IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319-1775 Online 2320-7876

 UGC CARE Listed (Group -I) Journal Volume 12, Iss 1, January 2023

Quantitative Assessment of Essential and Trace Elements in the Traditional Medicinal Plant Gentiana Chirayita using ICP-MS

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Abstract

The method of inductively coupled plasma mass spectrometry (ICP-MS) was used to measure the amounts of micro and macro elements in the medicinal herb Gentiana Chirayita, which is commonly used in traditional medicine. The analysis indicates that these plant extracts include a total of twenty elements, namely Li, Al, Be, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Ag, Cs, Ba, and Tl. The elements content is quantified in units of parts per million (ppm). ICP-MS, or inductively coupled plasma mass spectrometry, is a technique that can be used to analyze and monitor the nutritional content of medicinal plants and their daily usage. New guidelines for delivering dosages of herbal medication were established based on the findings of this study.

Keywords: Medicinal plant, Micro elements, Macro elements, ICP-MS.

INTRODUCTION

Herbal medicinal plants are indispensable for the humanity for their basic and primary health care as they are commonly available, safe, better tolerability and high efficacy. These herbs are mainly beneficial due to lesser side effects and rich source of phytochemical ingredients hence prompted for medicine formulation in pharmacology. Gentiana Chirayita belonging

ISSN PRINT 2319-1775 Online 2320-7876
 UGC CARE Listed (Group -I) Journal Volume 12, Iss 1, January 2023

family of Gentianaceae is an accepted medicinal plant usually found at an altitude of 1200-1500m from sea level. It contains xanthones which are reputedly effective against malaria, loss of appetite, digestive disorder and tuberculosis. The human body requires essential metals for proper biological functions and their deficiency causes diseases. Most of the research is focused on phytochemistry of the plants. In this perspective the authors highlight the importance of essential metals in the Gentiana Chirayita herb to its discriminate nutritive values that provide support to design new herbal drugs[1].

The therapeutic and toxic characteristics of medicinal plants are attributed to the active chemical components, which are synthesized from trace elements[2]. Zinc, iron, copper, chromium, and cobalt are essential elements that only exhibit toxicity at elevated levels, whereas lead and cadmium lack any acknowledged health advantages and are thus solely hazardous at high quantities. Metal ions are chemical constituents found in plants that contribute to their medicinal, nutritional, and toxic properties. They function as cofactors for enzymes and are significant trace elements in plant metabolism and biosynthesis[3]. Due to their effectiveness in treating a variety of human disorders, herbal medications are becoming more popular worldwide[4]. The human body absorbs the essential and trace components present in therapeutic plants through the ingestion of herbal medication. Due to the small range between insufficiency and toxicity of different elements in the human body, it is difficult to determine the correct dosage and health guidelines for herbal medicine. The soil's geochemical characteristics govern the accumulation of macro and trace elements in medicinal plants. In addition, the accumulation of elements in plants from their aquatic and atmospheric environments enables some plants to serve as biomonitors[5-9].

The popularity of herbal therapy has significantly increased in the past decade due to its minimal risk of harmful effects, ubiquitous availability, and universal acceptance, especially in developing countries. People of all ages, including infants and the elderly, can benefit from consuming these plants, which contain both essential and non-essential minerals[10]. The traditional use of medicinal plants has been demonstrated to be effective in the treatment of many human illnesses when studied in an experimental setting. Trace elements are one of the

ISSN PRINT 2319-1775 Online 2320-7876

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many aspects that contribute to the therapeutic properties of these plants. It has been found that major and trace elements play important roles in the treatment of a wide range of human disorders and diseases[11]. However, it is well-known that trace elements in medicinal plants are responsible for their toxicity when they are present in large concentrations. The pharmacological properties of these medicinal plants need to be looked into because they could affect human health. Knowing how much of these trace elements are in a plant is important for figuring out how well it can treat different diseases and for understanding how it works as a drug. It also makes it easier to understand how traditional knowledge about the healing power of these plants came to be.

Commonly employed techniques for analyzing trace elements in medicinal herbs include flame atomic absorption spectrometry[12], energy dispersive X-ray fluorescence (EDXRF)[13], and electrothermal atomic absorption spectrometry (ETAAS)[14], ICP-AES (inductively coupled plasma-atomic emission spectrometry)[15], ICP-MS (inductively coupled plasma-mass spectrometry)[16, 17], and instrumental neutron activation analysis (INAA)[18]. ICP-MS has higher sensitivity than conventional methods and is a trustworthy and efficient approach for determining several elements at the trace level. This work employed inductively coupled plasma mass spectrometry (ICP-MS) to analyze the constituents of the medicinal herb Gentiana Chirayita.

