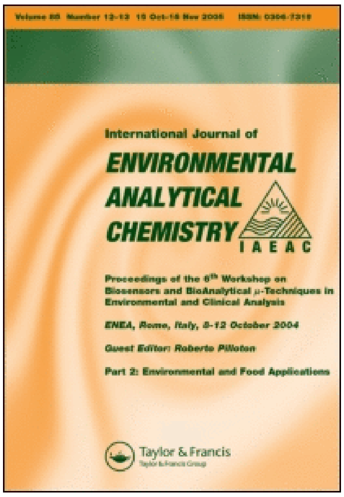

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ELEMENTAL DISTRIBUTION IN MEDICINAL PLANTS COMMONLY USED IN FOLKLORE MEDICINE IN MEXICO

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The concentration of twenty two elements in thirty plants had been determined using instrumental neutron activation analysis. These plants are commonly used, in Mexico, for medicinal purpose to treat different illnesses, conditions or discomfort (e.g., sterility, digestive problems, weakens, anxiety, depression, hair loss, cough, ..etc.). Except for Br, the concentration of the other elements measured are similar to those found in agriculture products of similar use. Eleven elements in all samples investigated showed similar elemental distribution pattern.

Keywords: Trace elements; neutron activation analysis; folklore medicine; medicinal plants; Mexico

INTRODUCTION

While the majority of agriculture products are used for human food and animal feed, others have a unique and specific use due to the pharmacological active constituents in the plant. The use and the legal control of these plants are significantly different, and are depending on the agriculture product itself, the social acceptance, the accessibility to the medical profession and the prevailing standard of living. It is generally known that chewing coca leaves (*Erythroxylon coca*) in South America, for their narcotic alkaloid content (i.e., cocaine), and

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chewing qat in Yemen for its stimulant effect are socially accepted and legal in these regions, where as chewing tobacco (as a source for nicotine) in The United States is not socially appealing and in some locations its sale is being controlled. Nevertheless, boiling or brewing tea leaves (*Camellia sinensis*), coffee beans (*Coffee arabica*) or cacao beans (*Theobroma cacao*) to ingest the stimulant alkaloid (i.e., caffeine) is a worldwide accepted tradition.

Several decades ago, it was these agriculture products that were used to affect the human body functions in order to cure human illnesses or to alleviate pain. Nowadays, this use of "traditional or folklore" medicine is rare in the developed countries, yet it is still practiced everyday in the developing countries. The wide spread use is partially attributed to the unavailability of institutional medicine or the higher cost associated with them. Not to mention the "spiritual" advice that comes with the trade of prescribing these agriculture products.

Although it is known that the isolated pure active constituent from an agriculture product is very effective and specific in its pharmacological action, it is the "other" compounds or elements that are co-present in the plant that may have undesirable side effects. Such effects may depend, among other factors, upon the duration of administering the plant, the nature of the elements and their chemical form, and the accumulation of the elements (or compounds) in certain body organs. It is known that As, Sb, Br, Se, Hg, and Pb are toxic for the human biosystem even at very low levels of intake and there are no known deficiency symptoms for these elements, but Se[1–4].

Recently, there has been an increase interest in determining the concentration of trace and other elements in medicinal plants[5], spices[6,7] and the alike[8] in order to establish a base line for the level of various elements in these plants. In this study, the concentration of 22 elements in 30 plant preparation were reported. These preparations are commercially available in Mexico and are used in folklore medicine. The elements measured were: As, Br, Ce, Co, Cr, Cs, Eu, Fe, Hf, Hg, K, La, Na, Rb, Sb, Sc, Se, Sm, Sr, Th, U, and Zn.

EXPERIMENTAL

Thirty different agriculture products prescribed in curing illness were purchased from a local market in Zacatecas city, Mexico. Each product was individually packaged. A parial or complete list of the following information were indicated on the package: the common name of the plant; the botanical name; the method of administration; and the therapeutic use (e.g., treatment of sterility, digestive problems, weakens, anxiaty, depression, to prevent hair loss, cough, ..etc.) Table I lists the plant common name, the botanical name, recommended preparation method and the therapeutic use.

