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Analysis of some Medicinal Plants from Adamawa State, Nigeria used in the Management of *Diabetes mellitus* by Neutron Activation Analysis

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Abstract

Analysis of some medicinal plants from Adamawa State, Nigeria used in the management of diabetes mellitus was carried out by Neutron activation analysis (NAA) using Nigerian research reactor (NRR-1) facility, to determine the distribution of Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Iron (Fe), Cabolt (Co), Manganese (Mn), and Zinc (Zn) in the various parts of medicinal plants . Samples were collected from three local Government Areas Mubi north, Mubi South and Maiha of Northern Adamawa State. The results showed that, the levels of elements in the plants parts ranged from, 6763.0±417.0 - 82750.0±993.0 (mg/kg) for Ca, 591.0±140.0 – 6012.0±331.0 (mg/kg) for Mg, 34.5±0.3 - 620.0±1.0 (mg/kg) for Na, 703.0±3.0- 80250.0±321.0(mg/kg) for K, 0.3±0.0 -3701.0±96.0 (mg/kg) for Fe , 0.1±0.0 - 51.0±8.0 (mg/kg) for Co , 25.9±0.2 - 1969.0±14.0 (mg/kg) for Mn and 8.2±1.9 - 64.0±4.0, (mg/kg) for Zn respectively. The result revealed that the medicinal plants contain the elements K, Ca, Mn, Mg and Zn which play vital roles in potentiating insulin, thereby aiding in management of diabetes mellitus. The elements analyzed could be useful in determining the quality of the plants and its medicinal values.

Keywords: Medicinal plants; Nutrients; Neutron Activation Analysis (NAA); Quality; Mineral elements; Diabetes mellitus.

Introduction

The use of medicinal plants is as old as the beginning of human civilization; people used what was immediately accessible to them in the environment for the treatment of different types of ailments. Herbal medicine is one of the noteworthy traditional systems of medicine, which mainly depends on the usage of medicinal remedies from herbs, flowers and flora surrounding them for the treatment of different types of diseases (Sofowora, 2008).The various parts of plants have health promoting effects on human. Medicinal plants may be used either singly or in combination as herbal medicine for treatment of different types of ailments. They are used worldwide and very common in many countries.

It is a well-known fact that African continent is richly endowed with vast species of medicinal plants and more than 70% of the global population utilizes these medicinal plants for the treatment of different types of ailments (WHO, 1998; Sofowora, 2008). These medicinal plants are used as a viable option to improve people's health worldwide. Medicinal plants have been used in traditional medicine for the management of diabetes mellitus for long time (Michael *et al.*, 2012). It has been reported that the natural products from plants have insulin potentiating activity (Bushra, 2013).These medicinal plants act by supplying ß- cells with the necessary trace and macro elements such as Mg, Ca, Zn, V, Cr, Mn, Ni, Se and K which are well known in potentiating insulin and aiding in the management of diabetes mellitus (Ma *et al.*, 1995; Candilish, 2000). Numerous studies have revealed that an association of trace and macro elements with Diabetes mellitus and the action of insulin on reducing sugar was reported to be potentiated by some trace elements such as Cr, Mg, V, Zn, Mn, Mo and Se (Candilish ,2000,Carol,2005,Cesar,2005,Masood *et al.*, 2009).). The exact mechanism of these elements and active metabolites is yet to be established. In another studies it was also reported that Zinc is required for insulin synthesis and storage and insulin is secreted as zinc crystals which maintains the structural integrity of insulin (Chausmer, 1998; Kruse-Jarres and Rukgauer, 2000).These elements increases insulin sensitivity and acting as antioxidants in preventing tissue per oxidation.

Diabetes mellitus (DM) has been shown to be associated with abnormalities in the metabolism of these elements and the impairment of these elements had been reported as aggravating factors in the progression of this life threatening disease (Praveena, *et al.*, 2013; Bushra, 2013).DM is a complex disorder of carbohydrate metabolism characterized by impaired ability of the body to produce or respond to insulin and to maintain proper levels of glucose in the blood (Elavarasi and Saravanan, 2012). It is a common and very prevalent disease affecting the citizens of both developed and developing countries. It has been estimated that about 25% of the world population is affected by this disease (WHO, 2007). This progressive increase in the global prevalence of diabetes probably is due to life style changes such as feeding habit (Shaw *et al.,* 2010). The management of DM without any side effects is still a challenge to the medical system (WHO, 2007).

This disease requires new approaches to treatment and management, such as use of trace elements, body exercise and also dietary modifications (Chalmers, 2005, Muula, 2000).

Most of medicinal plants that are used for the management of diabetes mellitus have been found to be rich in one or more individual elements, thereby providing a possible link to the therapeutic action of the medicinal plants (Praveeen *et al*., 2013).This could be concluded that the therapeutic action is either from the organic or inorganic constituents of the medicinal plants. Trace elements content has become of prime importance for both the clinical diagnosis and curing of different ailments (Khan *et al*., 2012).Trace elements play a vital role in the production of bioactive chemicals in medicinal plants and are therefore responsible for their medicinal properties (Khan *et al*., 2012). It has been reported that Inorganic constituents like magnesium, zinc, manganese, calcium, Iron, potassium and sodium are essential for a healthy life and play a vital role in potentiating insulin and can serve as a source of food supplements (JothiKarumari, *et al*., 2014).These elements are mostly found at varying concentrations in different parts of the plants, especially in roots, stem bark, seeds and leaves, which are used as a dietary supplement as well as an ingredient in herbal preparations. As trace elements they are important metabolic products for the plant cells and also play an important role in the plant metabolism and biosynthesis as co-factors for enzymes (Hagemeyer, 2004).There are many works on the phytochemical components of these selected medicinal plants. However, studies related to the inorganic elements that play vital roles in potentiating insulin are very scarce. Hence in the present investigation, the plant parts were analyzed for its quantitative determination of Ca, Mg, Na, K, Fe, Co, Mn and Zn using Neutron Activation Analysis (NAA).

Materials and Methods

Collection of plant materials and preparation

Ethno-botanical characteristics of the selected medicinal plants often used traditionally in Nigeria as remedy for the treatment and management of DM informed the choice of the respective plants. The leaf, stem bark and root bark samples of the selected medicinal plants collected from Mubi North, Mubi South and Maiha Local Government Areas of Adamawa State, Nigeria were used in the study. The plants used in the study are: *Terminalia avicennioides, Hymenocardia acida, Leptadenia hastate, Balamites aegyptiacae, Ageratum conyzoide, Sclerocarya birrea, Anogeissus leiocarpus, Jatropha gossypiifolia, Daniellia oliveri, Sarcocephalus latifolius*. Following the sampling, the respective plants were fully authenticated by Mr. Jarafu U. Mamza, from the Department of Biological Sciences, Adamawa State University, Mubi, Nigeria and a voucher specimen samples deposited accordingly (Magili *et al.*, 2014, Magili and Bwatanglang, 2018). The dried powdered samples of the plants tissues for each plants species and the disaggregated dried and homogenized prior to the elemental analysis by NAA. For the NAA analysis, about 250 mg to 300 mg of the respective plant samples were heat-sealed and processed following same methods adapted in our previous work (Magili *et al.*, 2014, Magili and Bwatanglang, 2018).

