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Full Length Research Paper

Determination of heavy metal concentration of different traditional medicine formulations available at the East Coast Region of Malaysia

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Traditional medicines (TM) of herbal origin have been increasingly getting popular in the last few decades. In Malaysia, a significant number of people consume locally available traditional medicine for their health care needs. Due to the wide use of herbal medicines, regulatory authorities express concern about the safety of using these products. Heavy metal content of the medicinal formulation is one of them. Exposure to heavy metals may cause many adverse health effects. This study was designed to determine the toxic heavy metals content in locally available traditional medicine in the East Coast Region of Malaysia. Twenty five samples of TM were collected from different places to identify the concentration of five heavy metals namely Zn, Fe, Pb, Cd and Ni. The determination of Zn and Fe were conducted using Flame Atomic Absorption Spectroscopy (FAAS), while Pb, Cd and Ni analysis were conducted using Graphite Furnace Atomic Absorption Spectroscopy (GFAAS). Most of the samples show the presences of those heavy metals with different concentration namely Cd (0.1 to 1.23 ppm), Pb (1.51 to 19.35 ppm), Ni (2.47 to 14.94 ppm), Zn (13.2 to 125 ppm) and Fe (109.4 to 1484.7 ppm).

Key words: Traditional medicines, heavy metals, atomic absorption spectroscopy.

INTRODUCTION

Traditional medicine refers to knowledge theory and practice based on the beliefs and experience indigenous to different culture and society. Herbal medicine is the most ancient form of medicinal therapy among other mode of therapies in traditional medicine. More than 4000 years ago, ancient civilization performed medical treatments that consisted of herbal remedies to cure various ailments (Saganuwan, 2010). For the last few decades there was a vast growth globally, in traditional medicine consumption probably due to the affordability and availability of such products (Abas, 2001). Beside the general perception that herbal remedies are more likely to be safer and it can help to avoid unnecessary contact with conventional western medicine, it apparently have more side effects due to synthetic origin (Rai and Mehrotra, 2005). According to World Health Organization (WHO) estimation, more than 70% of the world population relies on traditional healing modalities (Inamdar et al., 2008). This trend is parallel, growing in both developing and developed countries (Ernst and White, 2000). Asians are well known for their rich heritage and high dependency on traditional medicine. Unfortunately, the majority of TM consumers have a very limited knowledge about the safety and efficacy of such products. Some herbs might contain a potentially toxic amount of heavy metals (Saeed et al., 2010; Kiran et al., 2011), which mainly comes from the ingredient itself or during the processing (Chan, 2003). Thus, improper usage may cause toxicity.

The number of reported health complication cases

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Table 1. Working condition for FAAS for determining Fe and Zn.

Metal	Wavelength (nm)	Slit (nm)	Flame
Fe	248.3	0.2	Air-acetylene
Zn	213.9	0.7	Air-acetylene

which are directly associated with consumption of TM has been increasing. There may be various reasons for such problems, mainly the insufficient attention being paid to the quality control of these products (Nortier et al., 2000). Although WHO has developed guidelines for the quality control of herbal medicine, the producers of such products do not have enough knowledge which results in products with various types of contamination like heavy metals and pesticide residues (Musa and Hamza, 2009).

Some heavy metals are essential for the human body at trace amounts however it can be dangerous and even toxic if present in a higher concentration (David and Fred, 1999). They have capability to bioaccumulate thus initiating disruption of the functions of vital organs and glands in the human body such as brain, kidney and liver (Suranjana and Manas, 2009).

In Malaysia, a significant number of people consume locally produced TM for their health care needs. Such reality would impose a serious responsibility on the government and academic sector to evaluate TM which is consumed on a daily basis by a wide range of people. The prime focus of our study is to determine the amount of toxic heavy metals in locally available traditional medicines, both registered and unregistered products in the East Coast region of Malaysia in order to evaluate the safety of these products.