MATERIALS AND METHODS

Experimental details[19]

Sampling

Collecting samples of various plant components, including leaves, aerial parts, roots, fruits, and rhizomes, from medicinal plant (Table 1) used traditionally. These samples were extensively cleansed with water, ethanol, and triple-distilled water to eliminate surface contaminants, soil, and foreign particles. The fruits have been peeled. Cut the fruits into small pieces. The fruit pieces were then air-dried under shade in the laboratory before being oven-dried at 40 degrees Celsius and ground. The fragments were crushed mechanically and pulverized into powder. The leaves were also air-dried separately in the shade before being

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ISSN PRINT 2319-1775 Online 2320-7876
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pulverized into a powder. For subsequent investigation, the powdered plant materials were stored at room temperature away from direct sunlight in sealed, dry plastic bags. For analytical purposes, solvents and substances of analytical grade were utilized. Other solvents, chemicals, and reagents were all of pure quality (S.D. fine chemicals or E. Merck India). Whenever water is specified, distilled water is substituted. Table 1 provides the medicinal plant selected for this study, along with its scientific name and plant sections.

Table 1: Medicinal plants and their useful parts

Local Name	Scientific Name	Part used
Nelavemu	Gentiana Chirayita	Roots, Seeds, Leaves (1:1:1)

ICP-MS

Analyzing the samples' concentrations of various elements with an ICP-MS from the 7700 series (Agilent Technologies, USA). Table 2 summarizes the ICP-MS system's initial configuration. The ICP-MS was calibrated with MERCK XVII multi-element ICP-MS calibration standards (Merck KGaA, Germany) diluted with 3% nitric acid (HNO_3).

Table 2: ICP-MS configuration

RF power	1550W
Plasma gas	Argon, 151 min^{-1}
Peristaltic pump speed	0.3 rps
Autosampler	ASX-520 (Agilent)
Measuring mode	Helium and no gas

Digestion Procedure of samples

1 g of each sample (1:1:1 weight ratio of various plant components) was digested in nitric acid/perchloric acid (6:1) using the wet digestion method by slowly heating on a hot plate until white residue was formed. The residue was dissolved in 0.1N nitric acid, and the volume was adjusted to 10 ml. ICP-MS Instrument analysis of the digested sample.

Results and Discussion

The list of macro- and microelements determined by using ICP-MS technique were given in the Table 3. Totally twenty-elements (Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se,

IJFANS International Journal of Food And Nutritional Sciences Official Publication of International Association of Food and Nutrition Scientists

ISSN PRINT 2319-1775 Online 2320-7876

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Rb, Sr, Ag, Cs, Ba and Tl) were identified in examined medicinal plant. The concentrations of macro- and microelements that have been determined are presented in Figure 1.

Chromium, Manganese, Iron and Aluminium

The examination of the table's data indicates that the plant extract has chromium levels of 3.9984 parts per million (ppm), manganese levels of 108.3942 ppm, iron levels of 1318.8288 ppm, and aluminum levels of 874.5726 ppm. Chromium serves as an activator in the majority of enzymes and promotes the metabolism of lipoproteins, carbohydrates, and nucleic acids. A high concentration of chromium damages the kidney, liver, and lungs, whereas a deficit decreases insulin function, which is responsible for an increase in cholesterol and blood sugar levels. Manganese is the second most essential trace element necessary for numerous metabolic activities in plant and animal bodies.

Table 3: Average elemental concentration in ppm.

S.NO	E/SMPL	Gentiana Chirayita
1	Li	0.6453
2	Be	0.0465
3	Al	874.5726
4	V	1.8162
5	Cr	3.9984
6	Mn	108.3942
7	Fe	1318.8288
8	Co	0.5358
9	Ni	1.8111
10	Cu	5.8437
11	Zn	44.736
12	Ga	21.2886
13	As	0.2448
14	Se	0.1347
15	Rb	10.1415
16	Sr	74.8461
17	Ag	0.0408
18	Cs	0.1428
19	Ba	82.3905
20	Tl	0.0252