Elemental Analysis of the Anti-diabetic Medicinal Plants using NAA

The elemental analysis was carried out using the Nigerian Research Reactor-1 (NIRR-1) facility at the center for energy research and training ABU Zaria. For the analysis, reference material SRM NIST-1547 (Peach leaves) and NIST- 1515 (Apple Leaves) were used for quality control test and quantitative analyses. The analytical values obtained were equally compared with the actual values in mg/kg according to the method described by (Magili and Bwatanglang 2018). The protocols for sample irradiation were performed in two irradiations stages. The first irradiation was designed to capture short lived radionuclide while, the second irradiation was designed to capture the long lived radionuclide (Magili and Bwatanglang 2018) Following the various irradiation regime, the retrieved irradiated samples were then collected for the identification of various radionuclide concentration using gamma ray spectrum analysis software, a software developed at CIAE, Beijing, China (IAEA, 1996), NIST- 1515 (Apple Leaves), NIST-1547 (Peach leaves), IAEA Soil-7 and Coal Fly Ash SRM (1633STD)

Statistical Analysis

The obtained results were presented as mean ± SD (standard deviation). All differences are considered significant at $p<0.05$ using Analyse-it (version 2.3). Significant elemental concentration differences in plants samples were determined by analysis of variance (ANOVA).

Results and Discussion

The results of analysis of trace and macro elements in selected medicinal plants are presented in Figures 1-8. Calcium (Ca) **.**Figure 1: Present the distribution of Ca in leaves, stem bark and root bark of medicinal plants studied. Leaves Ca concentrations varied from *Sarcocephalus latifolius* (8493±323 mg/kg) to *Leptadenia hastata* (34960±804 mg/kg). Ca was not detected in the leaves of *Hymenocardia acida*. Stem bark Ca concentrations varied from *Ageratum conyzoides* (12870±438 mg/kg) to *Terminalia avicennioides* (82750±993 mg/kg).

Root bark Ca content ranged from *Ageratum conyzoides* (6763±417 mg/kg) to *Hymenocardia acida* (734700±1323 mg/kg). Ca was not detected in the root bark of *Daniellia oliveri*. All pairwise Ca concentration variation differences between plants samples were statistically significant ($P<.05$).The order of Ca concentrations distribution is stem bark >root bark>leaves, on average. Concentration of Ca in plant parts revealed that *Ageratum conyzoides*is (6763±417 mg/kg) was lowest while *Terminalia avicennioides* (82750±243.4 mg/kg) was highest.

Ca is the most abundant element detected in all 10 medicinal plants samples analyzed in this study, with the stem bark of *Terminalia avicennioides* (82750±993 mg/kg) being the most potent in Ca concentration. Stem barks samples tend to be the most potent source of Ca as in the stem bark of *Terminalia avicennioides*. The stem bark of *Anogeissus leiocarpus* (79780± 1277.0 mg/kg) suggests a good alternative, followed by the root bark of *Hymenocardia acida* (73470±1323.0 mg/kg). But the leave samples of *Leptadenia hastata* (34960±804.4 mg/kg) indicate the most potent option compared to other parts of the plants root bark (26190.0±707.0 mg/kg) and the stem bark (15410.0±447.0 mg/kg).

According to Hodgkin *et al.,* (2008), since the identification and characterization of the extracellular calcium-sensing receptor (CaR) 15 years ago, it has become increasing apparent that this cationic binding receptor is found on many tissues, not associated with the control of plasma calcium.. This suggests that the selected medicinal plants could be used for the management of DM since it has a high content of calcium.

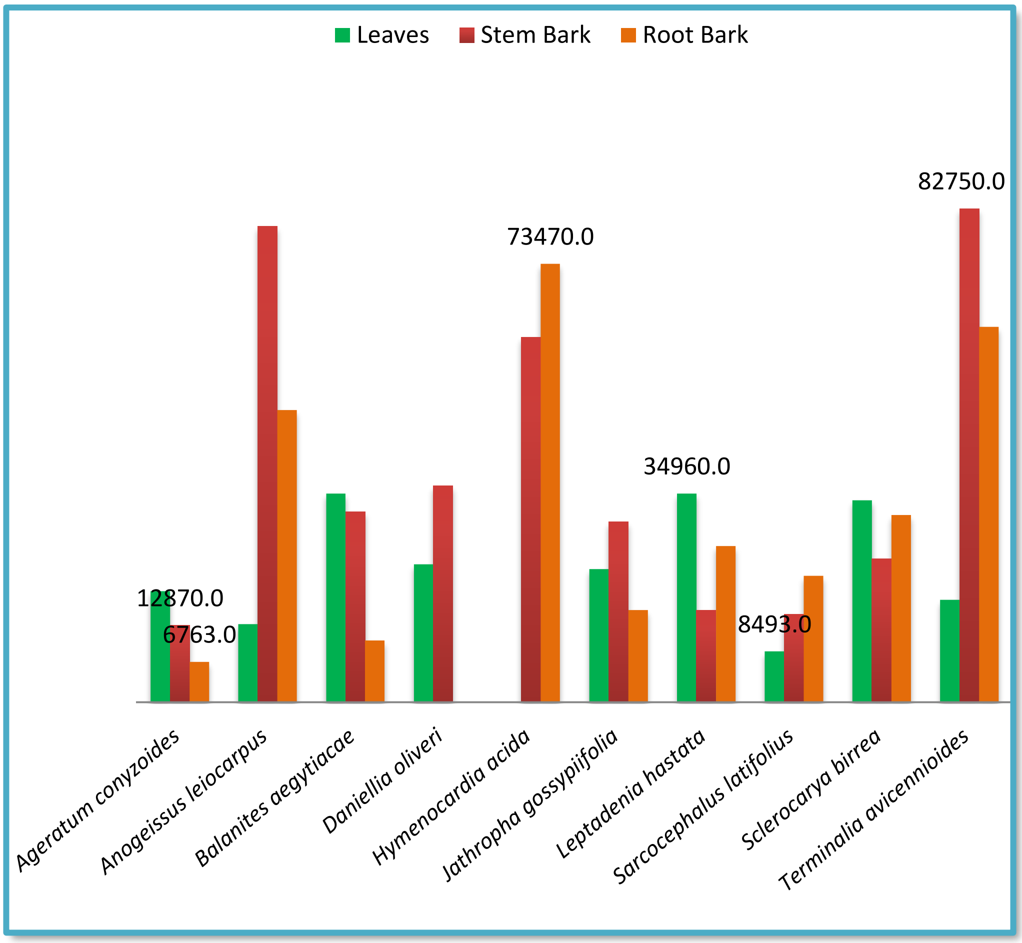

Figure 1: Distribution of **Ca** in leaves, stem bark and root bark of medicinal plants.

