INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 12, No. 2, p. 247-252, 2018

RESEARCH PAPER OPEN ACCESS

Determination of heavy elements content of some sudanese medicinal *Cassia* species using X-RAY fluorescence spectroscopy

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Key words: Heavy elements, Content analysis, Sudanese, *Cassia*, XRF

http://dx.doi.org/10.12692/ijb/12.2.247-252 Article published on February 26, 2018

Abstract

Cassia species have wide distribution in tropical and subtropical regions and medicinally used worldwide. The concentration levels (ppm) of selected toxic trace elements (Ti, Cr, Mn, Fe, Cu, Zn, Pb, Br, Rb, Sr, Zr and Nb) were determined in some important *Cassia* species that most commonly used in the Sudanese Traditional Medicine. The plants namely, *Cassia senna, Cassia tora* and *Cassia occidentalis* were collected from different locations in the Central Sudan (EL-Hassaya in north central Sudan; Um Rawaba and EL-Obeid in west central Sudan). X-Ray Fluorescence (XRF) spectroscopy was employed for the estimation of studied heavy trace elements. The element contents in the samples were found at different levels. The highest mean levels (ppm) of Ti (229 ppm), Cr (98ppm), Fe (489 ppm), Br (38.4ppm), Pb (6.4 ppm), Sr (189 ppm) and Zr (14 ppm) were found in *Cassia tora* fermented leaves (EL-Obeid sample) while those of Mn (61.2 ppm), Cu (9.1 ppm), Zn (174 ppm) and Nb (1.0 ppm) were found in *Cassia occidentalis* roasted seeds (Um Rawaba sample). The result also showed that *Cassia senna* (EL-Hassaya sample, fruit pulp) had the highest content of Rb (17 ppm). These results can be used to set new standards for prescribing the dosage of herbal drugs prepared from these plant materials in both folk remedies and pharmaceutical industry.

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Introduction

The medicinal plants are widely used to treat many human diseases in Sudan (Basgel and Erdemoğlu, 2006; Nafiu *et al.*, 2011). The human body needs a number of minerals in order to maintain good health (Ozak *et al.* (2002); Chan *et al.* (2005).

Inorganic constituents of medicinal plants, including heavy elements, have received attention of many authors; there have been many reports of the use medicinal plants to assess the impact of environmental contamination of heavy elements Rashed (1995); Chuang *et al.* (2000); Ozak *et al.* (2002); Chan *et al.* (2005) and Flokowski *et al.* (1977).

Vartika and co-workers (2001). concluded that the medicinal values of some plant species used in homoepathic system may be due to the presence of Ca, Cr, Cu, Fe, Mg, K and Zn.

These elements also take part in neurochemical transmission and serve as constituents of biological molecules and in a variety of different metabolic processes (Mayer, 1989).

Determination of mineral elements in plants is very important since the quality of many foods and medicines depends upon the content and type of minerals (Bahadur *et al.,* 2011). Malnutrition is of major concern for many tropical developing countries.

Deficiency or excess of elements may cause a number of physiological disorders. For example, Iron deficiency cause anemia that affects one third of the world population (Kumari *et al.,* 2004); (Leterme *et al.,* 2006). Low levels of Zn can induce the pathogenesis of lung cancer (Cobanoglu *et al.*, 2010). Breast cancer patients had low levels of Ca, Mg, Fe, Cu, Mn and Zn in their hair (Joo *et al.*, 2009).

Therefore, it is of major interest to establish the levels of some metallic elements in common used plants because, at elevated levels, these metals could be dangerous and toxic (Schumacher, *et al.*, 1991); (Jabeen *et al.*, 2010).

Determination of metals in medicinal plants is a part of quality control to establish their purity, safety and efficacy according to the World Health Organization (WHO, 1992).

In Sudanese Traditional Medicine, *Cassia senna* is used to relief constipation, *Cassia tora* fermented leaves is sprinkled over popular food is considered as an appetizer and for diabetes, while *Cassia occidentalis* roasted seeds are used to treat backache and for hypertension (EL-Kamali, 1996).

The present study was done on some medicinal *Cassia* plants collected from different regions in Central Sudan by X-Ray Fluorescence method for the measurement of pollutants in plant material.

Experimental

Plant samples

The dried plant species were purchased from local markets at ELObeid (West central Sudan), EL-Hassaya region (Ed-Damer , North central Sudan), and Um Rawaba (West central Sudan) in the Central Sudan during the Summer and Autumn of 2002. The samples were cleaned and powdered.

Determination of heavy elements content

Powdered plant samples were analyzed for concentration of Ti, Cr, Mn, Fe, Cu, Zn, Pb, Br, Rb, Sr, Zr and Nb by X-Ray Fluorescence (XRF) spectroscopy (Cited by EL-Kamali, 2002).