Except for careful mixing of each lot sample to insure complete homogeneity, no further treatment was performed on the lot samples. From each package a representative analytical sample (0.2–0.4 g) was taken and weighted. Each analytical sample was introduced into a 1.4-ml polyethylene vial and thermally sealed. This primary vial was then sealed into a 7-ml polyethylene vial. The double vial encapsulation procedure was intended to minimize any possible analytical sample contamination. A series of biological reference standard materials were prepared at the same way as the analytical samples. The standards used were purchased form the National Institute of Standards and Technology (NIST) and included Tomato Leaves (SRM-1573), Citrus Leaves (SRM-1572), Pine Needle (SRM-1575) Bovine Liver (SRM-1577A), Coal Fly Ash (SRM-1633) and others. The accuracy of the method was checked by analyzing Quality Control Standard #19 (SPEX, NJ) traceable to NIST. Blank experiments were performed under identical conditions to establish the purity of the polyethylene vials.

Samples, standards and blanks were irradiated for four hours at the Nuclear Engineering Teaching Laboratory at the University of Texas TRIGA Mark II reactor. The reactor operated at a steady state power of 1 MW, and the irradiation period lasted for four hours. The neutron flux used during the irradiation was approximately 2×10^{12} n $cm^{-2}s^{-1}$. After a decay period of 36 hours the activity of the gamma-rays emitting radionuclide was measured to determine As, Br, K, La, Na and Sm. After a second decay period of four weeks the activity was measured again to determine the rest of the elements indicated in this study. Gamma ray emission was measured at a fixed geometry with a HPGe detector (TENNELEC, TN) coupled to a 4096 multichannel pulse-height analyzer. The resolution of the detection system is 1.99 keV full width at half maximum for ^{60}Co 1332 keV gamma-rays with 40% relative efficiency. The nuclear reaction, half life and photon energy used during this study are shown in Table II.

RESULTS AND DISCUSSION

The concentration of the 22 elements measured in the 30 plants investigated in this study is shown in Table III. Based on element concentration (using the less than value as the upper concentration level), the measured elements are divided into three groups:

TABLE I Plant local name, scientific name, form of preparation and uses of 30 different plant species used with medicinal purposes as indicated on the package and in reference 9

ID	*Common Name*	*Botanical Name*	*Part of Plant*	*Preparation*	*Uses*
1	Ruda	Ruta Graveolens	Leaves	Decoction	Abortive and digestive problems
2	Sangre de Drago	Jatropha Dioica	Leaves	Chew	Teeth strength
3	Aceitilla	Bidens Odorata	All plant parts All plant parts	Boiled for vapor Decoction	Hair loss, diuretic and anitdepressant
4	Ajenjo	Aretemisa Absinthium	All plant parts	Decoction	Bilious problems and anorexia
5	Laurel	Litsea Glaucesceus	Leaves	Boiled for vapor	Bronchitis
6	Epazote del zorrillo	Chenopodium Ambrosioides	All plant parts	Decoction	Cough
7	Romero	Rosmarinus Officianalis	Leaves	Attachment	Skin revitalization
8	Gordolobo	Gnaphalium Attenuatum	All plant parts	Decoction	Cough and bronchitis
9	Cedron	Aloysia Triphylla	Leaves	Decoction	Stomach pain
10	Hoja de olivo	Olea Europea	All plant parts	Maceration	Hypertension
11	Hierba de la gallina	Comellina Palida	All plant parts	Decoction	Kidney pain and digestive disorders
12	Diente de leon	Taraxacum Officinale	All plant parts	Decoction	Anemia and liver problems
13	Eucalipto	Eucaliptus Globulus	Leaves Leaves	Boiled for vapor Decoction	Lungs congestion Cold and flu
14	Tabardillo	Piqueria Trinervia	All plant parts	Boiled for vapor Decoction	Fever
15	Arnica de flor amarilla	Grindelia Oxylepis	All plant parts	Decoction	Abortive, menstrual problems and diabetes
16	Cenizo	Coldenia Greggi	Leaves	Decoction	Gastric problems
17	Hierba del golpe	Gaura Coccinea	Leaves All plant parts	Attachment Decoction	Muscle damage Gastritis
18	Escobilla	Apoplanesia Paniculata	All plant parts	Decoction	Stomach problems
19	Estafiate	Ambrosia Artemisaefolia	Leaves	Chew or decoction	Digestive problems
20	Orejuela	Chiococca Alba	Leaves	Decoction	Stomach problems
21	Epazote	Chenopodium Ambrosioides	Leaves	Decoction	Intestinal parasites and abortive
22	Malva	Malva Neglecta	Leaves Leaves	Decoction Attachment	Dysentery & rthritis Burns and wounds
23	Engordacabra	Dalea Seemani	All plant parts	Chew or decoction	Stomach problems
24	Pelos de elote	Zea mays	Plant hairs	Eaten raw Decoction	Bilious and kidney stones. Hepatitis
25	Escobilla	Apoplanesia Paniculata	Leaves	Decoction	Stomach pain

