However, the concentration of some essential elements (K, Na and S) is much higher than reported or within acceptable levels. The high concentration of K, Na and S may be due to deposition of particulate matter on the leaves of the plant (Reuben *et al.*, 2008), as the values of these macro nutrients were lower in the soil. Thus, the concentration of these elements is not due to root uptake from the soil. The moderately high concentration of Fe in the fruit may be due to the uptake from the soil as the concentration of Fe in the soil was very high (1,780.40±8.60)μg/g as compared to that in the fruit (552.45±7.38)μg/g. Thus the intensity of extent of the uptake therefore influences the actual contents of an element in the plant. Presence of Fe in high concentration in plant poses serious pollution and health problem. Toxicity of Fe in human leads to vomiting, cardiovascular collapse and diarrhoea (Turnland, 1988). Since the Fe content in the fruit is moderate, the fruit is probably not toxic.

Ca in the fruit and soil are moderate 254.31±9.87μg/g and 123.40±2.65μg/g respectively. The lower concentration in the soil implies that the Fe content in the fruit is not due to the soil-water complex or evapotranspiration, but it is probably due to the deposition on the leaves. Ca is used in bone formation and usually occurs in the body with flourine in the ratio 2:1 (Aliu, 2007).

Pb, Cd and Se were not detected in both the soil and the fruit. They are toxic metals which can accumulate in the human tissues when they are not metabiolized by the body for absorption and utilization (Ewers and Shlipkoter 1991, Health Concerns, 2003; Amartey *et al.,* 2011). Thus, the fruit is safe for human consumption and the soil has probably not been contaminated with these heavy metals. The danger of these toxic metals on the human body is enhanced when there is low intake of the essential mineral nutrients for their absorption (Wilson, 2008). For instance, Cd causes kidney damage and bone degradation because it affects calcium metabolism (Waalkes, 1991; Amartey *et al*., 2011). The low concentration of As and Cr may be an indication of degree of pollution in the area where the fruit was obtained or poor absorption of these elements by the plant root (Abdulrahman, 2004). Borno State is not an industrial area, hence it is expected that the production and disposal of these toxic metals will be minimal as to contribute to environmental pollution. This must have contributed to the low accumulation of these toxic metals in the plant (Abdurahman, 2004). The low concentration of the toxic elements may also be due to the low deposits of these elements in the soil, since the concentration of elements in the plant is a reflection of the concentration in the soil (Abdulrahman, 2004).

The Fe which is present in the fruit in moderate concentration is within safety limits as reported by (Alloway, 1998; WHO, 1998), is important in haemoglobin production and is used in the treatment of iron deficiency anaemia (Lawrence *et al.,* 1997). The moderate level of Fe in the fruit of the plant is probably an indication of the concentration of Fe in the soil (1,780.40±8.60μg/g). Also it may be related to the high Packed Cell Volume (PCV), Red Blood Cell (RBC) and Haemoglobin (Hb) recorded when graded doses of the fruit extract were administered to hyperchlosterolaemic rats (Sodipo *et al.,* 2009a).

It has been reported by Kloke *et al.,* (1984) that Cd, T and Zn have the highest soil to plant transfer coefficient, in part because of their relatively poor sorption in the soil, while elements such as Cu, Ca, Cr, and Pb have low transfer coefficient and are strictly bound in the soil structure.

Cu is an essential substance to human life, however in high concentration it can be highly toxic to fish (Grosell *et al.,* 1997) and causes anaemia, liver and kidney damage, stomach and intestinal irritation (Turnland, 1988). From the study, concentration of Cu in the soil was small, (10.21±1.23)μg/g whilst that in the fruit was moderate 151.75±2.69μg/g. The moderately high concentration of the Cu in the fruit was therefore not due to the uptake from the soil and the fruit is probably not toxic.

CONCLUSION

The implication of the low concentration of some heavy metals and the non-detection of others in both the fruit and soil is that heavy metal intoxication following the administration of either the whole fruit or its extract to man and animal is safe and that the degree of pollution in the area where the fruit was obtained was low or there was poor sorption of these elements by the plant root.

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