African Journal of Biotechnology Vol. 11(76), pp. 14064-14068, 20 September, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB12.757

Full Length Research Paper

Heavy metals and nutritional composition of some selected herbal plants of Soon Valley, Khushab, Punjab, Pakistan

Abdul Ghani[1]*, Sadia Saeed[1], Zulfiqar Ali[1], Iftikhar Ahmad[1], and Muhammad Ishtiaq[3]

[1]Department of Biological Sciences, University of Sargodha, Sargodha, Pakistan.
[2]Department of Botany, Mirpur University of Science and Technology (MUST), Bhimber Campus, (AJK), Pakistan.
[3]Department of Botany Mirpur University of Science and Technology (MUST), Bhimber Campus, (AJK), PAKISTAN.

Accepted 23 July, 2012

Herbal plants and their extracts deserve special attention because of the important influence they have on human health. For the majority of the world population, herbal plants represent the primary source of the health care. According to the World Health Organization (WHO) report, almost 80% of people in marginal communities use only herbal plants for the treatment of various diseases. Although, the effectiveness of the herbal plants is mainly associated with their constituents such as essential oils, vitamins, glycosides and many other products but prolonged intake can cause health problems due to the presence of heavy metals. The human body requires both the metallic and the non-metallic elements within certain permissible limits for growth and good health. Therefore, the determination of element compositions in food and related products is essential for understanding their nutritive importance. The accumulation of some heavy metals in large quantities in the body may have a toxic effect. The concentration levels (mg/L) of selected heavy metals (Fe, Mn, Cu, Zn and Pb) and macronutrients (Na, Ca, Mg, K and P) in eight useful herbal plants of Soon Valley District Khushab were determined by atomic absorption spectrophotometer and colorimeter. The herbal plants having different growing seasons and uses were collected from different locations. The results revealed that the herbal plants accumulate the elements at different concentrations. The maximum concentrations (mg/L) of heavy metals in the analyzed samples were 47.25 ± 0.01, 26.6 ± 0.01, 207.6 ± 0.08, 78.90 ± 0.04 and 0.39 ± 0.01 for Zn, Cu, Fe, Mn and Pb, respectively. The maximum concentrations (mg/L) of macro elements were 728 ± 0.60, 28300 ± 113, 68500 ± 25, 24250 ± 55 and 3700 ± 299 for Na, K, Mg, Ca and P, respectively. The levels of heavy metals determined in the analyzed samples were found below the maximum allowable limit. Hence they were safe for consumption. Fe was accumulated most among the plants analyzed for heavy metals. The analyzed samples were good source of important macro elements.

Keywords: Heavy metals, nutritional composition, medicinal herbs, Soon Valley.

INTRODUCTION

In the last few decades, growing interests in environmental concerns in connection with human and animal health have prompted a renewed focus on trace elements (Korkmaz et al., 2010). For many decades, traditional remedies are being practiced in this area to treat various diseases. A good percentage of the population relies on herbal preparations for some aspect of primary health care. Indigenous plants are used in the treatment of high blood pressure, diarrhea, fever and so on. WHO has listed over 2000 plants that are known to perform one function or the other (WHO, 2002). Plant accumulates a number of mineral elements essential to human nutrition, though it equally accumulates other mineral elements such as Cd, Co and Ag, which are in no direct use to humans but injurious to health (Baker, 1989; Kumar et al., 1985; Mark et al., 2000). Trace elements have been

*Corresponding author. E-mail: ghaniuaf@yahoo.com.

Table 1. Herbal plants, local names, parts assayed and medicinal properties.

Herbal plant	Local name	Parts assayed	Medicinal use
Tribulus terrestris	Bhakra	Leaves	Fever treatment, has antifungal activity
Solanum nigrum	Mako	Stem bark	As an abortive
Datura metel	Datura	Root	Treatment of fever
Mentha longifolia	Podina	Root	Purgative, treatment of intestinal problem, has anthelmintic activity.
Convolvulus arvensis	Valvehri	Leaves	For treating venereal disease and epilepsy.
Chenopodium alba	Bathu	Leaves	Treating conjunctivitis of the eye, has antimicrobial activity.
Peganum harmala	Harmal	Stem bark	Sexual asthenia
Cannabis sativa	Bhang	Leaves	Antimicrobial activity.

reported to have curative and preventive role in medicine (Perma et al., 1994; Brichard, 1999; Ahmed et al., 1994). More recently, medicinal plants are known to perform more important role in agronomy production and pharmacy (Ali, 1993; Rafl, 1987; Kim et al., 1994; Ahmed et al., 1994; Bowen, 1966). Heavy metals are defined as those groups of elements that have specific weights higher than 5 g/cm^3. A number of them (Co, Fe, Mn, Mo, Ni, Zn and Cu) are essential micronutrients and are required for normal growth and take part in redox reac-tions, electron transfers and other important meta-bolic processes in plants.