METHODOLOGY

In this study, we analyzed twenty five samples of TM for the content of cadmium (Cd), lead (Pb), nickel (Ni), zinc (Zn) and iron (Fe) using atomic absorptions spectrometer (AAS). All samples were collected from various places in the East Coast Region of Malaysia such as shops, open markets, night market and weekend markets. Most of them are not registered with the Malaysian Drug Control Authority (DCA). Majority of the samples were from herbal origin in a different dosage forms. Out of twenty five, fourteen of them were in capsule form, five of them were in a round pill shape and two samples in tablet form and the rest were in the powder form.

Chemical and reagents

All chemicals and reagents used in this study were of analytical grade: Hydrochloric acid 37% (1.33, Merck); Nitric acid 65% (1.40, Merck). Standard solutions for each metal and matrix modifier were obtained from Perkin Elmer.

Treatment of glass wares

All glass ware were soaked in 5% nitric acid for 2 h and then washed with de-ionized water prior to use.

Standard preparation

Working standards were prepared by serial volume/volume (v/v) dilution of the stock standard solution (1000 ppm). Freshly prepared standards were used for the calibration purposes. Matrix modifier to stabilize the analyte or to make the matrix more volatile, for both Pb and Cd was added to the standards and samples prior to each injection. Calibration line for all the metal showed good linearity and the R^2 values were above 0.990.

Sample preparation

Samples were digested using a mixture of two concentrated mineral acids, (Nitric acid 65%, Hydrochloric acid 37%; Trace metal grade) in a ratio of (1:3). 0.5 g of each sample was weighed and placed in 100 ml PTFE beaker after which 9 ml of freshly prepared acid mixture was added. Then the mixture was boiled gently over a water bath (95℃) for 4 to 5 h (or until the sample had completely dissolved). Then it was allowed to cool at room temperature. Later, it was filtered with Whatman 42 filter paper, and sufficient amount of de-ionized water was added to make the final volume up to 50 ml (Ang and Lee, 2005). Appropriate dilution of the final volume of the sample was made to assure the measured concentration was within the calibration range.

Instrumentation

Metal concentrations in the samples were determined using Perkin Elmer Atomic Absorption Spectrometer (AAS 800), equipped with a hollow cathode lamp (HCL) or electrode less discharge lamp (EDL). EDL provides much higher light output and longer life time compared to the conventional HCL at specific wavelength for each metal.

Two different atomization techniques of AAS were used to conduct the analysis of the listed elements; both (Zn) and (Fe) were analyzed using Flame Atomic Absorption Spectrometer (FAAS), working condition of the spectrometer is given in Table 1. Graphite Furnace Atomic Absorption Spectroscopy (GFAAS) with Transverse Heated Graphite Atomizer (THGA), that provides uniform temperature distribution across the entire length of the graphite tube, were used to overcome the potential chemical interference effects, also the instrument offers an auto sampler system and provides an accurate background correction (Zeeman correction). This technique was used to perform the analysis of the trace amount of cadmium (Cd), lead (Pb) and nickel (Ni); working condition for the instrument is given in Table 2.

RESULTS AND DISCUSSION

In this study, samples were collected from various places such as shops, open markets, night markets and weekend markets. Most of them are not registered with the Malaysian drug authority. We analyzed twenty five samples of TM for the content of zinc (Zn), iron (Fe), cadmium (Cd), lead (Pb) and nickel (Ni). The analysis was performed using atomic absorption spectroscopy (AAS). Limit of quantification (LOQ) was measured for each element Cd (1 ppb), Pb (11.7 ppb), Ni (20.1 ppb), Zn (0.1 ppm) and Fe (0.9 ppm). Majority of the samples

Table 2. Working condition for GFAAS for determining toxic heavy metals.

Metal	Wavelength (nm)	Slit (nm)	Lamp	Atomization temperature (℃)
Cd	228.8	0.7	HCL	1400
Pb	283.3	0.7	EDL	1500
Ni	232.2	0.2	HCL	2300

Table 3. The mean concentration of heavy metals in twenty five TM samples.