Magnesium (Mg).The distribution of Mg in leaves, stem bark and root bark of medicinal plants studied is showed on figure 2.The concentrations of Mg in the Leaves of *Terminalia avicennioides* varied from (1980±178 mg/kg) to (6012±331 mg/kg) in *Daniellia oliveri*,. Mg was not detected in the leaves of *Hymenocardia acida*. Stem bark Mg content ranged from *Daniellia oliveri* (593±147 mg/kg) to *Ageratum conyzoides* (3463±208 mg/kg), Mg was not detected in the stem bark of *Terminalia avicennioides*.Root bark Mg ranged from *Terminalia avicennioides* (591±140 mg/kg) to *Jathropha gossypiifolia* (4386±307 mg/kg) .Mg was present in all root bark samples analysed. The order of Mg concentrations distribution is leaves > root bark>stem bark, on average. Concentration of Mg in plants parts revealed that *Terminalia avicennioides* (591±140 mg/kg) was lowest while *Daniellia oliveri* (6012±331 mg/kg) was highest.

The result of this study indicated that in the overall order of elemental contents of plants tissues analyzed, Mg ranked 3rd in leaves and stem bark respectively, but was 4th in root bark samples. The results generally suggests that the most potent source of Mg is the leaves samples as the order of preference revealed in *Daniellia oliveri* (6012±333.1 mg/kg) followed by *Leptadenia hastata* (5641±299.0 mg/kg), *Ageratum conyzoides* (5402±265.0 mg/kg),and the leaves of *Jathropha gossypiifolia* (4785±321.0 mg/kg). The results however suggest that root bark alternative for a potent source of Mg is *Jathropha gossypiifolia* (4386±307.0 mg/kg), while stem bark alternative is *Ageratum conyzoides* (3463±208.0 mg/kg)(figure 2).These plants contain appreciable amount of Mg which is an element well known for potentiating insulin and have important roles in metabolic activities and insulin action (Prasad, 1993; Praveeena *et al.*, 2013). The efficacy of the leaves, root bark and stem bark of these plants in diabetes treatment may possibly depend on both inorganic and organic aspect as it contains appreciable amount of magnesium. Magnesium appears to be fairly uniformly distributed within the plants parts analyzed. The findings for Mg in this work were much higher than those reported by Sheded *et al*,(2006) in the medicinal plants, *cympobogon proximus, Acacia elirebengiana, acacia albida, pergulania tomentasa, solenostemma arghel, Balanites aegyptiaca* and *citrullus cococynthis* . Mg status is associated with insulin sensitivity, and a low magnesium intake predicts the development of type II diabetes in most studies. Mg supplements largely prevent diabetes in a rat model (Ma *et al.*, 1995). In vitro and in vivo studies (Praveeena *et al.*, 2013) have demonstrated that insulin may modulate the shift of Mg from extracellular to intracellular space. Intracellular Mg concentration has also been shown to be effective in modulating insulin action, mainly oxidative glucose metabolism.

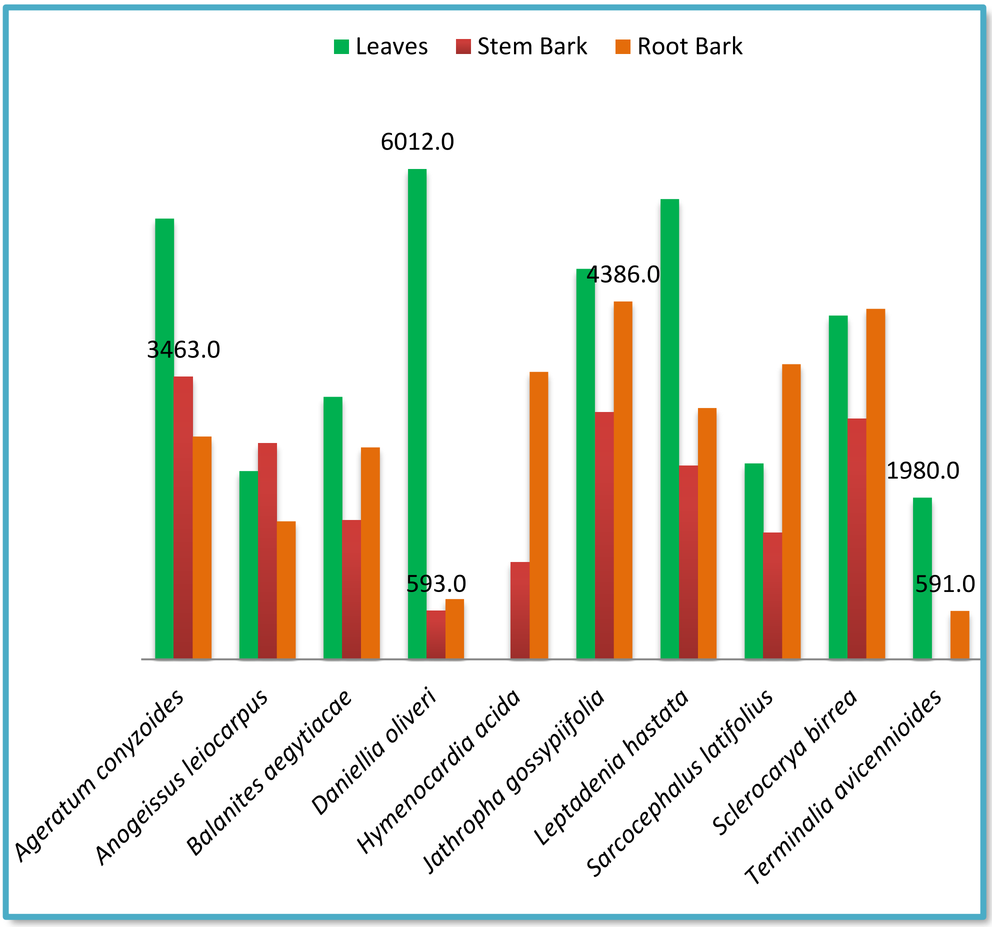

Figure 2: Distribution of **Mg** in leaves, stem bark and root bark of medicinal plants.

Sodium (Na)

Figure 3: present the distribution of Na in leaves, stem bark and root bark of medicinal plants studied. Leaves Na concentrations varied from *Sarcocephalus latifolius (34.5±0.3 mg/kg) to Jathropha gossypiifolia (553±1.00 mg/kg).* Na was detected in all leaves samples analyzed. With exception of *Terminalia avicennioides* and *Anogeissus leiocarpus* all other pairwise concentration variation differences were statistically significant *(*P*<.05).*

Stem bark Na concentration varied from *Terminalia avicennioides* (54.6±0.2 mg/kg) to *Hymenocardia acida* (305±1.0 mg/kg). All pairwise concentration variation differences in stem bark samples were statistically significant (*P*<.05).Root barks Na concentrations ranged from *Terminalia avicennioides* (96.2±0.3 mg/kg) to *Balanites aegytiacae* (620±1.1 mg/kg). Na was present in all samples analyzed. All pairwise Na concentration variation differences between plants samples were statistically significant (*P*<.05).

