DETERMINATION OF SELECTED MACRO AND TRACE ELEMENTS IN TWO GREEN LEAFY VEGETABLES: *SPINACIA OLERACEA* (SPINACH) AND *CORCHORUS OLITORIUS* (JUTE LEAF) COMMONLY CONSUMED IN SHANGO, MINNA, NIGER STATE.

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ABSTRACT

Vegetable is a nutritionally valuable food with very complex chemical composition and whose elemental contents is affected by the area they were cultivated. It can accumulate toxic metals, which may present hazards to human health. The aim of the study was to determine the concentration of some ten heavy or essential metals (Co, Cr, Cu, Fe, Mn, Zn, Ca, K, Mg & Na) present in two green leafy vegetables: *Spinacia oleracea* (Spinach) and *Corchorus olitorius* (Jute Leaf) consumed in Shango Minna, Niger State, Nigeria; using Atomic Absorption Spectrophotometer. Zero concentration was recorded for Co in both samples, while the highest mean concentrations recorded in *Spinacia oleracea* were for K, Ca, and Na (550.0±0.0000 ppm, 389.1995±0.0021 ppm, and 235.5±0.0000 ppm respectively). Similarly, the highest mean concentration recorded in *Corchorus olitorius* were for K, Ca, and Na (150.0 ± 0.0000 ppm, 142.326±0.0045 ppm, and 103.5±0.0000 ppm respectively). The mean concentration for the other determined elements (Cr, Cu, Fe, Mn, Zn & Mg) in *Spinacia oleracea* were 0.0500±0.0004 ppm, 0.0775±0.0007 ppm, 4.937±0.0005 ppm, 5.0425±0.0007 ppm, 0.616±0.0005 ppm and 198.9605±0.0018 ppm respectively; and 0.066±0.0006 ppm, 0.183±0.0002 ppm, 6.038±0.0009 ppm, 1.119±0.0015 ppm, 0.4135±0.0007 ppm and 48.375±0.0037 ppm respectively in *Corchorus olitorius*. The analytical data shows a good level of quality of the analysed vegetable samples, especially with regards to the absence or low concentration of toxic elements (like Co and Cr) and significant amount of trace/major elements (K, Ca, Mg & Na) with little of Cu and Zn. It was recommended among others that people should be sensitized about possible contamination and the need for regular monitoring of levels of these metals in vegetables to minimize or prevent ingestion through the food chain.

Keywords: *Spinacia* o*leracea* (Spinach), *Corchorus olitorius* (Jute Leaf), Essential trace metals, and Atomic Absorption Spectrophotometer

1. INTRODUCTION

Vegetables are the fresh and edible portions of herbaceous plants that contain valuable food ingredients, which can be eaten raw or cooked to build up or repair damaged body tissues (Dhellot *et al.*, 2006; Chionyedua *et al.*, 2009). They are the major source of minerals in the diet (Oyekanmi *et al.*, 2014). Spinach improves blood glucose control, diabetes management, cancer prevention, asthma prevention, lowers blood pressure, improves bone health, promotes digestive regularity, healthy skin, and hair; while Jute leaf is rich in minerals, vitamins, and antioxidants. It also contains iron, calcium, sodium, phosphorus, potassium, proteins, fibers, vitamins A, C, and E, riboflavin, niacin, and folate. These nutrients help the body fight diseases and maintain good health (Fasola and Ogonsola, 2014).

Heavy metals naturally are non-biodegradable constituents of the earth's crust that accumulate and persist indefinitely in the ecosystem as a result of both human and natural activities (Madu *et al.*, 2021). They occur naturally in the earth's crust, but maximum contamination of soil results from anthropogenic activities like smelting operations and mining, industrial, agricultural, and domestic use of heavy metals or metal-containing composites (Anushri *et al.*, 2018; Ram *et al.*, 2011).