TABLE I (Continued)

ID	*Common Name*	*Botanical Name*	*Part of Plant*	*Preparation*	*Uses*
26	Hierba del negro	Hyptis Verticillata	Plant branches	boiled for vapor	As wash liquid for hair loss
27	Yerbabuena	Mentha Piperita	Leaves	Chew or decoction	Intestinal parasites, digestive problems in newborn babies
28	Oreja de raton	Dichondra Argentea	All plant parts	Decoction	Fever and laxative
29	Guachilillo	Loeselia Mexicana	Leaves	Decoction	Cold and flu
30	Jarilla	Baccharis Glutinosa	Branches	Decoction	Muscle pain and abdominal pain

group I: elements with concentration less than 1 μg/g,
group II: elements with concentration between 1 to 10 μg/g, and

group III: elements with concentration higher than 10 μg/g.

It can be seen from Figure 1 that 11 elements belong to a single group (Eu, Hf,

TABLE II Nuclear reaction, half life and gamma-ray energy measured for the determined elements

Element	*Nuclear Reaction*	*Half life*	*γ-ray measured (ke V)*
As	$^{75}As(n,\gamma)^{76}As$	2.64E+01 h	559.1
Br	$^{81}Br(n,\gamma)^{82}Br$	3.53E+01 h	776.5
Ce	$^{140}Ce(n,\gamma)^{141}Ce$	3.25E+01 d	145.5
Co	$^{59}Co(n,\gamma)^{60}Co$	5.26E+00 y	1332.5
Cr	$^{50}Cr(n,\gamma)^{51}Cr$	2.78E+01 d	320.1
Cs	$^{133}Cs(n,\gamma)^{134}Cs$	2.05E+00 y	797.0
Eu	$^{151}Eu(n,\gamma)^{152}Eu$	1.27E+01 y	1408.1
Fe	$^{58}Fe(n,\gamma)^{59}Fe$	4.56E+01 d	1099.3
Hf	$^{180}Hf(n,\gamma)^{181}Hf$	4.25E+01 d	482.2
Hg	$^{202}Hg(n,\gamma)^{203}Hg$	4.69E+01 d	279.2
K	$^{41}K(n,\gamma)^{42}K$	1.24E+01 h	1524.7
La	$^{139}La(n,\gamma)^{140}La$	4.02E+01 h	1596.6
Na	$^{23}Na(n,\gamma)^{24}Na$	1.50E+01 h	1368.4
Rb	$^{85}Rb(n,\gamma)^{86}Rb$	1.87E+01 d	1078.8
Sb	$^{123}Sb(n,\gamma)^{124}Sb$	6.03E+01 d	1691.1
Sc	$^{45}Sc(n,\gamma)^{46}Sb$	8.39E+01 d	889.3
Se	$^{74}Se(n,\gamma)^{75}Se$	1.20E+02 d	264.6
Sm	$^{152}Sm(n,\gamma)^{153}Sm$	4.68E+01 h	103.2
Sr	$^{84}Sr(n,\gamma)^{85}Sr$	6.40E+01 d	514.0
Th	$^{232}Th(n,\gamma)^{233}Th \longrightarrow {}^{233}Pa$	2.70E+01 d	311.9
U	$^{235}U(n,f)^{140}Ba \longrightarrow {}^{140}La$	4.02E+01 h	1596.6
Zn	$^{64}Zn(n,\gamma)^{65}Zn$	2.43E+02 d	1115.5