The Na concentration is in this order root bark>leaves>stem bark, while average concentrations of Na in plants parts revealed that *Sarcocephalus latifolius* (34.5±0.3 mg/kg) is lowest while *Balanites aegytiacae* (620.0±1.0 mg/kg) is highest. Sodium acts as electrolyte in the human body and is the principal cation in the extracellular fluids and modulates the maintenance of the intracellular and interstitial volumes. Na was found to be present in all the samples analyzed with concentrations of (345±0.3mg/kg) *sacrcocephalus latifolia* (553±1.00 mg/kg). The concentrations of Na in plants *Termimalia avicenmoides* stem bark (546±0.2 mg/kg). *Terminalia avicenmoides*, root bark (96.2±0.3 mg/kg), *Balanites aegytiacae.* Root barks (620±1.1mg/kg). The total body contents of Na are between 70-95 mg (Nguyen *et al.*, 2011). The safe and adequate sodium intake recommended for adult by the US National Research Council spans a wide range of 1100-3300 mg. Although a sodium deficiency is rare, its symptoms include decrease of blood pressure, tendency to collapse, dehydration, fever and dizziness. Values of Na in the analyzed plants are not higher than the recommended daily intake. These plants can be used as a source of Na supplement.

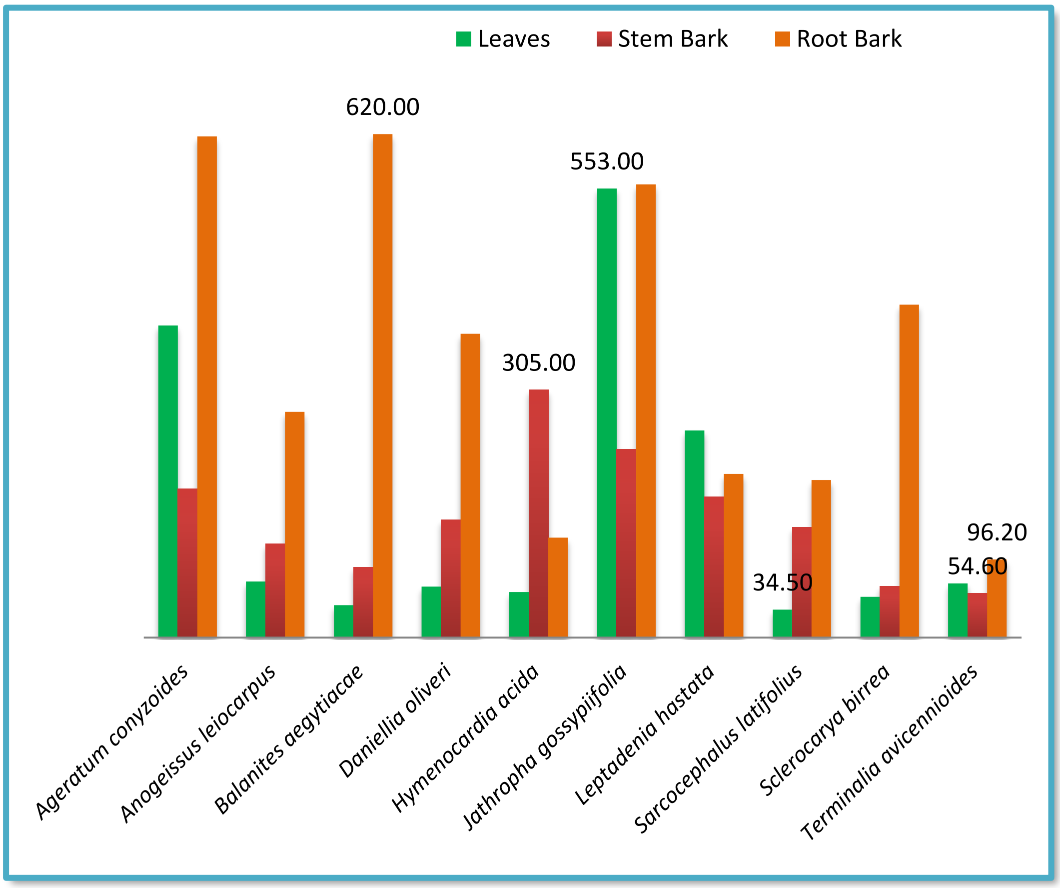

Figure 3: Distribution of **Na** in leaves, stem bark and root bark of medicinal plants.

Potassium (K)

The distribution of K concentrations in leaves, stem bark and root bark of medicinal plants studied is shown on figure 4. It was observed that K was present in all plants samples analysed. In the Leaves K concentrations varied from *Terminalia avicennioides* (703±3.0 mg/kg) to *Jathropha gossypiifolia* (28000±112 mg/kg).All pairwise concentration variation differences of K in leaves samples were statistically significant ($P<.05$).Stem bark K ranged from *Terminalia avicennioides* (2530±15 mg/kg) to *Ageratum conyzoides* (51880±156 mg/kg). Except *Hymenocardia acida and Anogeissus leiocarpus*, all other pairwise concentration variation differences of K in stem bark samples were statistically significant (*P*<.05).

Root bark K content varied from *Terminalia avicennioides* (2665±16 mg/kg) to *Jathropha gossypiifolia* (80250±321 mg/kg). The order of K concentrations distribution is root bark>stem bark>leaves on average. Concentrations of K in plants parts revealed that *Terminalia avicennioides* (703.3±3.0 mg/kg) is lowest while *Jathropha gossypiifolia* (80250.0±321 mg/kg) is highest. K is the second most abundant element in the overall order of elemental concentrations determined in leaves; stem bark and root bark samples of the medicinal plants samples studied. The results also clearly revealed that *Jathropha gossypiifolia* maintained the lead in high K contents in root bark (80250±321mg/kg) and leaves (28000±112 mg/kg) respectively, while for stem bark samples *Ageratum coryzoides* (51880±156 mg/kg) indicated the highest concentration. The root bark of *Ageratum coryzoides* (35880±108.0 mg/kg) was also found to be a good alternative to *Jathropha gossypiifolia* in terms of K content, as the leaves of *Leptadenia hastata* (23370±94.0 mg/kg) as shown in figure 4.

K is a well proven insulin secretagogue in the intact organism and the isolated pancreas. Insulin is a key defender against exogenous K load by using intracellular buffering to minimize hyperkalemia before renal excretion (Nguyen et *al*., 2011).