Metals which are considered non essential (Pb, Cd, Cr, Hg, etc.) are potentially highly toxic to plants (Sebastiani and Scebbaf, 2004; Rama and Prasad, 1998; Rai et al., 2004). Excessive concentrations of trace elements (Cd, Co, Cr, Hg, Mn, Ni, Pb and Zn) are toxic and lead to growth inhibition, decrease in biomass and death of the plant (Zenk, 1996; Korkmaz et al., 2010). Heavy metals inhibit physiological processes such as respiration, photosynthesis, cell elongation, plant-water relationship, N-metabolism and mineral nutrition (Zornozap et al., 2002). The aim of this study therefore, was to investigate and establish the level of some macro and microelements in selected herbal plants with a view of determining their nutritional status and safety.

MATERIALS AND METHODS

A total of eight samples representing eight herbal plants that have different growing season and uses were harvested from different locations of Soon Valley, Khushab District in 2011. The plants were collected from pollution free site. The collected samples were kept in plastic bags until their analysis. The herbal plants, their local and scientific names as well as medicinal properties are listed in Table 1.

Sample treatment

The samples were washed with distilled water and dried in moisture extraction oven for two days at temperature of 60°C. The dried samples were ground and sieved through a 0.5 mm diameter sieve. The powdered samples were kept in sample paper bag and stored in desicator prior to analysis.

Reagents

Concentrated per chloric acid, $HClO_4$, HNO_3, (GFS Chemical, Inc. Colombia) were used for the digestion. They were of analytical grade.

Standards

A stock standard solution of chloride and nitrate salts of zinc (Zn), copper (Cu), Iron (Fe), potassium (K), manganese (Mn), lead (Pb), sodium (Na) and magnesium (Mg) containing100 mg/L of each metal were used by appropriate dilution of the stock solution. A stock solution of phosphorus was also prepared.

Digestions of samples

A wet-ashing micro wave assisted method was employed for the digestion of the herbal plants. The weights of the samples were between 0.40 to 0.50 g. Each sample was weighed into the Teflon PFA vessels and treated with 5 ml (2:1) of 69% w/w HNO_3 and 70% w/w $HClO_4$ (perchloric acid**)**. The vessels were covered with a lid and siever caps. The content of each vessel were arranged and put in the microwave oven for digestion in preselected programme (one stage at 0% for 5 s, two stages at 60 s each at 10 and 0%, one stage at 30% of 300 s and a final stage vented for 300 s). A 25 ml of ultrapure water was added to each of the samples and later trans-ferred to vials. Three sub-samples of each material were digested.

Method of analysis

Atomic Absorption Spectrophotometer with hollow cathode lamp for Zn, Mn, K and Ca; Buck Scientific hollow cathode lamp of Cu, Na, Pb and Fischer Scientific hollow cathode lamp for Fe were used as radiation sources. The elements were measured under the optimum operation conditions. The level of P in the plant samples were de-termined by double beam colorimeter at 630 nm. All measurements were taken in triplicate for the samples and standard solutions.

RESULTS AND DISCUSSION

In all, eight herbal plants were analyzed for their charac-teristic heavy metals and macro elemental constituents.

Table 2. Distribution levels [mg/L ± SD, n = 3)] of heavy metal contents in the analyzed herbal plants.