TABLE III Concentration, in μg/g, of 22 elements measured in 30 plants investigated

	Sample ID														
Ele.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
As	<0.16	<0.68	1.22	<0.34	<0.09	<0.11	0.72	0.67	0.81	0.31	1.90	1.70	<0.28	0.45	<0.17
Br	67.5	65.0	113	126	11.5	423	58.3	322	51.8	55.6	274	109	90.9	172	280
Ce	0.57	2.07	3.45	0.57	0.40	<0.46	1.79	0.96	1.19	<0.25	4.22	3.45	0.41	<0.37	<0.34
Co	0.13	0.96	1.28	0.51	0.10	0.32	0.63	0.34	0.37	0.13	1.94	1.50	0.15	0.59	0.24
Cr	1.06	5.70	8.04	2.17	<0.60	<0.74	5.98	1.54	3.61	1.11	21.32	12.53	1.04	2.92	2.50
Cs	0.07	0.49	0.68	0.14	0.05	0.15	0.48	0.19	0.22	0.09	1.14	0.94	0.07	1.84	0.11
Eu	<0.01	0.05	0.08	<0.03	<0.01	<0.01	<0.05	<0.01	<0.04	<0.01	0.13	0.08	<0.01	0.06	<0.01
Fe	28	2720	2560	541	115	353	1630	564	1030	268	4610	3330	289	1130	504
Hf	<0.02	0.39	0.32	<0.06	<0.02	<0.03	0.25	0.12	0.16	<0.03	0.90	0.37	<0.02	<0.06	<0.07
Hg	<0.03	<0.02	<0.03	<0.03	<0.08	<0.04	<0.04	<0.04	<0.06	<0.02	<0.04	<0.02	<0.01	<0.01	<0.01
K	25800	15800	26800	21600	11000	11900	10800	12400	25000	8740	44300	46000	4150	6600	21200
La	<0.15	1.16	1.74	<0.22	0.64	0.26	0.73	0.49	0.62	<0.15	2.13	1.44	<0.08	0.43	0.31
Na	675	619	399	119	64.2	56.8	2850	109	436	33.6	1430	3060	2230	327	113
Rb	4.74	7.62	8.67	3.43	10.8	7.77	<4.6	6.76	5.73	<1.1	14.1	23.2	<0.62	14.0	13.6
Sb	<0.07	0.31	0.32	0.14	<0.04	<0.15	0.32	<0.11	<0.18	<0.06	0.73	0.75	<0.08	<0.07	0.15
Sc	0.07	0.71	1.02	0.19	0.02	0.11	0.65	0.20	0.36	0.08	1.79	1.24	0.09	0.53	0.19
Se	<0.09	<0.25	<0.31	<0.05	<0.12	<0.11	<0.21	<0.46	<0.12	<0.14	<0.34	<0.10	<0.02	<0.23	<0.04
Sm	<0.05	0.23	<0.32	0.06	0.04	<0.03	0.09	0.10	0.13	<0.03	0.43	0.31	<0.04	0.12	<0.05
Sr	77.5	<33	<63	48.0	73.4	<17	<52	105	99.0	115	101	<49	36.4	<23	<18
Th	<0.01	0.32	0.49	0.07	<0.01	<0.05	0.24	0.13	0.19	<0.02	0.56	0.49	<0.02	<0.08	0.08
U	<0.20	<0.44	<0.63	<0.50	<0.26	<0.36	<0.33	<0.28	<0.83	<0.46	<0.72	<0.52	<0.10	<0.53	<0.55
Zn	35.5	23.7	36.0	34.6	28.8	32.7	25.5	28.6	38.1	22.8	97.4	83.1	13.6	27.3	43.9