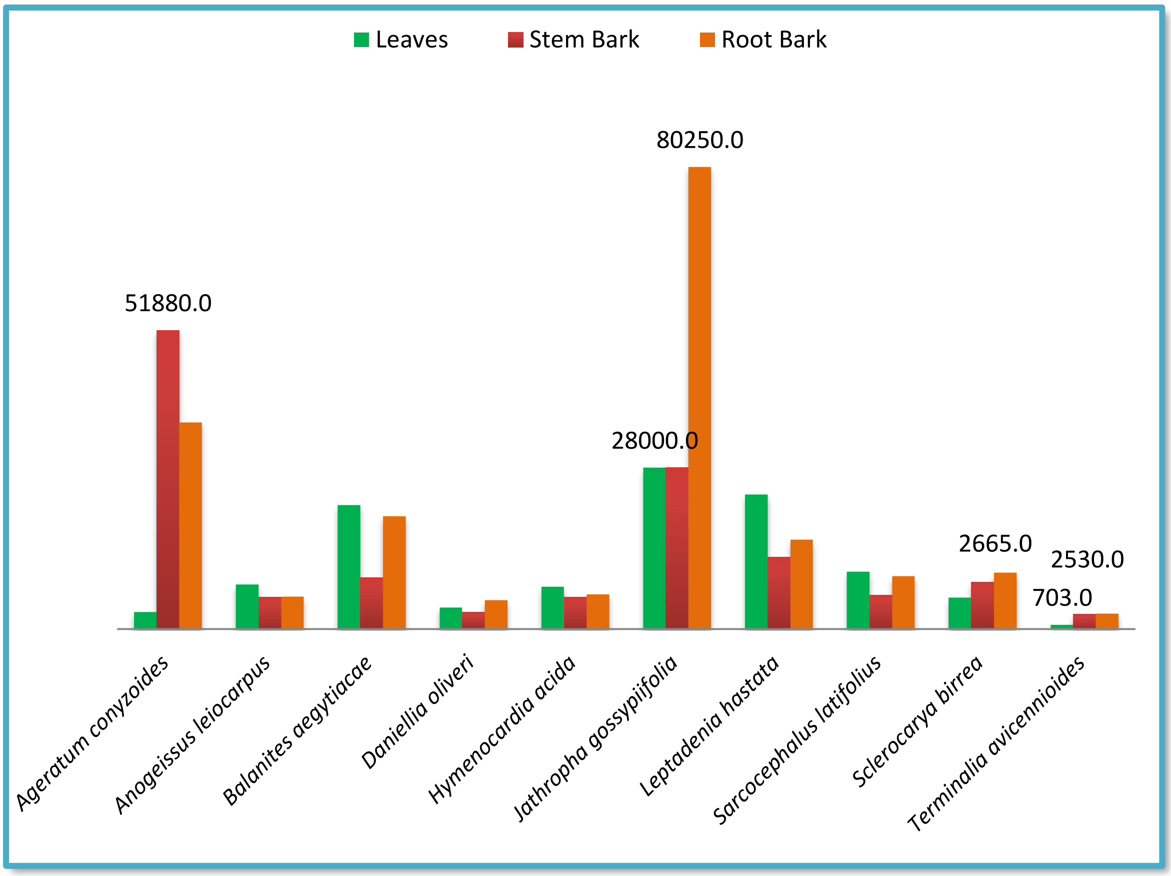

Figure 4: Distribution of **K** in leaves, stem bark and root bark of medicinal plants.

Iron (Fe). The distribution of Fe in leaves, stem bark and root bark of medicinal plants studied is presented in figure 5. It shows that with the exception of the leaves of *Hymenocardia* acida, Fe was present in all plants samples analyzed. Leaves Fe concentrations varied from *Daniellia oliveri* (108±27 mg/kg) to *Ageratum conyzoides* (1088±62 mg/kg).Stem bark Fe concentration ranged from *Anogeissus leiocarpus* (0.300±0.04 mg/kg) to *Leptadenia hastata* (534±47 mg/kg). Root bark Fe ranged from *Sclerocarya birrea* (222±23 mg/kg) to *Ageratum conyzoides*

(3701±96 mg/kg) with a variability coefficient of 104%. More than 75% of all pairwise concentration variation differences of Fe in root bark samples were statistically significant (P<.05).The order of Fe concentrations distribution is root bark>leaves>stem bark, on average. Concentration of Fe in plants parts revealed that *Anogeissus leiocarpus* (0.3±0.04 mg/kg) is lowest while *Ageratum conyzoides* (3701.0± mg/kg) is highest. Excess iron has been implicated in the pathogenesis of diabetes and its complication. Free iron serves as a catalyst for lipid and protein oxidation and the formation of reactive oxygen species. In addition, iron induces are correlated with obesity and insulin sensitivity.

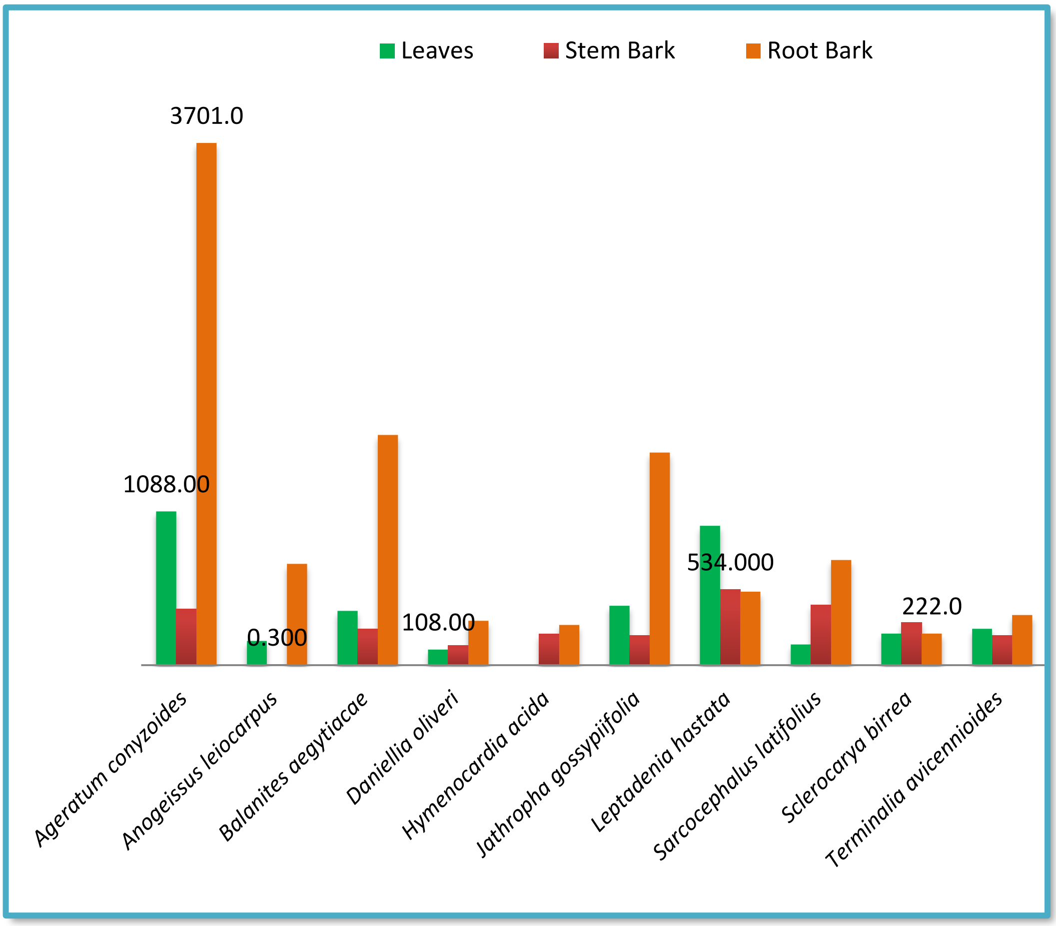

Figure 5: Distribution of **Fe** in leaves, stem bark and root bark of medicinal plants.