Herbal plant	Zn	Cu	Fe	Mn	Pb
Tribulus terrestris	34.75 ± 0.20	17.21 ± 0.01	100.20 ± 0.01	35.75 ± 0.0I	0.38 ± 0.02 2
Solanum nigrum	30.85 ± 0.0I	0.13± 0.0I	37.50 ± 0.90	78.90 ± 0.04	0.39 ± 0.03
Datura metel	46.6 ± 0.01	12.09 ± 0.02	83.39 ± 0.05	29.49 ± 0.03	0.26 ± 0.01
Mentha longifolia	3.75 ± 0.03	4.04 ± 0.01	48.30 ± 0.01	15.12 ± 0.03	0.38 ± 0.01
Convolvulus arvensis	38.25 ± 0.01	13.33 ± 0.01	172.0 ± 0.06	75.30 ± 0.06	0.32 ± 0.02
Chenopodium alba	5.05 ± 0.01	6.25 ± 0.02	207.6 ± 0.08	25.10 ± 0.02	0.23 ± 0.02
Peganum harmala	47.25 ± 0.01	15.17 ± 0.01	114.16 ± 0.02	14.30 ± 0.01	0.34 ± 0.01
Cannabis sativa	2.25 ± 0.01	26.6 ± 0.01	135.20 ± 0.12	40.30 ± 0.05	0.30 ± 0.01

Table 1 reveals the medicinal values of the sampled herbal plants as found in literature and local environment where the plants were collected. A look at the data showed that the plants have various therapeutic properties; hence the determination of the level of metal and other macro nutrients accumulation is desirable. The result of the mean concentration (mg/L) of heavy trace metals (Zn, Pb, Cu, Mn and Fe) in the selected plants is shown in Table 2. The determination was carried out by means of atomic absorption spectrum. The data reveal that all analyzed metals were accumulated by the plants species at different concentration. The accumulation of heavy metals in medicinal plants have been reported to depend on climatic factors, plant species, air pollution and other environmental factors (Sovljanski et al., 1989).

The highest mean level of concentration of Zn (47.25 mg/L) was found in *Peganum harmala* while *Cannabis sativa* has the lowest value (2.25 mg/L). The concentration level of Zn in the samples analysed ranged from 2.25 to 47.25. The concentration (mg/L) of Cu in the herbal plants ranged from 0.13 to 26.06 mg/L. The highest and lowest concentrations of Cu were accumulated by *C. sativa* (26.6 mg/L) and *Solanum nigrum* (0.13 mg/L), respectively. As definite permissible tolerant limits of Zn and Cu in foods and agricultural products have not been established by WHO, the limit values published by Bowen (1966), Allaway (1968) and Kim et al. (1994) were used as reference in this work.

Comparing the results obtained with the data of Kim et al. (1994), the result of Zn and Cu concentrations found in the plant species are within the tolerable level. Bowen (1966) and Allaway (1968) published the tolerable range of elements in agricultural products as 4-I5mg/L and I5-200mg/L for Cu and Zn, respectively. The mean concentration of Fe in the analysed herbal plants ranged from 37.50 to 207.6 mg/L. The highest level of Fe concentration (207.6 mg/L) was found in *Chenopodium alba*, while *S. nigrum* had the lowest value (37.50 mg/L). The mean concentration level of Mn ranged from 14.30 to 78.90 mg/L. *S. nigrum* had the highest and *P. harmala* had the lowest mean concentration of Mn, respectively.

Iron forms part of haemoglobin in the blood cell, myoglobin in the blood muscle cells and plays a role in drug detoxification pathways (Perry, 1972). Given the level of Fe in the analysed samples, it is evident that the herbal plants can serve as a source of iron especially in anaemic patients. Mn is found to be natural essential component of co-enzymes and is important for growth and photosynthesis. The concentration of Fe and Mn in the analysed samples fell within the tolerable limit proposed by Kim et al. (1994). The mean concentration of Pb in the herbal plants analysed ranged from 0.23 to 0.39 mg/L.

S. nigrum had the highest mean concentration of Pb, while *C. alba* had the lowest value (0.23 mg/L). The concentrations of Pb in these medicinal plants are generally low. Some types of metals such as Cu, Mn and Zn are natural essential micronutrients, others such as Pb, Cd and Hg have no biochemical or physiological importance and are considered as toxic pollutants. With reference to WHO (1992), the plant species under investtigation accumulated Pb below the WHO (1992) data. Similar data obtained from medicinal plants collected in Saudi Arabia shows the level of Pb in samples collected from non-polluted sites as 0.75 to 2.1 mg/g (Al-Kathiri and AI-Attar, 1997). The levels of Pb obtained in the present study does not indicate a potential health hazard to users. Reports have shown that leafy plant samples contained higher levels of Pb than the fruit and root sample (Nasralla and AIi, 1985). The extent of contamination of Pb depends on the traffic densities and environmental pollution (Nasralla and Ali, 1985; Sovljanski et al., 1990).