TABLE III (Continued)

Ele.	Sample ID 16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
As	0.32	<0.40	1.06	<0.2	0.54	1.14	<0.15	<0.11	<0.04	<0.09	0.90	<0.49	<0.34	1.35	<0.36
Br	80.1	705	186	270	106	139	181	8.64	72.1	132	177	776	555	53.9	174
Ce	<0.11	0.77	1.43	<0.27	<0.76	2.85	<0.19	<0.10	<0.14	<0.15	0.73	<0.33	<0.55	1.99	<0.53
Co	0.52	0.41	0.47	0.21	0.80	0.73	0.18	0.20	<0.01	0.14	0.52	0.80	0.35	1.02	0.15
Cr	1.71	1.95	4.20	<0.59	4.84	6.46	0.73	<0.59	<0.21	<0.47	4.61	1.70	2.58	6.82	<0.21
Cs	0.07	0.29	0.37	0.08	1.15	0.31	0.06	0.07	<0.01	0.38	0.19	1.43	0.53	0.53	0.08
Eu	<0.01	0.04	<0.04	<0.01	0.05	0.06	<0.01	<0.01	<0.01	<0.01	<0.02	0.03	<0.02	0.06	<0.01
Fe	390	808	1280	241	1420	1930	196	271	19.3	118	1220	477	672	1960	120
Hf	<0.06	0.12	0.19	<0.02	<0.09	0.29	<0.02	<0.03	<0.01	<0.03	0.13	0.15	0.12	<0.16	<0.01
Hg	<0.02	<0.02	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.01	<0.03	<0.04	<0.02
K	25600	12100	9190	16600	10700	40100	28100	15000	8200	15700	11500	25900	14800	12500	30700
La	<0.10	0.56	0.60	0.24	0.32	0.98	<0.25	<0.17	<0.07	<0.16	0.06	0.32	0.34	1.48	<0.09
Na	73.1	144	255	64.3	358	342	597	67.9	34.0	34.3	211	106	125	280	71.3
Rb	5.22	25.6	8.18	10.1	17.1	13.3	<2.1	4.72	4.60	14.9	<3.5	30.1	16.2	<5.6	<2.2
Sb	<0.05	<0.11	<0.23	<0.04	<0.12	<0.26	<0.05	<0.06	<0.02	<0.04	0.90	0.32	<0.11	<0.15	<0.07
Sc	0.14	0.35	0.58	0.10	0.66	0.88	0.06	0.08	0.01	0.04	0.51	0.16	0.29	0.89	0.03
Se	<0.20	<0.59	<0.22	<0.03	<0.31	<0.39	<0.24	<0.24	<0.08	<0.08	<0.26	<0.22	<0.13	<0.35	<0.19
Sm	<0.03	0.09	0.15	<0.02	0.13	0.21	<0.03	<0.03	<0.01	<0.01	0.12	<0.05	<0.05	0.23	<0.03
Sr	<16	70.8	<34	<15	<32	<36	<15	<18	<6.6	<15	<27	52.7	<24	<33	<19
Th	<0.03	0.17	0.28	<0.04	<0.10	0.22	<0.03	<0.01	<0.01	<0.02	0.09	<0.05	<0.07	0.26	<0.02
U	<0.07	<0.73	<0.88	<0.38	<0.74	<1.0	<0.46	<0.79	<0.28	<0.58	<0.71	<1.1	<0.77	<0.73	<0.72
Zn	31.6	33.9	37.6	27.5	35.9	58.7	35.3	22.2	15.1	28.7	30.9	31.7	25.6	33.1	47.8

