

Heavy Metal Analysis of Some Anti-Diabetic Medicinal Plants in Côte d'Ivoire

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Abstract: Trace elements concentrations in four plants with anti-diabetic potency in Côte d'Ivoire were studied using Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis technique. The aim of this study is to determine qualitatively and quantitatively trace elements in these plants and their medicinal roles in the human body. Leaves and roots were analyzed for their trace element contents. The plant samples were found to contain essential trace elements such as Cr, V, Zn and Mn which are well known for their important roles in anti-diabetic preparations (herbal drugs). All the medicinal plants were found to be rich more than one of the essential elements under study. The elemental concentrations in different part (root, stem and leaf) of the medicinal plants and their biological effects are discussed.

Keywords: Anti-diabetic, energy-dispersive x-ray fluorescence analysis, medicinal plants, trace elements

INTRODUCTION

One of the most dangerous and life threatening diseases in the world today, involving the pancreas, is Diabetes mellitus (Verbrugge *et al.*, 1989). It is a condition primarily defined by the level of hyperglycaemia giving rise to risk of micro vascular damage (retinopathy, nephropathy and neuropathy). It is associated with reduced life expectancy, significant morbidity due to specific diabetes related micro vascular complications, increased risk of macro vascular complications (ischaemic heart disease, stroke and peripheral vascular disease) and diminished quality of life (World Health Organization, 2006). The record of its prevalence in the world today and the increase in morbidity and mortality rates calls for an urgent attention from the health professionals, policy makers and executioners in tackling this disease. In Côte d'Ivoire, the rate of morbidity is 5.7% (Zmirou, 1979). Traditional medical herbs used for strengthening the body immune system and for therapeutic purposes are known to have many essential and nutritional elements. Many plants have been documented to have the efficacy to treat diabetes in Côte d'Ivoire (Aké and Adjanohoun, 1979). Some heavy metal are well known to play essential roles in the curative properties of plants. These heavy metals are usually associated with organic molecules.

The aim of this study is to investigate the trace element contents in plants and their therapeutic properties with emphasis on Diabetes mellitus. Due to

increasing industrialization and environmental pollution, the study was also extended to estimate the level of toxic elements present in the medicinal plant samples. The possibility of having some traces of toxic element in plant materials makes it necessary for scientific research to be conducted into plant medicine to ensure safe methods of application especially considering the tolerable Upper intake Level (UL) and Recommended Daily Dietary Allowance (RDA) values. This study can be of help in deciding the proportion of various active constituents and also managing dose of a particular formulation since dosage has been a major challenge facing traditional herbalists or healers.

MATERIALS AND METHODS

Sample collection and preparation: Plants species shown in Table 1 were collected from July 2007 to July 2008 at AGBAN-Bingerville, a village of Bingerville, a town, situated at about 20 km from Abidjan, (Fig. 1) in forest zone. Ethno botanical studies in Côte d'Ivoire have revealed ten anti-diabetic plants used to treat diabetes mellitus but this study considered four of the known plants materials. The plant samples were made up of the Leaves and roots. The following four plants were sampled for analysis: leaves of *Catharanthus roseus* (Singh *et al.*, 2006), *Solenostemon monostachyus* (Olabanji *et al.*, 2008), *Phyllanthus amarus* (Hanumanthachar and Milind, 2007) and roots of *Boerhavia diffusa* (Pari and Anamath, 2004). The samples were gently and thoroughly washed with

Table 1: Some anti-diabetic medicinal plants used ethno medically in Côte d'Ivoire

Scientific name	Family	Parts used	Biological activities	Method of use
<i>Boerhavia diffusa</i> L. (BD)	Nyctaginaceae	Roots	Anti-diabetic	Decoction/infusion
<i>Catharanthus roseus</i> (L.) Sw. (CR)	Apocynaceae	Leaves	Anti-diabetic	Decoction/infusion
<i>Phyllanthus amarus</i> <i>schumach. and thann</i> (PST)	Euphorbiaceae	Leaves	Anti-diabetic	Decoction/infusion
<i>Solenostemon monostacyus</i> (SM) (<i>P. beauv.</i>) Brig.	Lamiaceae	Leaves	Anti-diabetic	Decoction/infusion



Fig. 1: Map showing the sampling site

distilled water to avoid contamination. They were then dried at ambient laboratory temperatures in the range of 20°-30°C and then grinded into fine powder. About 300 mg of each sample were pelletized using a SPECAC press with a pressure of 2 tons/Cm² to produce an intermediate thick pellet sample. The pellets produced

were kept in a desiccators for at least 24 h to get rid of the moisture contents before the elemental analysis.