From Table 3, it is observed that macro elements were accumulated differently by the plants. The mean concentration of Na ranged from 73.7 to 728 mg/L with the highest value found in *Tribulus terrestis* and the lowest in *C. alba*. The crucial role of Na in conduction of nerve impulses or its deficiency which may result in thirst and muscles weakness cannot be overlooked (Perman et al., 1993).

The concentration of K in the analysed samples ranged from 4373 to 28300 mg/L. *S. nigrum* had the highest concentration of K, while *C. alba* had the lowest value. The concentration of Mg varied from 66.2 to 68500 mg/L.

The highest concentration of Mg was found in *Datura metel*, while *S. nigrum* had the lowest. The mean concentration of Ca varied from 28.519 to 24250 mg/L. *Mentha l*

Table 3. Distribution levels [Mg/l, ± SD, n = 3)] of macro elements in the analyzed medicinal plants.

Herbal plant	Na	K	Mg	Ca	P
Tribulus terrestris	728 ± 0.60	7050 ± 25	2410 ± 42	7400 ± 25	2064.50 ± 22
Solanum nigrum		4373± 1102	66.2 ± 10	3008 ±10	814.20 ± 15
Datura metel		19126.1 ± 9.6	68500 ± 25	2450 ± 40	2950 ± 25
Mentha longifolia	373.1 ± 0.40	8372 ± 16	5672 ± 59	24250 ± 55	102 ± 1.9
Convolvulus arvensis	614.20 ± 0.50	28300 ± 113	3350± 13	2810 ± 10	3400 ± 5
Chenopodium alba	73.7 ± 0.49	7200 ± 29	2650± 60	5510 ± 12	1500 ± 15
Peganum harmala	548 ± 0.03	15200 ± 88	1285± 9.0	13350 ± 20	202 ± 4.8
Cannabis sativa	198 ± 0.65	16300 ± 15	-	28.519 ± 6	3700 ± 299

ongifolia accumulated Ca in the largest proportion, while *C. sativa* had the lowest concentration of Ca. The functions of Ca in the structure and metabolism of bones, blood clotting and muscle contraction is wellknown (Hooker, 1987). The level of phosphorous (P) in the analysed plant species ranged from I02 to 3700 mg/L with the highest mean value found in *C. sativa* and the lowest mean concentration in *M. longifolia*. Phosphorus is a component of enzymes (ATP) cell membrane; it equally participates in plant control.

The result of the present study agrees with earlier study of elemental distribution in medicinal plant species as reported by Kim et al. (1994). The result of the present study shows a high level of macro elements accumulation in the sampled plants except in very few cases where the mean concentration is considerably low. It is important to emphasize that the best benefit to human health depends on obtaining the correct amount of the elements in the right form and at the right time. The medicinal values of some plant species used in homeopathic system has been traced to the presence of Ca, Cr, Cu, Fe, Mg, Ca, K and Zn in plants (Perma et al., 1993). Elements equally contribute to neurochemical transmission, which are food constituents of biological molecules, co-factors of various enzymes and in various metabolic processes (Mayer and Yykhcky, 1989).

Conclusion

The herbal plants used in this work are good sources of important elements and therefore, may have therapeutic properties mentioned in Table 1. Hence, they could serve as supplements of macro and micro elements in the body. The mode of application of these medicinal plants as a source of mineral supplements in the body has been traced to insufficient data on the mineral element accumulation in such plant. The need to screen medicinal plants used in traditional medicine for their elemental composition is highly desirable.

REFERENCES

Ahmed S, Rahman A, Qadiruddin M, Badar Y (1994). Elemental analysis of a herbal drug intella. A neuroenergiser. J. Fac. Pharm. Gazi Univ. Turk. 2(I):83-90.

Ali SL (1993). Assay of pesticide residues and toxic heavy metal traces in plant drugs and their tea infusions. Pharm. Ztg. 132(March 12):633-638.