ISSN PRINT 2319-1775 Online 2320-7876

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Manganese is deposited in the kidney and liver of animals and is needed for appropriate reproductive and central nervous system function[20]. Manganese insufficiency prevents both male and female reproduction. Mn phytotoxicity is characterized by a decrease in biomass and photosynthesis, as well as metabolic disturbances such as oxidative stress[21]. Some studies on the toxicity of manganese and its transfer from soil to plants proved its significance under conditions of low pH and redox potential. Some enzymes[22] include manganese, which is abundant in mitochondria and activates enzymes like as hydrolases, transferases, kinases, and decarboxylases. pyruvate carboxylase is a well-known manganese metalloenzyme that catalysis the conversion of pyruvate to oxaloacetate 2. Other enzymes include arginase, which converts arginine to urea, and mitochondrial superoxide dismutase (SOD). Aluminium hydroxide is used to treat ulcers and renal conditions. Aluminum salts are used in cosmetics, medicine, and to reduce perspiration on the skin. Iron is the most important trace element since it is the central atom of haemoglobin; therefore, it plays an essential role in blood production. Iron is also required for appropriate central nervous system[23] function.

Cobalt, Nickel, Copper and Zinc

The analysis discovered trace elements, including cobalt, nickel, copper, and zinc, with quantities of 0.5358, 1.8111, 5.8437, and 44.736 parts per million (ppm) respectively. Cobalt is an essential component of vitamin B-12 and aids in the production of DNA and blood cells[24]. Its lack is detrimental to biological activities. Boron and Molybdenum were lacking from these plants entirely. Copper, Boron, and Molybdenum are necessary for the growth and health of plants and animals. Copper deficiency in animals[25] can result in anaemia, bone abnormalities, and neutropenia. As it is found in DNA and RNA[26], nickel may function as a nucleic acid stabiliser. The high copper concentration in foetal liver is extraordinary. During the last three months of a normal pregnancy, a significant buildup of copper in the liver occurs in the kid. This impact lasts for about four years, after which the liver copper returns to adult levels. This accumulation of copper in the liver guarantees adequate supply for the newborn during the first few months[27].

ISSN PRINT 2319-1775 Online 2320-7876

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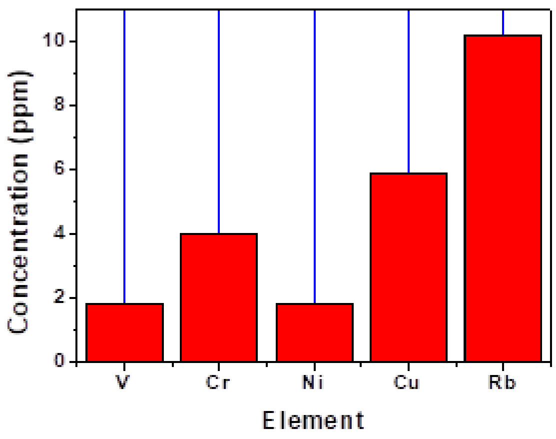
The increased copper levels in the liver could just be a reflection of the foetus's high copper requirement. However, it should be noted that zinc appears to be more closely associated to neonatal growth rates than copper. All of the elements mentioned above play a critical role in the body's overall function and needs. These critical ingredients are present in both formulations, indicating that they may be valuable to humans in the treatment and prevention of a variety of disorders. Zinc plays a key role in the metabolism of a variety of metabolic events in both animals and plants[28]. Zinc is required for cell-mediated innate immunity, neutrophils, and natural killer cells to grow and function normally[29]. Zinc levels are critical in phagocytosis, cytokine production, T and B cell development and function, DNA synthesis, RNA transcription, and cell activation[30].

Arsenic, Beryllium, Lithium and Silver

Significant quantities of heavy metals and ultra-trace elements, including Arsenic, Beryllium, Lithium, and Silver, were found in Gentiana Chirayita, with concentrations of 0.2448, 0.0465, 0.6453, and 0.0408 parts per million (ppm) respectively. When ingested by animals, some heavy metals can result in severe health problems. According to the World Health Organization, prolonged exposure to arsenic causes skin cancer. Beryllium is responsible for pneumonia, lung diseases, cardiovascular damage, and allergies. Due to its neuroprotective properties, lithium is the trace mineral most beneficial to mental health; its lack influences prevalent metal diseases and social evils.