The plant samples were pressed into pellet from using a 15 ton pressing machine. The diameter of each pellet was about 2.5 cm and the mass about 1 gram. The pellets were presented to the XRF spectrometer system, where each of them was measured for 2000 sec.

The spectra were first analyzed using program called Analysis of X-Ray Spectra by Iterative least square filling (AXIL), which is a FORTRAN program. The AXIL software is able to separate overlapping peaks, and in this way to identify the elements and determine the net area of the peaks.

The net area will be proportional to the concentration of the element in the sample. A plant standard was used to ensure reliability of the results (Hay standard was obtained from the International Atomic Energy Agency (IAEA, Vienna).

Results and discussion

In the present work, heavy element contents (Ti, Cr, Mn, Fe, Cu, Zn, Pb, Br, Rb, Sr, Zr and Nb) of *Cassia senna, Cassia tora* and *Cassia occidentalis* were determined. The results of the elemental composition are shown in the Table 1.

Table 1. Content of heavy elements (ppm) in some Sudanese Medicinal *Cassia* spp.

Plant (Region)/Plant part	Elemental analysis of some *Cassia* species by XRF technique (ppm)											
	Ti	Cr	Mn	Fe	Cu	Zn	Pb	Br	Rb	Sr	Zr	Nb
Cassia senna (Hassaya region)/Fruit pulp	163	39.4	22	215	6.0	77.2	3.0	0.0	17.0	35.0	1.0	0.4
C. senna (Um Rawaba region)/Fruit pulp	262	81.8	36.7	345	15.7	86.7	6.0	19.6	14.8	83.2	6.0	0.8
C. senna (EL- Obeid region)/Fruit pulp	179	38.7	32.6	253	9.9	82.5	5.0	4.8	8.2	30.5	2.5	0.6
C. tora (Um Rawaba)/Seeds	127	41.3	29.8	85.3	10.6	47.6	3.5	1.0	6.5	50.6	1.0	0.5
C. tora (EL- Obeid)/Fermented leaves	229	98	48.6	489	18.3	85.1	6.4	38.4	8.3	189	14.0	0.8
C. occidentalis (Um Rawaba)/Seeds	127	53.4	42.8	83	12.7	65.2	3.6	1.9	5.1	20.2	1.0	0.6
C. occidentals (Um Rawaba)/Roasted seeds	208	54.7	61.2	108	19.1	174	4.7	3.4	6.1	26.8	1.3	1.0

The results obtained for Titanium (Ti) showed enrichment in some of the medicinal plants were analyzed with concentrations reaching values between 127 and 262 ppm highest value obtained by *Cassia senna* (Hassaya region fruit pulp) whereas, the lowest value gained by *Cassia tora* (Um Rawaba seeds) and *Cassia occidentalis* (Um Rawaba seeds). The levels of Chromium Cr in our samples ranged from 38.7 to 98 ppm in the samples of *Cassia senna* (ElObeid region fruit plup) and *Cassia tora* (ElObeid fermented leaves) respectively. Manganese (Mn) concentration level ranged from 22.0 to 61.2 ppm *Cassia senna* (Hassaya region) (fruitplup) had the lowest value whereas, *Cassia occidentalis* (Um Rawaba)(roasted seeds) had the highest value, most of samples being in the range of 32.6 to 48.6 ppm.

The Fe concentrations varied from 83 to 489 ppm for *Cassia occidentalis* (Um Rawaba seeds) and *Cassia tora* (ElObeid fermented leaves), respectively. Four samples have concentrations between 215 and 489 ppm, other three samples gained 83, 85.3 and108 ppm for *Cassia occidentalis* (Um Rawaba seeds) *Cassia tora* (Um Rawaba seeds) and *Cassia occidentalis* (Um Rawaba roasted seeds) respectively. The concentrations of copper were obtained varied from 6.0 to 19.1 ppm in samples of *Cassia senna* (Hassaya region fruit pulp) and *Cassia occidentalis* (Um Rawaba roasted seeds), respectively. The Zn concentrations varied from 47.6 to 174 ppm. *Cassia tora* (Um Rawaba seeds) had the lowest value and *Cassia accidentalis* (Um Rawaba seeds) had the highest value.