Iron is necessary for red blood cell formation and required for transport of oxygen throughout the body and very important for brain function (Ashraf *et al.*, 2010). The concentration of Fe (leaves) varied from *Daniellia Oliveir* (108±27mg/kg) to *Ageratum conyzoides* (1088±62 mg/kg). Stem bark Fe ranged from (0.300±0.04 mg/kg) *Anogeissus leiocarpus* to (534±47 mg/kg) *leptadania hastata*. Root bark Fe range from (222±23 mg/kg) Sclerocarya birrea to (3201±96 mg/kg) *Ageratum Conyzoides*. The trend of Fe concentration in the studied plant samples is root bark>leaves>stem bark on average. The concentration of Fe in plants parts revealed that *Hymenocardia acida* is lowest while *Ageratum conyzoides* is highest. The maximum tolerable level for animals was suggested as 1000 mg/kg by National research council (1994). On the other hand, the permissible limit set by FAO/WHO (1984) in edible plants was 20mg/kg. Fe is an important element for human beings and animals because it is an essential component of hemoglobin (Ashraf *et al.*, 2010). It facilitates the oxidation of carbohydrates, protein and fat to control body weight which is a very important factor in DM (Khan *et al.*, 2008). When compared with metal limit proposed by FAO/WHO (1984), the concentration of Fe in this study is above the proposed permissible limit. High Fe content in these plants could be a possible risk factor for diabetes but could be good for managing anemia as they are rich in iron (3201±96 mg/kg).

Cobolt (Co)

The distribution of Co, in leaves, stem bark and root bark of antidiabetic medicinal plant samples studied is presented in figure 6. It shows that Co was present in all leaves samples, but was not detected in stem bark samples of *Anogeissus leiocarpus, Balanites aegytiacae, Daniellia oliveri, Hymenocardia acida* and *Leptademia hastata*, and root bark samples of *Daniellia oliveri*. Leaves Co, concentrations varied from *Sarcocephalus latifolius* (0.07 ± 0.02 mg/kg) to *Daniellia oliveri* (0.25 ± 0.03 mg/kg). Only *Leptadenia hastata vs Balanites aegytiacae, Leptadenia hastata vs Sarcocephalus latifolius, Balanites aegytiacae vs Daniellia oliveri, Jathropha gossypiifolia vs Daniellia oliveri and Daniellia oliveri vs Sarcocephalus latifolius* were statistically significant ($P<.05$). Stem bark Co content ranged from *Sclerocarya birrea* (0.050 ± 0.01 mg/kg) to *Sarcocephalus latifolius* (0.180 ± 0.04 mg/kg). The results showed that about 50% of all pairwise concentration variation differences of Co, in stem bark samples are statistically significant ($P<.05$). Root bark Co content ranged from *Leptadenia hastata* (0.080±0.02 mg/kg) to *Sarcocephalus latifolius* (51.0±8.0 mg/kg). Also, about 50% of all pairwise concentration variation differences of Co, in root bark samples were statistically significant ($P<.05$).

The Co concentrations distribution follows this order, root bark>leaves>stem bark, on the average. Concentration of Co, in plants parts revealed that *Hymenocardia acida, Jathropha gossypiifolia, Sarcocephalus latifolius, Leptadenia hastate, Balanites aegytiacae* (0.1±0.0 mg/kg) is lowest while *Sarcocephalus latifolius* (51.25±8.06mg/kg) is highest. The result of this study revealed that the concentration Co in leaves samples in *Danillia Oliveri* (0.25±0.03 mg/kg) and stem bark samples in *Sacocephalus latifolius* (0.180±0.04 mg/kg) and in root bark samples, in *Sarcophalus latifolius* (51.0±8.0mg/kg). The result generally suggests that while root bark samples are the most potent source of Co, the root bark sample of *Jathropha gossypiifolia* (36.0±7.0 mg/kg) is a suitable alternative to *Sarcophalus latifolius* followed by *Sclerocarya birrea* (28.0±4.0 mg/kg)

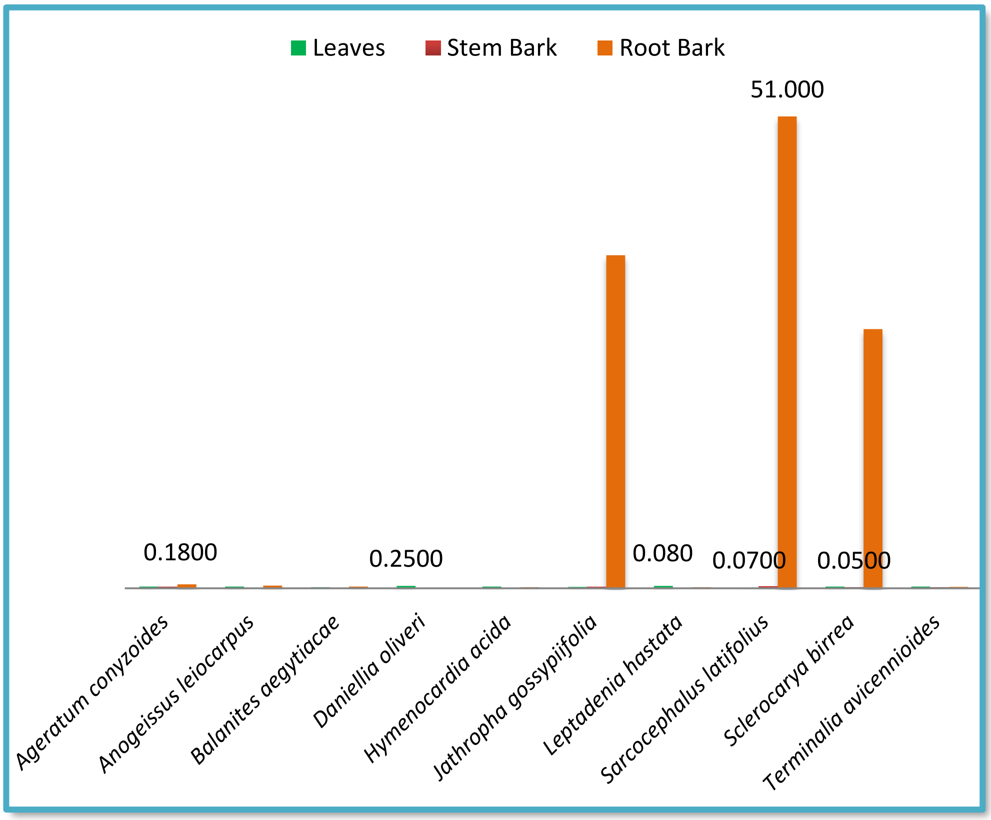

Figure 6: Distribution of **Co,** in leaves, stem bark and root bark of medicinal plants.