AI-Kathiri MN, AI-Attar AF (1997). Determination of lead and Cadmium in parsley tissues grown in the Riyadh area. Bull. Environ. Contam. Toxicol. 58(5):726-732.

Baker B (1989). Plants as natural sources of concentrated mineral nutritional supplements. Food chemistry, Michael Blaylock. Elsevier, Science Ltd. p. 81.

Bowen H1M (1966). Trace elements in biochemistry, New York; Academic Press. J. Appl. Biol. 70:52-56.

Brichard SM, Leaderer L (1991). Vernadium as a treatment for diadetes; Encyclopaedia of Inorganic Chemistry, Bruce R, King, John Wiley & Sons, New York. 4:2170.

Hooker JD (1982). The flora of British India (Vol. 111p 64v). Receve and Co.

Kim BY, Kim KS, Lee 1S, Yoo SH (1994). Survey on the natural content of heavy metal In medicinal herbs and their cultivated soils in Korea, RDA 1. Agric. Sci. Soil Fen. 36(2):310-320.

Kumar PAN, Motto H, Raskin I (1995). Rhizofiltration: the use of plants to remove heavy metals from aqueous streams. Environ. Sci. Technol. 29:1239-1245.

Korkmaz K, Kara SM, Ozkutlu F, Gul V (2010). "Monitoring of heavy metals and selected micronutrients in hempseeds from north-western Turkey". Afr. J. Agric. Res. 5(6):463-467.

Mayer MI, Yykhcky L (1989). The action of zinc in synaptic transmission of mouse neuronal excitability in culture of mouse hippocampus. J. physiol. 415:351-365.

MarkPEl, Michael JB, Jianwei WH (2000). Plants as natural source of concentrated mineral nutritional supplements, Food chem. 77:181-188.

Nasralla MM, Ali EA (1985). Lead accumulation in edible portions of crops grown near Egyptian traffic roads. Agric. Ecosyst. Environ. 13(1):73-82.

Perman VS, Gupita AK, Jha HN (1993). Metal contents accumulation in some herbal drug. Pharmaceut. Biol. 39(5):384-387.

Perry HM (1972). Hypertension and true geochemical environment in relation to health and diseases, New York; Academic Press. pp. 1012-1019.

Rafl A (1987). Screening plants for new drugs, Biotechnology and Development monitor, pp. 9, Directorate General Cooperation of Ministry of Foreign affair in Hague and University of Armslerclam (1989). Schilcher H, Peters H, Wank H: Pestizide and Schiwermeralle in Arzeneipflanzenancl Arzneipflanzanzubereitungenparm. Ind. 49:203-211.

Rama DS, Prasad MNV (1998). Copper toxicity in *Ceratophyllum demeresum* L. (Coontail), a free floating macrophyte: Response of antioxidant enzymes and antioxidants. Plant Sci. pp. 138-157,

Rai V, Vaypay EEP, Singh SN, Mehrotra S (2004). Effect of chromium accumulation on photosynthetic pigments, oxidative stress defense system, nitrate reduction, proline level and eugenol content of *Ocimum tenuiflorum* L. Plant Sci.167:1159.

Sovljanski R, Obradovie S, Kisgeci 1, Lazie S, Macko V (1989). The heavy metal contents and quality of hops canoes treated by pesticides during the vegetation. Acta Hortic. 249:81-88.

Sovljanski R, Lazic S Macko, Y Obradovic S (1990). Heavy metal contents in medicinal and spice plants cultivated in Ygoslavia. Herba Hung. 29(3):59-63.

Sebastiani L, Scebbaf T (2004). Heavy metal accumulation and growth responses in poplar clones Eridano (*Populus deltoids* × maximowiczii) and I-214 (P. × euramericana) exposed to industrial waste. Env. Exp. Bot. pp. 52-79.

WHO (2002). Expert committee on specifications for pharmaceutical preparations. WHO Geneva report. 32 (pp 44-82. 75-76).

WHO technical report series, 823 (1992).WHO: WHO monographs on selected medicinal plants. Geneva 2:11-46.

Zenk MH (1996). Heavy metal detoxification in higher plants-a review. Gene pp. 21-179.

Zornozap V, Steban E, Fernandez-PM, Carpena R (2002).Cadmium-stress in nodulated white lupin: strategies to avoid toxicity. Plant Physiol. Biochem. pp. 40-1003.