The contamination of vegetables remains an issue of public health interest due to the frequency, and quantity of consumption (Madu *et al.*, 2021). Green leafy vegetables absorb water from contaminated soil along with heavy metals present in them which get accumulated (Sipter *et al.,* 2008). The accumulation of these heavy metals is easier in the edible parts of leafy vegetables than in grains or fruits (Ayejuyo *et al*., 2014).

Globalization and population growth are associated with an increasing demand for vegetables, even in developing countries, indicating this study's importance. In this study, two leafy vegetables: spinach and jute leaf, that are traditionally an important component of diets across different cultures in Nigeria were analysed for their essential trace metals content since the excess level of such metals has been widely reported as being toxic and harmful to health. The aim of this research is to determine the concentration of ten selected macro and trace elements (Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Na, and Zn) in the two green vegetables (Spinach and Jute leaf) commonly consumed in Shango, Niger State, Nigeria.

2. MATERIALS AND METHOD

2.1 Study Area

Shango is a neighborhood in Minna, Niger State, Nigeria. The study area lies between Latitude 9° 33¹ and 9° 40¹ North, and Longitude 6° 29¹ and 6° 35¹ East on a geological base of undifferentiated basement complex of mainly gneiss and magnetite. At the Northeast corridor of the town lies a continuous steep outcrop of granite, which form a limitation towards physical development in that axis. The Minna town has grown to engulf suburbs settlements such as Chanchaga, Bosso, Maitumbi, Dutsen Kura, Kpakungu, and Shango. Shango enjoys a climate typical of the middle belt zone, guinea savannah with distinct wet and dry seasons. The rainy season starts around April and till October; it has a mean annual rainfall of about 1334mm (52 inches) with September recording the highest rains of about 300mm (11 inches). The lowest mean monthly temperature is highest in March at 35 ^{o}C and lowest in August at 22.3 ^{o}C. The mean monthly relative humidity is highest in August at 60% and lowest in January at 19% respectively.

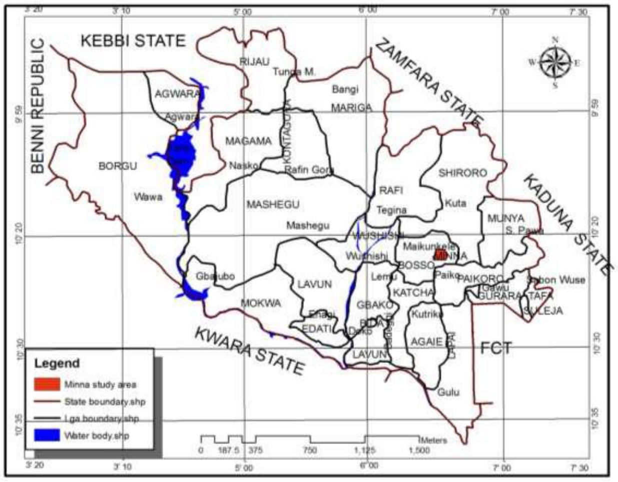

Fig. 1: Map of Minna, Niger State, Nigeria

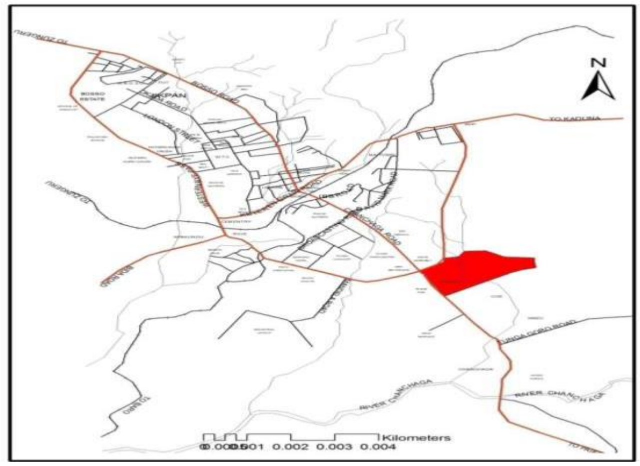

Fig. 2: Minna Township map showing Shango

Source: Ministry of Lands and Housing, Minna, (2019).