Sample analysis: The irradiation was done using an Energy Dispersive X-Ray Fluorescence (EDXRF) spectrometer. Tube excited X-Ray photons from a Mo-

Table 2: The various plant parts analysed and their elemental concentrations

Elements	Boerhaviadiffusa	Cataranthus roseus	Phyllanthus amarus	Solenostemon monostachyus	RDA (per day) adults. mg Nielsen and Uthus (1990)	UL/day Nielsen and Uthus (1990)
S	-	-	1779.8±1203.0	-	-	-
Cl	-	-	-	780.7±691.2	1525-5625 mg	-
K	8408.8±471.1	5504.9±504.0	4068.3±2474.4	10000.0±4000.0	1525-5625 mg	-
Ca	3228.9±174.2	5951.2±511.5	3181.2±1931.7	10600.0±4300.0	800-1200 mg	-
Ti	-	-	-	136.8±61.8	-	-
V	-	-	-	17.9±13.1	<1.8 mg	1.8 mg
Cr	5.1±4.4	-	6.2±5.2	13.0±9.8	-	-
Mn	9.9±3.0	37.2±4.6	64.6±36.7	57.6±23.9	1.0-5.0 mg	11 mg
Fe	98.1±5.5	241.6±19.1	244.3±131.6	1094.8±439.3	8-18 mg	45 mg
Co	2.5±1.6	5.5±1.8	3.8±2.7	11.6±6.3	-	-
Ni	2.2±1.0	2.1±1.0	2.9±1.7	3.8±2.0	0.13-0.4 mg	1.000 µg
Cu	5.1±0.8	7.8±0.9	7.0±3.1	10.8±4.3	1.0-3.0 mg	10 mg
Zn	12.7±0.9	6.3±4.0	37.8±14.6	150.3±54.7	15 mg	40 mg
Se	-	-	-	-	55 µg	400 µg
Br	10.6±0.6	19.7±1.1	11.7±2.6	18.5±4.6	1.5-2.5 mg	-
Rb	26.2±1.2	29.6±1.5	16.8±2.9	29.6±6.0	-	-
Sr	15.1±0.9	29±1.4	24±3.7	40.8±7.5	-	-
Pb	1.4±0.9	3.1±1.1	1.4±0.9	4.9±1.8	-	-

UL: Tolerable upper intake levels; RDA: Recommended dietary allowance; Concentrations of elements are in ppm or mg/kg; L: Leaves; R: Roots

anode in a Mo secondary target excitation arrangement was used for the irradiation. The tube has a maximum output power of 3 kW and was operated at 45 kV/5 mA for the biological samples. A 30 mm² active area Si (Li) detector with an energy resolution (FWHM) of 165 eV at 5.9 keV Mn K α line, placed at 45° to the sample surface area was used for the detection of characteristic photons. An ortec maestro Multichannel analyser with a maestro software programme was employed for the data collection (peak collection).

Three irradiations were made for each sample, being the intermediate thick sample, multi element target and Sample+Target for a spectrum collection life time of 1500 s. Linear least squares fitting of the AXIL software programme was used for the spectrum deconvolution (IAEA, 2005). Emission-Transmission method in the Quantitative X-Ray Analysis Software (QXAS) package was used to convert spectrum peak areas to concentrations. Olive leaves (BCR No 62) was used as the standard reference materials for the validation of the analytical results.

RESULTS AND DISCUSSION

The results of the elemental analysis of the selected anti-diabetic medicinal plants presented in Table 2 show nineteen elements. The major elements detected were potassium and calcium. The elements present in trace quantities were Vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, arsenic, selenium, bromine, rubidium and strontium.

The Recommended daily Dietary Allowance (RDA) and the Tolerable Upper Intake Level (UL) values of some of these elements for adults are also reported in the Table 2. An element is considered toxic

if its concentration exceeds the tolerable Upper intake Level (UL) (DRI, 2001). The Recommended Daily Dietary Allowance (RDA) per day for some detected elements for adults is given in Table 2. The elemental concentrations were determined to verify the biological role of trace elements in anti-diabetic medicinal plants. The variation in elemental concentration is mainly attributed to the differences in botanical structure, as well as in the mineral composition of the soil in which the plants are cultivated. Other factors responsible for variation in elemental content are preferential absorbability of the plant, use of fertilizers, irrigation water and climatologically conditions (Rajurkar and Pardeshi, 1997).

Some trace essential elements have significant useful functions in the human body but the roles of some of them in fighting diabetes are not well understood. Zinc is one of such element which is an extremely important part of insulin (Kinlaw *et al.*, 1983). Zn is known to assist in the regulation of insulin levels in the blood (Hamid *et al.*, 1998). It has been reported to improve the sensitivity of insulin in the management of diabetes (Hamid *et al.*, 1998). Manganese deficiency has been observed in various species of animals with the signs of impaired growth, impaired reproductive function, impaired glucose tolerance and alterations in carbohydrate and lipid metabolism. Furthermore, manganese deficiency interferes with normal skeletal development in various animal species (Freeland-Graves *et al.*, 1987; Hurley and Keen, 1987; Keen *et al.*, 1994). Manganese is known to be an enzyme activator of the insulin metabolism (Keen *et al.*, 1994).