The highest level of lead occurred in *Cassia tora*(El-Obeid region, fermented leaves) (6.4 ppm) and the lower gained by *Cassia tora* (Um-Rawaba seeds) (3.5ppm). Bromine (Br) was found in the range of 0 to 38.4 ppm in *Cassia senna* (Hassaya region, fruit pulp) and *Cassia tora* (ElObeid fermented leaves), respectively. Rb concentrations varied from 5.1 to 17.0 ppm highest Rb value obtained by *Cassia senna* (Hassaya region fruit pulp) followed by *Cassia senna* Um Rawaba region fruit plup and the lowest value gained by *Cassia accidentalis* (Um Rawaba seeds). Most samples have concentrations in the range of 5.1 to 8.3 ppm. The highest Sr content in plants was obtained by *Cassia tora* (ElObeid fermented leaves).The Zirconium (Zr) concentrations ranged between 1.0 and 14.0 ppm for *Cassia senna* (Hassaya region fruit pulp) and *Cassia tora* (ElObeid fermented leaves), respectively. Niobium (Nb)element concentrations in some *Cassia spp.* varied between 0.4 and 1.0ppm. highest value obtained by *Cassia occidentalis* (Um Rawaba seeds) followed by *Cassia tora* (ElObeid fermented leaves) and *Cassia senna* Um Rawaba region fruit plup, the lowest value gained by *Cassia senna* (Hassaya region fruit pulp).

According to Perry (1972), Cr, Mg and Zn have important roles in the metabolism of cholesterol as well as heart diseases. The presence of Cr and Mn in plants may be correlated with therapeutic properties against diabetic and cardiovascular diseases (Perry, 1972). The toxic effects of Cr intake is skin rash, nose irritations, bleeds, upset stomach, kidney and liver damage, nasal itch and lungs cancer. Cr deficiency is characterized by disturbance in glucose lipids and protein metabolism (McGrath and Smith, 1990). The daily intake of Cr 0.05-0.20 mg has been recommended for adults by US National Academy of Sciences (Waston, 1993). Deficiency of Mn in human causes myocardial infarction and other cardiovascular diseases, also disorder of bony cartilaginous growth in infants and children and may lead to immunodeficiency disorder and rheumatic arthritis in adults (Barceloux, 1999)

Iron (Fe) is an essential element for human beings and animals as an essential component of hemoglobin. It facilitates the oxidation of carbohydrates, protein and fat to control body weight, which is very important factor in diabetes. Iron can be found chelated with tannic acid and this subsequent chelation may be eliminated faster from the body as compared to non-chelated iron (Delazar, *et al.*, 2003). Nevertheless, the safety of this plant in the traditional medicine should be verified by much further testing, including *in vivo* experiments and clinical studies. Copper (Cu) is a micronutrient and an essential enzymatic element for normal plant growth and development, but it can be toxic at excessive levels and it is a harmful element for human health (Yruela, 2005). Zinc (Zn) is the component of more than 270 enzymes (Zinpro Corporation, 2000), and its deficiency in the organism is accompanied by multisystem dysfunction. Besides, Zn is responsible for sperm manufacture, fetus development and proper function of immune response (Serfor-Armah *et al.,* 2002).

Lead (Pb) is considered very harmful for plants, animals and particularly for microorganism (Khan, *et al,* 2007). It has no physiological role. The highest level of lead occurred in *Cassia tora* (El- Obeid region, fermented leaves) (6.4ppm) and this exceeded the WHO standard of 10 μg/g for lead in raw materials for herbal medicines (WHO, 1998). The level of lead was just below the allowable limit, suggesting that toxicity could arise from long term use of these plants. Rubidium (Rb) is considered as non-essential element for human organism (Underwood, 1971). The strontium (Sr) concentrations varied between 26.8 and 189ppm, but the element is mentioned between the richer and enriched. The highest Sr content in plants was obtained by *Cassia tora* (ElObeid fermented leaves). The levels of the samples studied considered high, which is much high compared with the TDI of 9.1 mg/day for an adult (Watts and Howe, 2010).

Heavy and trace elements are either inherited from soil parent materials or inputs through human activities. Many chemical processes are involved in the transformation of trace elements in soils controlling bioavailability and mobility of trace elements in soils.

Our results suggest that the user of medicinal plants should be warned of the potential danger of heavy metal poisoning because their concentrations are often considered as contaminants. Plants are currently used as bio- indicators to monitor soil pollutions and to follow changes in pollution patterns. In order to perform reliable biomonitoring, the analysis should be accurate. One way to achieve accuracy is to use analytical procedures by comparing different instrumental techniques.

Conclusion

The different concentrations of elements present in the investigated plants leads to the conclusion that these elements will have the different specific roles in the treatment of different diseases. This study provides a comprehensive investigation of the contents of 12 elements in *Cassia* spp. growing in Central Sudan. Cr, Pb and Cu contents were high in

Cassia tora fermented leaves which is an edible medicinal plant compared to the others; however, Zn levels were also extremely high. Moreover, concentrations of most of the elements detected values in plants studied here are highest from the WHO permissible levels and may constitute a health hazard for consumers.

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