Manganese (Mn)

The distribution of Mn in leaves, stem bark and root bark of antidiabetic medicinal plants studied is presented on Figure 7.The plants show that Mn was present in all plants samples analyzed. Leaves concentrations of Mn varied from *Anogeissus leiocarpus* (32.9±0.2 mg/kg) to *Hymenocardia acida* (1969.25±14.0 mg/kg). Excepting *Balanites aegytiacae* vs *Sclerocarya birrea, Sclerocarya birrea* vs *Sarcocephalus latifolius* and *Anogeissus leiocarpus* vs *Sarcocephalus latifolius* all other pairwise concentration variation differences of Mn in leaves samples were statistically significant ($P<.05$).Stem bark Mn ranged from *Sclerocarya birrea* (25.9±0.2 mg/kg) to *Hymenocardia acida* (139±0.4 mg/kg) . With execption of *Terminalia avicennioides* vs *Leptademia hastata*, *Terminalia avicennioides* vs *Daniellia oliveri* and *Balanites aegytiacae* vs *Anogeissus leiocarpus* all other pairwise concentration variation differences of Mn in stem bark samples are statistically significant ($P<.05$).

Root bark Mn ranged from *Anogeissus leiocarpus* (37.54±0.23 mg/kg) to *Hymenocardia acida* (317.6±0.6 mg/kg). Except *Terminalia avicennioides* vs *Daniellia oliveri*, *Terminalia avicennioides* vs *Sarcocephalus latifolius* and *Daniellia oliveri* vs *Sarcocephalus latifolius* all other pairwise concentration variation differences of Mn in root bark samples were statistically significant ($P<.05$).

The pattern of Mn concentrations distribution is leaves> root bark>stem bark, on average. Concentration of Mn in plants parts revealed that *Anogeissus leiocarpus* (25.9±0.2mg/kg) is the lowest while *Hymenocardia acida* (1969.0±14 mg/kg) is the highest.

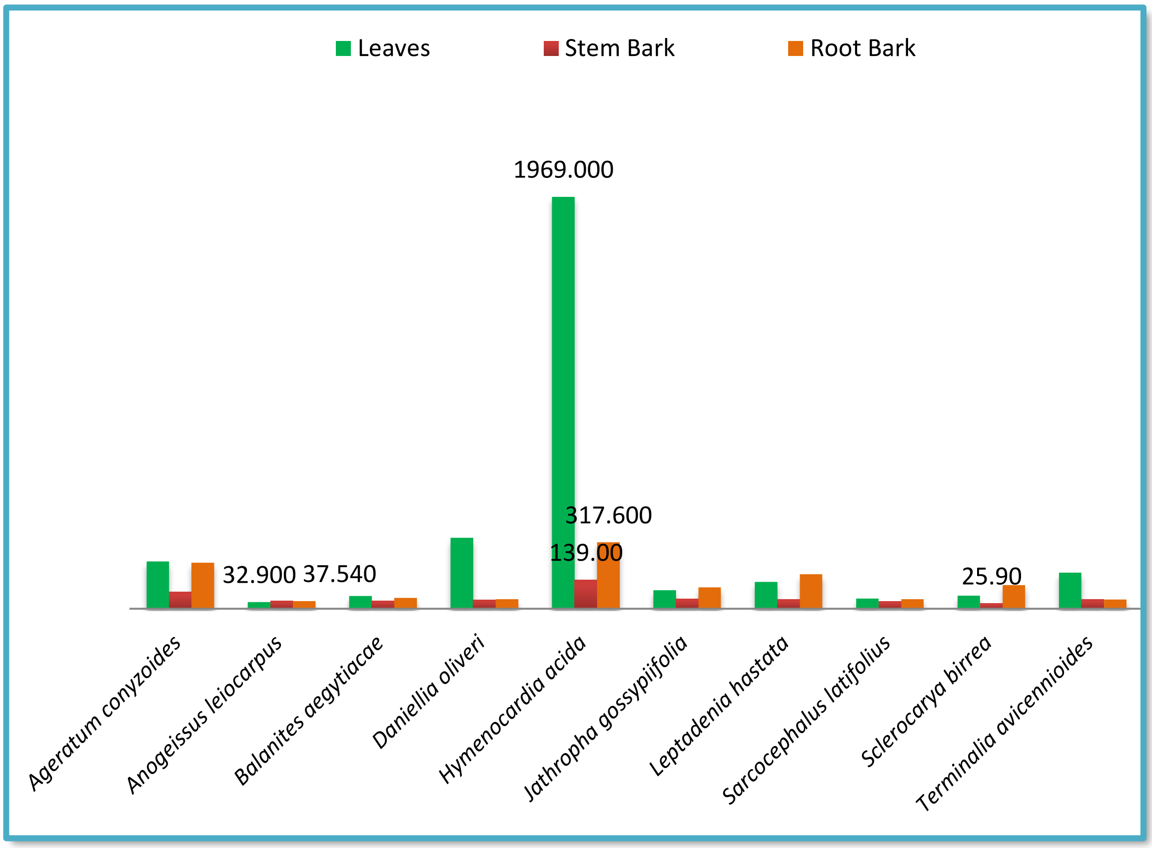

Figure 7: Distribution of **Mn** in leaves, stem bark and root bark of medicinal plants

The results generally indicated two potent plant sources of Mn. These are the leaves of *H. acida* (1969.25±14.0 mg/kg) and *D. oliveri* (339.2±0.7 mg/kg). Again, *H. acida* was found promising in Mn content in both its root bark (317.6±0.6) and stem bark (139.0±0.4 mg/kg) samples. However, the results suggest *Ageratum conyzoides's* leaves (226.1±0.5 mg/kg) and rootbark (220.4±0.4 mg/kg) as suitable alternative source of Mn (Figure 19).Manganese deficiency can impair glucose utilization. It is a key component of enzyme systems. In humans, the range between deficiency and toxicity of Mn is narrow. The recommended FAO/WHO (1984) values for adults range from 2 to 5 mg Mn/day (Merian, *et al;* 2004).These plants parts contain appreciable concentration level of Mn and are well established for pharmacological action in plants and this element is important in the regulation of insulin and control of the blood sugar levels in the human body and these plants hence suitable in management of diabetes mellitus. Manganese deficiency has been observed in various species of animals with the signs of impaired glucose tolerance and alterations in carbohydrate and lipid metabolism. It has been established also that Mn deficiency interferes with normal skeletal development in various animal species (Freeland-Graves *et al.,* 1987). Mn is known to be an enzyme activator of the insulin metabolism (Keen *et al.,* 1984; Hurley and keen, 1987).Mn is an important element to the human body. Its activities include several enzymic processes and it is also known to help in eliminating tiredness and nervous irritability (Djama *et al*., 2012). Mn occurs naturally in foods and the human body can benefit highly from it. Among the many benefits of Mn, it helps with natural insulin production. According to Bailey and Day (1989), Mn supplementation was effective in maintaining normal blood glucose level. It was also reported that diabetic conditions could be controlled to some extent by an extract of Lucene (alfalfa, *Medicago sativa*) because of high concentration of Mn (Bailey and 1989). In contrast to the effectiveness of Mn, oral supplements of zinc, magnesium, cobalt or iron had no effect on the patient's blood sugar levels, indicating a specific role for Mn in insulin release or action. Studies by Lee *et al.,* (2013) showed that Mn supplementation in normal mice on normal Chow, and Mn treatment increased insulin secretion which improves glucose tolerance under conditions of dietary stress These plants parts contain appreciable amount of Mn. This shows that the plants can be used for the management of diabetes mellitus and as a source of Mn supplement.