Chromium potentiates the action of insulin in vivo and *in vitro* (Mertz, 1969, 1993; Mertz *et al.*, 1961).

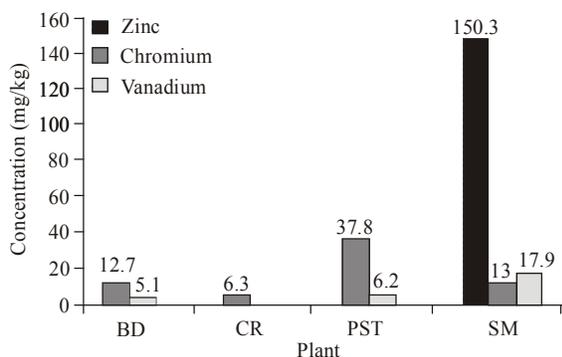


Fig. 2: Concentrations of Zn, Cr, and V in the sample plants BD: *Boerhavia diffusa* L.; CR: *Catharanthus roseus* (L.) Sw.; PST: *Phyllanthus amarus schumach.* And Thann; SM: *Solenostemon monostachyus* (P. Beauv.) Brig.

Schwarz and Mertz (1959) identified chromium as the element that restored glucose tolerance in rats. Because chromium potentiates the action of insulin and chromium deficiency in Total Parenteral Nutrition (TPN) patients, impairs glucose utilization and raises insulin requirements, it has been hypothesized that poor chromium status is a factor contributing to the incidence of impaired glucose tolerance and Type II diabetes (Harris, 1997). Chromium supplement use (particularly chromium picolinate) has increased in popularity as a result of reports that chromium potentiates the action of insulin and reduces hyperglycaemia and hyperlipidemia (Flodin, 1990). Vanadium in the forms of vanadyl sulfate (100 mg/day) and sodium metavanadate (125 mg/day) has been used as a supplement for diabetic patients (Boden *et al.*, 1996; Cohen *et al.*, 1995; Goldfine *et al.*, 1995). Vanadium mimics insulin and stimulates cell proliferation and differentiation (Heyliger *et al.*, 1985; Nielsen and Uthus, 1990). These trace elements (Zn, Cr, Mn and V) have important roles in metabolism and insulin action. The concentrations of Zn, Cr and V in the sample plants can be seen in Fig. 2.

Roots of *Boerhavia diffusa* seen to be extensively used by the traditional healers in the management of diabetes did not contain vanadium but have some amounts of zinc (15.7 mg/kg), chromium (5.1 mg/kg) and manganese (9.09 mg/kg) (Table 1). Leaves of *Catharanthus roseus* also have manganese (37.2 mg/kg), zinc (6.3 mg/kg) but no vanadium and chromium, the main elements for insulin efficiency. The efficacy of the leaves of *Catharanthus roseus* in diabetes treatment may possibly depend mostly on the organic aspect as it does not contain chromium and vanadium. Leaves of *phyllanthus amarus* are seen to have high levels of manganese (64.5 mg/kg) and zinc (37.8 mg/kg) low level of chromium (6.2 mg/kg) but no

vanadium. The non-existence of vanadium in this plant could possibly limit the efficacy in the management of diabetes. Leaves of *Solenostemon monostachyus* have significant amounts in zinc (150.3 mg/kg), manganese (57.6 mg/kg), chromium (13 mg/kg) and vanadium (17.9 mg/kg) which shows its usefulness in diabetes treatment. Leaves of *Solenostemon monostachyus* can be useful for diabetic patients.

CONCLUSION

This study is aimed at verifying the pharmacological action of herbs with emphasis on the medicinal values of the trace element contents. The elemental analysis of some medicinal plants used for the treatment of diabetic diseases by EDXRF technique revealed eighteen elements in varying concentrations. These plants contain appreciable concentration levels of Fe, Cu, Zn, Mn, Cr, Co and V which are elements well established for their pharmacological action in plants. Elements such as manganese, chromium, vanadium and zinc detected in these medicinal plants are implicated in the regulation of insulin and control of the blood sugar levels in the human body and are hence suitable in management of diabetes. These elements were found mostly in the leaves of *Phyllanthus amarus*, *Catharanthus roseus*, *Solenostemon monostachyus* and roots of *Boerhavia diffusa*, which are used for herbal preparations for anti-diabetic remedies in Cote d'Ivoire. Leaves of *Phyllanthus amarus* could be good for managing anaemia as they are rich in iron (244.3 mg/kg), copper (7 mg/kg), cobalt (8 mg/kg) and nickel (2.9 mg/kg). The data obtained in the present study, apart from revealing the curative potency of some well known herbs, will also be helpful in managing dose to be administered to patients considering the elemental contents and their concentrations. In order to develop a stronger basis for appreciating the curative effects of medicinal plants, there is a need for more investigations to be conducted to identify the role of essential elements in the medicinal values of plants.

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