Sample ID	Cd ± SD (ppm)	Pb ± SD (ppm)	Ni ± SD (ppm)	Zn ± SD (ppm)	Fe ± SD (ppm)
TM-1	0.56 ± 0.01	2.91 ± 0.02	8.62 ± 0.01	40 ± 0.1	252.6 ± 0.1
TM-2	0.19 ± 0.01	6.94 ± 0.04	2.48 ± 0.05	52 ± 0.9	302.7 ± 1
TM-3	0.30 ± 0.07	8.42 ± 0.04	7.87 ± 0.03	21.3 ± 0.2	115.8 ± 0.9
TM-5	0.61 ± 0.07	14.7 ± 0.12	8.32 ± 0.30	77 ± 1.2	ND
TM-6	0.56 ± 0.03	14.1 ± 0.02	7.46 ± 0.23	44 ± 0.6	182.6 ± 6.1
TM-8	0.23 ± 0.004	2.01 ± 0.04	2.76 ± 0.03	44.6 ± 0.2	321.6 ± 5.9
TM-9	0.17 ± 0.002	2.57 ± 0.001	4.27 ± 0.01	34.4 ± 0.20	194.9 ± 2.4
TM-11	ND	19.3 ± 0.09	2.47 ± 0.06	18.4 ± 0.1	418.5 ± 2.3
TM -13	0.43 ± 0.001	4.96 ± 0.08	2.78 ± 0.12	36.8 ± 0.5	784.7 ± 3.2
TM -14	1.23 ± 0.02	10.4 ± 0.19	11.8 ± 0.33	123.2 ± 0.7	109.4 ± 0.7
TM -16	0.17 ± 0.01	3.66 ± 0.01	5.84 ± 0.04	37.4 ± 0.3	157.4 ± 1.1
TM -17	0.19 ± 0.0003	5.09 ± 0.09	2.47 ± 0.01	32.9 ± 0.1	139.5 ± 1.5
TM -18	ND	1.92 ± 0.01	3.07 ± 0.02	26.8 ± 0.3	430.2 ± 0.8
TM-19	0.45 ± 0.09	7.704 ± 0.10	4.06 ± 0.08	46.5 ± 0.3	162.5 ± 1.3
TM -35	0.10 ± 0.05	10.35 ± 0.17	5.39 ± 0.05	41.6 ± 0.9	285.8 ± 0.4
TM-36	0.40 ± 0.01	9.85 ± 0.05	4.02 ± 0.03	27 ± 0.2	179.8 ± 0.9
TM -37	0.10 ± 0.02	10.14 ± 0.08	14.94 ± 0.1	35.3 ± 0.4	369.2 ± 11
TM -38	ND	1.51 ± 0.02	2.01 ± 0.16	17.4 ± 0.3	1319 ± 28.7
TM -39	0.12 ± 0.02	4.567 ± 0.14	36.20 ± 0.23	15.9 ± 0.1	713.3 ± 4.3
TM -40	ND	1.88 ± 0.04	7.21 ± 0.35	13.2 ± 0.1	315.3 ± 5.5
TM-41	0.20 ± 0.001	ND	4.00 ± 0.38	34.7 ± 0.4	1286.4 ± 16.5
TM -43	0.49 ± 0.09	3.15 ± 0.03	6.86 ± 0.28	38.3 ± 0.4	1484.7 ± 32.7
TM -45	0.18 ± 0.001	4.05 ± 0.04	5.9 ± 0.27	19.4 ± 0.2	521.5 ± 0.6
TM -46	0.37 ± 0.02	5.57 ± 0.06	8.37 ± 0.01	27.5 ± 0.2	643.1 ± 5.5
TM -52	0.70 ± 0.03	4.90 ± 0.01	4.8 ± 0.02	125 ± 1.8	447.2 ± 3

Capsule [1, 2, 8, 9, 16, 17, 18, 19, 35, 36, 37, 38, 40, 52]: Round pill [11, 13, 41, 45, 46]: Tablets [39, 43]: Powder [3, 5, 6, 14]. ND: Below LOQ. All the results are reported with standard deviation (SD) of three replicate.

show the presences of heavy metals, either of the remaining were less than the LOQ.