2.2 Sample Collection and Pre-treatment

The samples were bought from the Shango market (located within the Shango area) and transported in clean polythene bags to the laboratory. The leaves were detached from the stalk, washed with tap and distilled water to remove the dust and dirt particles. The samples were then cut into smaller pieces using a clean stainless knife. They were then air-dried on the laboratory benches for three days before further drying in the oven at 80 ^{o}C for six hours. The dried samples were then grounded into powder using mortar and pestle (Mohammed and Sharif, 2011).

2.3 Sample Digestion

The powdered samples were digested as reported by Anjorin *et al.* (2010); Mohammed and Sharif (2011). Concisely, 2 g of each powdered sample was weighed into separate beakers and 20.0 cm^3 of conc. HNO_3 acid was added to each. These were then covered with glass slides (to enable refluxing) and heated on an electric hot plate at 70 - 90 ^{o}C for an hour. Blank was prepared similarly by digesting 20.0 cm^3 of the conc. HNO_3 acid in a beaker (without the sample). The solutions in the beakers were allowed to cool and then filtered using Whatman No.42 filter papers into different 100 cm^3 volumetric flasks and made up to the mark with distilled deionised water. These were then transferred into clean polystyrene sample bottles prior to elemental content determination using Atomic Absorption Spectrophotometer (AAS).

2.4 Instrumental Elemental Analysis

The essential trace metal concentrations were determined using Atomic Absorption Spectrophotometer (Variant AA240FS – Fast Sequential Atomic Absorption Spectrometer).

3. RESULT AND DISCUSSION

The elemental (mineral) contents of green vegetables *Spinacia* o*leracea* (Spinach) and *Corchorus olitorius* (Jute Leaf) samples analysed are presented in Table 1.

Table 1: Elemental Composition of *Spinacia* o*leracea* (Spinach) and *Corchorus olitorius* (Jute Leaf) samples.

Metals/ Elements	*Spinacia oleracea* (Spinach) Mean Concentration (ppm)	*Corchorus olitorius* (Jute Leaf) Mean Concentration (ppm)
Cr	0.0500 ± 0.0004	0.0660 ± 0.0006
Cu	0.0775 ± 0.0007	0.1830 ± 0.0002
Fe	4.9370 ± 0.0005	6.0380 ± 0.0009
Mn	5.0425 ± 0.0007	1.1190 ± 0.0015
Zn	0.6180 ± 0.0005	0.4135 ± 0.0007
Ca	389.1995 ± 0.0021	142.326 ± 0.0045
K	550.00 ± 0.0000	150.00 ± 0.0000
Mg	198.9605 ± 0.0018	48.375 ± 0.0037
Na	235.5 ± 0.0000	103.5 ± 0.0000
Co	0.0000 ± 0.0008	0.0000 ± 0.0007