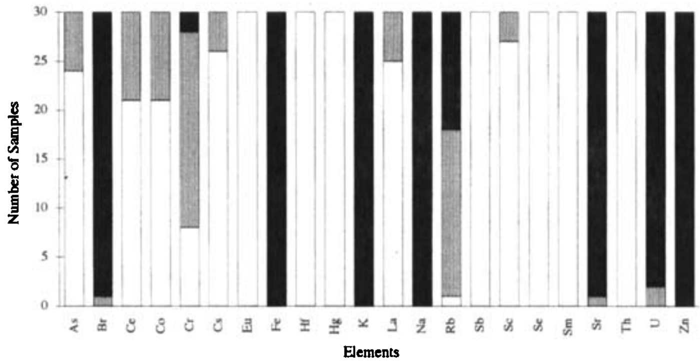

FIGURE 1 Concentration range for the 22 elements measured in the 30 plants studied. □ < μg/g, ▩ 1-10 μg/g and ■ > 10 μg/g.

Hg, Sb, Se, Sm and Th in group I; whereas K, Na, Fe, and Zn belong to the group III). Nine elements (As, Br, Ce, Co, Cs, La, Sc, Sr and U) belong to two groups. Only Cr and Rb are found in the three groups. That is to say 50% of the elements measured in the 30 sample investigated show similar elemental concentration pattern.

Because not only different plants have different elemental profile, but also different parts of the same plant have different elemental distribution, and because of the countless sources that may effect the concentration of various elements (soil, fertilizer, pesticides, water of irrigation, and other factors as transportation, processing, storage, packing,...etc.), identifying the source of each element will be impossible. However upon comparing our results to those reported in the literature (Table IV) for similar products, an assessment on the possible toxicity by these agriculture products can be addressed. Thus the concentration of As, Br, Hg, Se, Sb and Th will be discussed and compared to literature values.

The safe limit of As in food is 0.05 μg/g[10]. Higher uptake of As will induce myocardial necrosis[11]. Except for sample 24, all plants analyzed in this study contain higher values of As than those values considered as safe. None of the plants show concentration levels larger than 2 μg/g. There is no assurance that all the As content in the plant is extracted in the drinkable portion by brewing or boiling process. Nevertheless, a more detailed study of element transfer efficiency during medicinal plant preparation should be carried out. Another study on agriculture products of similar use showed the presence of As at a range of 0.05–0.86 μg/g[6]. The concentration of As in ginger (*Zingiber officinale*) and in coriander (*Coriandrum sativum*) was reported as 12 and 110 μg/g, respectively[7].

TABLE IV Comparison of trace element concentration (μg/g) in agriculture products used in Mexican folklore medicine with other agriculture products of similar use

Element	*Range This study*	*Eucalyptus Leaves*[a]	*Cumin Seeds*[b]	*Caraway Seeds*[c]	*Cinnamon Bark*[b]	*Tea Leaves*[c]
As	<0.04–1.9	–	0.86	0.42	0.13	0.7–1.4
Br	8.64–776	–	4.9	9.5	0.5	4.4–10.2
Ce	<0.11–4.22	–	–	–	–	–
Co	<0.01–1.94	–	0.031	0.042	0.305	0.066–0.49
Cr	0.21–21.32	1.7–12	5.9	1.6	0.4	0.02–0.08
Cs	<0.01–1.84	0.024–0.16	0.117	0.260	0.250	0.024–0.27
Eu	<0.01–0.13	0.0086–0.084	0.035	0.050	0.020	0.047–0.095
Fe	19.3–4610	150–1440	825	1058	67	92.6–431
Hf	<0.01–0.90	–	0.55	0.28	0.1	–
Hg	<0.01–0.08	–	0.028	0.049	0.010	0.004–0.032
K	4150–46000	–	21500	30700	4100	11800–32200
La	<0.08–2.13	–	–	–	–	0.28–1.69
Na	34.3–3060	–	4246	492	67	27–452.4
Rb	<1.1–30.1	0.69–4.0	13.0	7.6	26.0	22–108
Sb	<0.02–0.90	0.17–2.3	0.056	0.009	0.025	0.03–0.34
Sc	0.01–1.79	0.033–0.25	0.260	0.390	0.030	0.017–0.09
Se	0.02–0.59	–	0.85	0.17	0.12	0.013–0.030
Sm	<0.32	–	–	–	–	–
Sr	<6.6–115	17–160	–	–	–	–
Th	<0.01–0.56	0.024–0.26	–	–	–	–
U	<1.1	–	–	–	–	–
Zn	15.1–97.4	27–190	41.5	23.8	9.7	22.98–68