Cadmium

Both acute and chronic exposure to cadmium has a negative impact for human health. Acute oral ingestion results in severe gastroenteritis while chronic exposure primarily affects the bones, kidneys and possibly the lungs. Cadmium is a cumulative toxin. Its levels in the body increase over time due to its slow elimination. It accumulates in muscle, bone and more in the liver and kidneys. In certain cases such as iron deficiency cadmium absorption increases thus, women with lower iron status are believed to be at risk for greater absorption of cadmium after oral exposure (Olsson et al., 2002).

Based on the Malaysian regulatory limit for heavy metals in herbal medicine, the maximum limit for Cd is 0.3 ppm (National Pharmaceutical Control Bureau, NPCB). Out of twenty five traditional medicine samples, twenty one of them have shown the presence of Cd at a concentration range of 0.10 to 1.232 ppm, and eleven samples exceeded the permissible limit, the remaining four samples were below the LOQ, as listed in Table 3.

Lead

Lead is one of the major heavy metals, it has been known for its adverse effects on different body organs. Long exposure to Pb results in a decrease in the performance of the nervous system and lowers renal clearance (Salawu et al., 2009; Gamil et al., 2009). According to the international Agency for Research on cancer (IARC), inorganic lead is carcinogenic to human. The results for the twenty five tested samples show that twenty four of them contain lead in a concentration range of 1.51 to 19.3 ppm and only one sample was below the LOQ. Six samples were over the permissible limit of 10 ppm implemented by the National Pharmaceutical Control Bureau (NPCB) of Malaysia.

Nickel

Nickel is the most observed cause of immediate hypersensitivity (Chodak and Blaszczyk, 2008). The most common adverse health effect of nickel in humans is its ability to act as an immunotoxic agent in humans (Das et al., 2008). Oral exposure to large doses of nickel mainly targets the cardiovascular system, immune system and might cause liver and kidney damage. While inhaling exposure affects the lung and upper respiratory tract (Kusal, 2009). All samples contained Ni in a range of 2.01 to 14.94 ppm which is higher than the LOQ value.

Zinc

Zinc is an essential micronutrient that can be found in all tissues of the body and it plays vital roles for cell growth and other physiological activities (Edebi and Gideon, 2011). High doses of zinc for long periods of time may results in a variety of chronic effects on the hematological and respiratory systems along with alterations in the cardiovascular and neurological systems of humans (Jerome, 2011). All samples show availability of Zn in concentrations range from 13.2 to 125 ppm.

Iron

Although iron (Fe) is a very important element in human body especially in the formation of hemoglobin, oxygen and electron transfer in the body, excess of iron in a concentration level may cause a negative impact on human health.

The ingestion of large quantities of iron salts may lead to severe necrotizing gastritis with vomiting, hemorrhage and diarrhea (Edebi and Gideon, 2011). The estimated concentration of iron for twenty four samples was 109.4 to 1484.7 ppm. One sample was below the measured value of LOQ.

Conclusion

From the results we observed that the traditional medicines available in local markets in the East Coast Region of Malaysia contain a certain level of Cd, Pb, Ni, Zn and Fe. Some of them exceeded the permissible limit implemented by the NPCB. Eleven samples were found containing higher cadmium concentration than the permissible limit and six of them had higher lead concentration than the permissible limit. Regarding nickel zinc and iron there is no declared permissible limit from the NPCB so far. Based on the findings, we can conclude that products containing higher concentration of heavy metals may cause adverse health effects if consumed more than the permissible amount.

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