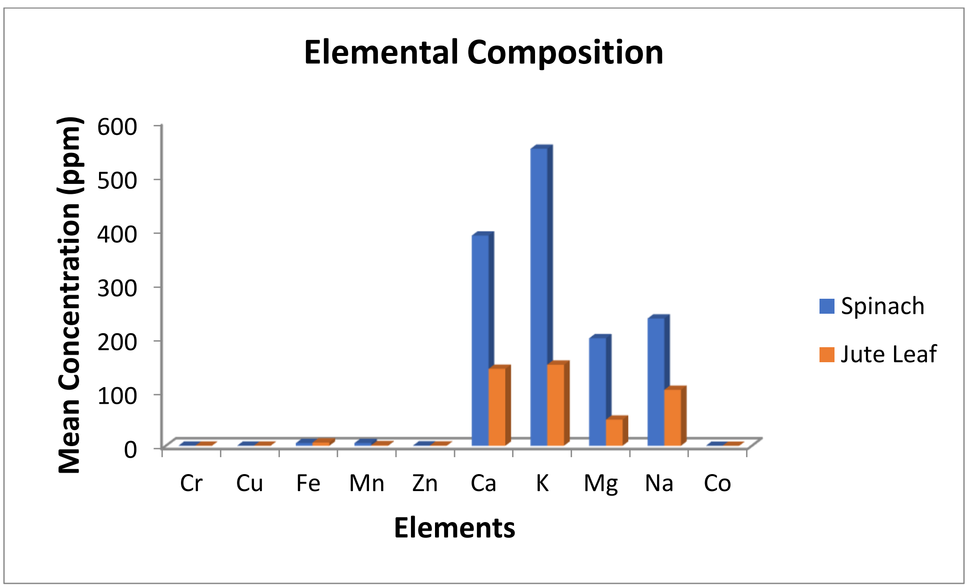

Figure 3: Concentration of metals in spinach and jute leaves from Shango

Table 1 showed the concentration of ten elements in the two leafy vegetable samples commonly consumed in Shango, Niger State, Nigeria. Zero concentrations were recorded from the two samples for Co. Cr, a widely reported toxic heavy metal that is hazardous to health even at low concentrations, has the lowest recorded values (0.050 and 0.066 ppm respectively); while the highest mean concentrations recorded from the analyzed samples were for K and Ca with average levels of 350 ppm and 315.8 ppm respectively. Chromium ion (Cr^{+6}) is harmful to both humans and animals even at low concentrations. The high contents of major elements (K, Ca, Na, and Mg) in the vegetable samples makes it advantageous and rich source of these metals to both human and animals especially children requiring calcium for the formation and strengthening of bones.

4. DISCUSSION OF RESULTS

The Concentration of the heavy/essential metals in the two green leafy vegetables *Spinacia* o*leracea* (spinach) and *Corchorus olitorius* (Jute leaf) samples are shown in Table 1. All samples were analysed in duplicates and their average values recorded. In this study, Spinach is found to be rich in Potassium with the highest content of 550.0±0.0000 ppm and the lowest metal content was Cobalt with concentration of 0.0000±0.0008 ppm. Jute leaf on the other hand has the highest metal content in Potassium with 150.0±0.0000 ppm and the lowest content of 0.0000±0.0007 ppm in Cobalt.

Cr is an essential element that renders the body's tissue more sensitive to insulin. It is a critical cofactor in the action of insulin (William and Frank, 2004). In this study, the Cr concentration in the spinach sample was 0.050±0.0004 ppm; while the Cr concentration in the Jute leaf sample was 0.066±0.0006 ppm. The Cr concentration of 0.050±0.0004 ppm recorded for spinach in this study was lower than the 21.54±0.000 ppm reported for spinach in Bhayandar, India (Anushri *et al.,* 2018). However, the 0.066±0.0006 ppm concentration of Cr in the Jute leaf analysed in this study was slightly higher than the 0.050 ppm recommended maximum permissible limit for chromium intake from vegetables (WHO, 2001).

Cu is essential in the aerobic respiration of all eukaryotes (Rubino and Franz, 2012). In this study, the Cu concentration in the two analysed samples was 0.0775±0.0007 ppm in spinach and 0.183±0.0002 ppm in Jute leaf. The Cu concentration of 0.0775±0.0007 ppm recorded for spinach in this study was lower than the 1.934±0.0007 mg/g reported for spinach in Zamfara, Nigeria (Salawu *et al.*, 2015); but higher than the 0.010±0.002 mg/kg recorded in Adamawa, Nigeria (Sarkiyayi and Samaila, 2017). However, the 0.183±0.0002 ppm concentration of Cu in Jute leaf analysed in this study is lower than the 4.990±0.06 mg/100g recorded in Niger State, Nigeria (Ndamitso *et al.*, 2016).