Zinc (Zn)*.*

The distribution of Zn in leaves, stem bark and root bark of anti-diabetic medicinal plants studied is presented on Figure 8. The result shows that Zn was not detected in all samples of *Sarcocephalus latifolius* and *Daniellia oliveri* analysed. It was also not detected in the stem bark samples of Anogeissus *leiocarpus, Hymenocardia acida,* and *Jathropha gossypiifolia,* and the root bark sample of *Hymenocardia acida*.

Stem bark Zn ranged from *Sclerocarya birrea* (9.0±2.0 *mg/kg)* to *Balanites aegytiacae* (36.0±4.0 mg/kg). The order of Zn concentrations distribution is root bark>leaves>stem bark, on average. Concentration of Zn in plants parts revealed that *Sclerocarya birrea* (8.2±1.9 mg/kg) was lowest while *Balanites aegytiacae (*64.0±4.0 mg/kg) was the highest.

The root bark of *Balanites aegytiacae* (64.0±4.0 mg/kg) was indicated as the most potent source of Zn with *Sclerocarya birrea* (44.0±3.0 mg/kg) and *Leptadenia hastata* (43.0±4.0 mg/kg) as suitable root bark alternatives. But for leaves samples, Zn may be reliably sourced in high concentrations from *Ageratum conyzoides* (62.0±4.0mg/kg) and its possible substitute *Balanites aegytiacae* (46.0±4.0 mg/kg).

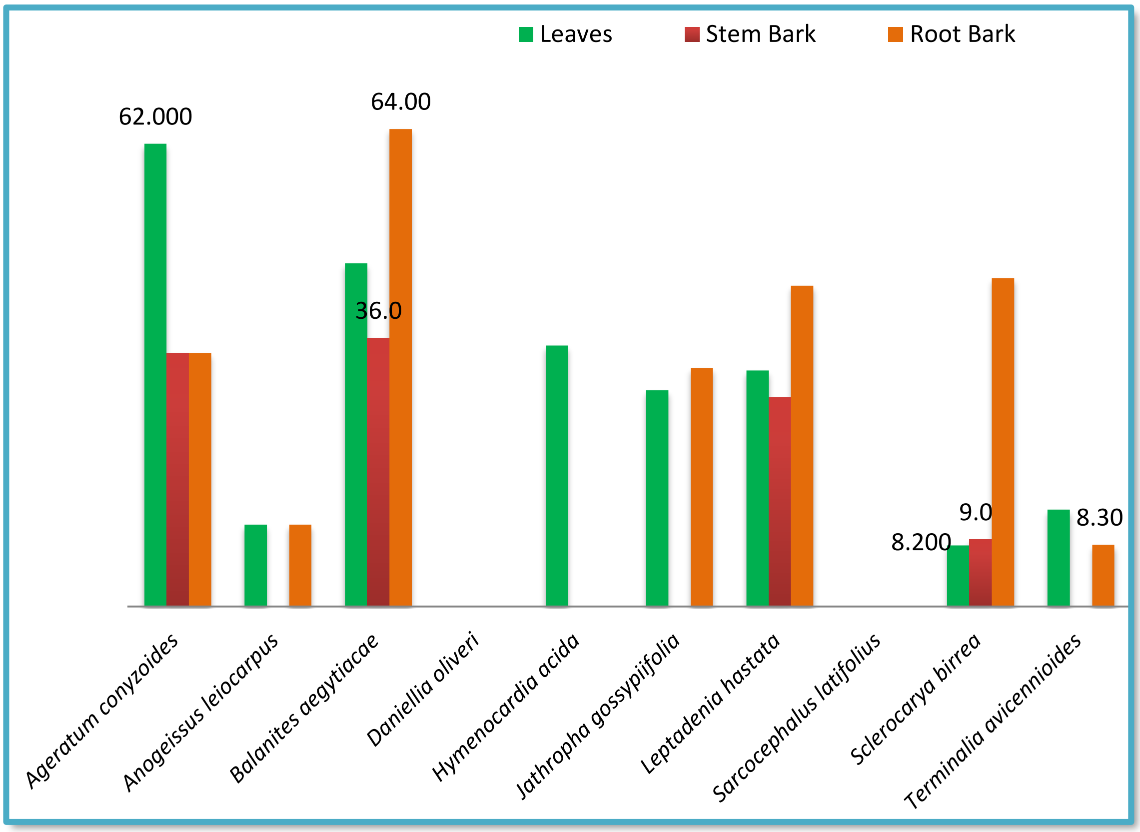

Figure 8: Distribution of **Zn** in leaves, stem bark and root bark of medicinal plants

Stem bark samples were indicated as relatively weak source of Zn, but where tissue availability is a challenge, the stem barks of *Balanites aegytiacae* (36.0±4.0 mg/kg) and *Ageratum conyzoides* (34.0± 4.0 mg/kg) root bark may be good alternatives

Some micro-elements have significant useful functions in the human body but the roles of some them in fighting diabetes mellitus are not well understood. Zn has been reported to be responsible for the secretion of insulin from the beta cells of pancreas (Kiran *et al.*, 2012).This shows that these plants have appreciable concentration of Zn and has proved that it has more medicinal value. Zinc is one of such element which is an extremely important in activation of insulin (Kinlaw *et al.*, 1983). Zinc is known to assists in the regulation of insulin levels in the blood (Hamid *et al.*, 1998). It has been reported that it improves the sensitivity of insulin in the management of diabetes mellitus (Hamid *et al.*, 1998). Some of these plant parts did not contain zinc but have some amounts in the other parts. The potency of the plants in the treatment of diabetes mellitus may possibly depend mostly on the organic content as it does not contain appreciable amount of zinc.

Conclusion

The results of this study confirm findings of several diverse studies on the elemental contents of different tissues of the medicinal plant species. The elements determined were (Ca, K, Mg; Na, Co, Fe, Mn; Zn). The distribution of these elements in plants tissues varied diversely with statistical significance in some instances across tissues and plants species. As indicated from the results of this study, all 8 elements determined were found present in at least one tissue of the plant species, but not one plant tissue indicated the presence of all 8 elements determined. In this study, elemental contents of the medicinal plants were determined using a highly sensitive technique of NAA and has provided a supportive evidence in the composition of the chemical elements in the selected medicinal plant parts which may be pharmacologically important. The result further revealed that the medicinal plants contains appreciable amount of these elements which play vital roles in potentiating insulin, thereby aiding in management of diabetes mellitus.. These plants can also served as potential sources of mineral elements and medicines for the revitalization of body systems. The result provides justification for the usage of the selected medicinal plants in the management of diabetes mellitus. Therefore, there is need to expand the research in much more variety of medicinal plants and also towards potency and side effect of the plants.

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