[a]Adapted from reference 5
[b]Adapted from reference 6
[c]Adapted from reference 8

Ahmad et al[8]. reported on the concentration of As in three different brands of tea leaves, commercially available in Pakistan, to contain as much as 0.7 μg As per g.

Bromine intake in higher amounts is toxic and may damage heart tissues. According to World Health Organization the maximum permissible amount of Br intake is 1 mg/day[12]. In this study we found that Mexican plants have Br content in the range of 8.84 to 776 μg/g with average value of 192 μg/g. Such Br concentration is higher than that reported in tea leaves (Br concentration ranges from 5.18 to 6.58 μg/g[8]).

Mercury was found in concentration less than 0.08 μ/g. All plants, except sample #5 and #9 present a concentration levels less than the concentration assumed as safe (0.05 μ/g) in food[10]. Mercury is known to be toxic in very low quantities[13]. Prolonged exposure to low levels of Hg produces symptoms of nervous disorder and myocardial necrosis, whereas large doses may damage the liver, kidney and brain tissues[14]. Hg concentration in tea leaves was reported as high as 0.032 μg/g[8]. Caraway seeds, used for gastric discomfort, were found to contain up to 0.049 μg/g Hg[6]. The average concentration of Hg in the plants under investigation is 0.024 μg/g. Due to the volatility of some of the mercury compounds, one can assume that complete transfer of Hg to the drinkable product is unlikely as portion of the element will be lost during the preparation process.

Selenium nutritional requirements is in the range of 0.1 to 0.3 mg per kg of body weight[10], whereas higher intake produces toxicity symptoms. Lassitude, dermatitis and gastrointestinal disorder are observed when Se intake ranges from 2 to 10 mg/kg body weight[10]. Investigated Mexican plants showed concentration levels less than 1 μg/g. Tea leaves showed Se concentration levels up to 0.03 μg/g[8]. Cumin seeds, used as carminative, were reported to contain 0.26 μg/g, and caraway seeds were reported to contain 0.39 μg/g[6].

Antimony is also a toxic element[8,15] and Mexican plants shows concentration levels less ranges from <0.02 to 0.90 μg/g, meanwhile Sb concentration in tea leaves was reported in the range of 0.047 to 0.34 μg/g[8]. It is worth mentioning that Sb content in tumeric, garlic was reported as 0.13 and 0.11 μg/g, respectively[7]. Eucalyptus leaves (*Eucalyptus camaldulensis Dehnh*) that used as a vermifuge was reported to contain up to 2.3 μg/g Sb[5].

The highest concentration of Th observed in the investigated plants is 0.56 μg/g, which is about twice that it was reported for the eucalyptus leaves (0.26 μg/g)[5], however eucalyptus leaves was reported to contain approximately twice as much Zn.

CONCLUSION

In comparison with the element content presented in other studies, it can be concluded that the concentration of the measured elements, with the exception of Br, in the Mexican plants used with medicinal purposes are in line with those reported for other agriculture products with similar use. It is also important to point out that the concentration of various elements in the agriculture products do vary with seasonal changes, geographical factors, soil composition, fertilizer utilization, contamination with dust, and distance from a near by pollution sources (e.g., metal smelter).

It is also of considerable importance to indicate that the uptake of any or all of the elements measured in this study will depend on the method of administration of these medicinal plant (brewing, boiling, chewing,...etc.). For example, it has been reported that only 19% of Hg is extracted by brewing compared to 34% by boiling[8]. Thus, a future study is planned to determine the trace and other element concentration in the residue left after brewing or boiling the prescribed plant and to calculate the amount of the element that will be ingested.

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