Fe plays many key roles in biological Systems including oxygen transport, respiration, energy metabolism, destruction of hydrogen peroxides, and DNA synthesis (Melaku, 2009). In this study, the Fe concentration recorded in the two analysed samples (Spinach and Jute leaf) was 4.937±0.0005 ppm and 6.038±0.0009 ppm respectively. The Fe concentration of 4.937±0.0005 ppm recorded for spinach in this study was lower than those recorded for Jos and Zamfara, 103.00±8.44mg/kg and 25.666±0.0011 mg/g respectively (Nanven e*t al.*, 2015; Salawu *et al.*, 2015) but higher than the 0.071±0.001mg/kg observed for spinach in Sabon Tasha Yola, Adamawa State Nigeria (Sarkiyayi and Samaila, 2017). Similarly, the 6.038±0.0009 ppm concentration of Fe in Jute leaf analysed in this study is lower than the 24.56±0.42 mg/100g recorded for *Corchorus olitorius* in Niger State, Nigeria (Ndamitso *et al.*, 2016) but higher than the 0.334 mg/g recorded for *Corchorus olitorius* in Kano, Nigeria (Mohammed and Sharif, 2011).

Mn is a trace mineral that helps the body to form connective tissue, bones, blood-clotting factors, and sex hormones (Palacios, 2006; Fraga, 2005). In this study, the Mn concentration in the two analysed vegetable samples are 5.0425±0.0007 ppm in the spinach sample; and 1.119±0.0015 ppm in the Jute leaf sample. The Mn concentration of 5.0425±0.0007ppm recorded for spinach in this study was lower than those recorded for Nigeria and Saudi Arabian studies, 220.65±33.24 mg/kg and 25.13±0.57 µg/g respectively (Nanven *et al.*, 2015; Mohammed and Khairia, 2012). However, the 1.119±0.0015 ppm concentration of Mn in the Jute leaf analysed in this study was higher than the 0.613 mg/g for *Corchorus olitorius* in Kano, Nigeria (Mohammed and Sharif, 2011).

Zn is an essential trace element that functions as a component of many enzymes. Zn is involved in the metabolism of proteins, carbohydrates, lipids, and energy (Falah and Saja, 2017). In this study, the Zn concentration in the two analysed samples (Spinach and Jute leaf) is 0.618±0.0005 ppm and 0.4135±0.0007 ppm respectively. The Zn Concentration of 0.618±0.0005 ppm recorded for Spinach in this Study was lower than those recorded for Jos and Zamfara; 53.77±22.11mg/kg and 1.842±0.0003mg/g respectively (Nanven *et al.*, 2015; Salawu *et al.*, 2015) but slightly higher than 0.067±0.002 mg/kg for Spinach in Adamawa, Nigeria (Sakiyayi and Samaila, 2017). Similarly, the 0.4135±0.0007 ppm concentration of Zn in Jute leaf analysed in this Study was lower than the 25.01±0.95 mg/100g recorded for *Corchorus olitoriurs* in Niger State, Nigeria (Ndamitso *et al.*, 2016) and lower than the 0.221 mg/g recorded for *Corchorus olitorius* in Kano, Nigeria (Mohammed and Sharif, 2011).

Ca is an essential nutrient to ensure the calcification and health of the bone (Tuyen, 2016). In this study, the Ca concentration recorded in the two analysed samples (Spinach and Jute Leaf) is 389.1995±0.0021ppm and 142.326±0.0045ppm respectively. The calcium concentration of 389.1995±0.0021 ppm recorded for spinach in this study was low than the 157.23±2.00 mg/g recorded for *Amaranthus hybridus* in Ibadan, Nigeria (Omonike *et al.*, 2015). However, the 142.326±0.0045 ppm concentration in Jute leaf analysed in this study was lower than those recorded for Nigeria and Ghana, 173.82±1.48 mg/100g and 7,960±699 mg/kg respectively (Ndamitso *et al.*, 2016; Baidoo *et al.*, 2014).

K is essential for normal body function. It is necessary for muscle function, the transmission of nerve impulses, and for the metabolism of carbohydrates and proteins (Baidoo *et al.*, 2014). In this study, the K concentration in the two analysed samples (Spinach and Jute leaf) was 550.0±0.0000 ppm and 150.0±0.000 ppm respectively. The K concentration of 550.0±0.0000 ppm recorded for spinach in this study was lower than the 88021±96 ppm recorded for *Spinacia oleracea* in Bangladesh (Fahad *et al.*, 2015) and 381.4±1.4 mg/g recorded for *Amaranthus hybridus* in Ibadan (Omonike *et al.*, 2015). Similarly, the 150.0±0.0000 ppm concentration of K in Jute leaf analysed in this study was lower than the 1140.50±2.18 mg/100g recorded for *Corchorus olitorius* in Niger State, Nigeria (Ndamitso *et al.*, 2016).

Na is a component of many foodstuffs, for instance, common salt, it is necessary for humans to maintain the balance of the physical fluids system. It is also required for nerve and muscle functioning (Munteanu and Iliuta, 2011). In this study, the Na content in the two analysed samples (Spinach and Jute leaf) is 235.5±0.0000 ppm and 103.5±0.0000 ppm respectively. The Na concentration of 235.5±0.0000 ppm recorded for spinach in this study was higher than the 6.85±0.00 mg/100g recorded for A*maranthus hybridus* in South-West Nigeria (Ajiboye *et al.*, 2014). However, the 103.5±0.0000 ppm concentration of Na in Jute leaf analysed in this study was slightly lower than the 104±15 mg/kg recorded for Ghana (Baidoo *et al.*, 2014); and much lower than the 91.43±1.49 mg/100g recorded for *Corchorus olitorius* in a Nigerian study (Ndamitso *et al.*, 2016).

5. CONCLUSIONS

The Study determined the concentration of ten macro/trace elements (Co, Cr, Cu, Fe, Mn, Zn, Ca, Mg, K, and Na) in two green vegetable leaves: *Spinacia* o*leracea* (Spinach) and *Corchorus olitorius* (Jute) bought from the market in Shango area of Minna, Niger State, Nigeria. The Composition of the above-listed elements were analysed using Atomic Absorption Spectrophotometer (AAS). The result showed Zero Concentration of Co in both *Spinacia* o*leracea* (Spinach) and *Corchorus olitorins* (Jute) leaves. Of all the analysed metals, K has the highest concentration with a value of 550.0±0.0000 ppm and 150.0±0.0000 ppm in Spinach and Jute leaves respectively; While Cr, on the other hand, has the lowest metal concentration in both Spinach and Jute leaves with the value of 0.0500±0.0004 ppm and 0.0660±0.0006 ppm respectively. The metal contents determined in the two analysed vegetables were within the standard values by the regulatory organization (FAO/WHO, 2004; N.I.H, 2016). The spinach and jute leaf studied are of high quality as they were not only free of toxic metal (Co) though with a very small Cr presence that might be dangerous to health (Serap *et al.*, 2017), but they also contain a significant level of some essential trace and major elements (Ca, K, Na, and Mg) that have been reported to play vital roles in human health.

5.1 RECOMMENDATIONS

1. As this study was limited (due to lack of resources and time) to determining the concentrations of only some ten metals (Co, Cr, Cu, Fe, Mn, Zn, Ca, Mg, K, and Na) in two green vegetable samples (Spinach and Jute leaves) from Niger state, it does not include evaluation of the proximate composition nor screening the antimicrobial activities of the vegetable samples. Therefore, further study is recommended to cover these areas.
2. The study also determined the levels of only two toxic heavy metals (Cr and Co) in the vegetable samples. It is therefore recommended that the presence of other toxic metals such as Pb and Cd be investigated.
3. Levels of some essential and toxic elements in vegetables grown in different parts of Niger State should be assessed.
4. People should be sensitized about possible contamination and need for regular monitoring of levels of these metals in vegetables to minimize or prevent ingestion through the food chain.

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