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Research paper UGC CARE Listed (Group -I) Journal Volume 12, Iss 1, January 2023

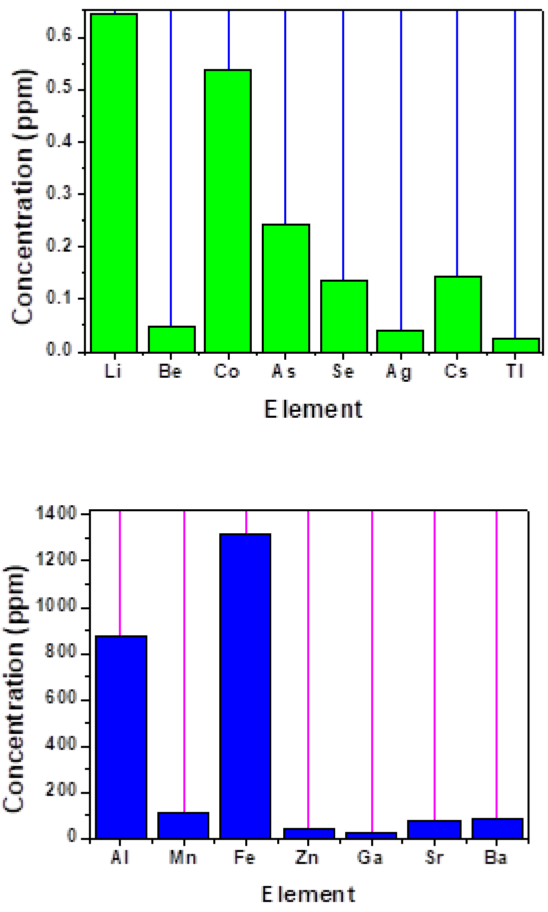

Figure 1. Distribution levels of various elements in ppm

CONCLUSIONS

An investigation was conducted on the Indian medicinal herb Gentiana Chirayita to understand the importance of its components in pharmacological activity. The researchers have determined that there is a substantial association between the concentration of elements and the therapeutic effectiveness of these plants. Due to soil characteristics, the plant has the ability to selectively accumulate various elements, including heavy metals, as a result of increased environmental pollution. The plant exhibits the ability to assimilate and amass heavy metals present in the soil. Therefore, this plant is employed to extract and eliminate toxic metals from the soil, thereby mitigating soil contamination. Based on these findings, the concentrations of heavy and dangerous metals were found to be within the acceptable range set by the World Health Organization. Therefore, it is likely that they do not pose a risk to

ISSN PRINT 2319-1775 Online 2320-7876

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human health. The pharmacological properties of this plant are substantiated by the identification of diverse levels of therapeutically important trace components. This study showcases satisfactory levels of elemental concentration, which are valuable in illustrating the therapeutic properties and disease-healing potential of this plant. The investigated medicinal plant may serve as potential sources for supplying a sufficient amount of essential elements in the diet and determining their nutraceutical value for traditional healers and users of herbal medicine.

References

1. Abdul Aleem and Hifzul Kabir, Review on Swertia Chirata as traditional uses to its phytochemistry and pharmacological activity, Journal of Drug Delivery & Therapeutics. 2018; 8(5-s):73-78.
2. Abugassa, I.O, Bashir, A.T, Doubali, K, Etwir, R.., Abu-Enawel, M. and Abugassa, S.O. (2008). Characterization of trace elements in medicinal herbs by instrumental neutron activation analysis. Journal of Radioanalytical and Nuclear Chemistry, 2008; 278: 559-563.
3. Maiga, A. Diallo, D, Bye, R, and Paulsen, B.S. Determination of some toxic and essential metal ions in medicinal and edible plants from Mali. Journal of Agricultural and Food Chemistry, 2005; 53:2316-2321
4. Fuh, C.-Bor, Lin, H.-Ia, and Tsai, H. Determination of lead, cadmium, chromium, and arsenic in 13 herbs of tocolysis formulation using atomic absorption spectrometry. Journal of Food and Drug Analysis, 2003: 11:39-45.
5. Carvalho, ML, Ferreira, JG, Amorim, P, Marques, MLM, and Ramos MT. Study of heavy metals and other elements in macrophyte algae using energy-dispersive x-ray fluorescence. Envi. Toxicol. and Chem. 1997; 16(4): 807-812.
6. Raez L., Bumbalova A., Harangozo M., Tolgessy J. and Tomecek O., Determination of Cesium and Selenium in Cultivated Mushrooms Using Radionuclide X-Ray Fluorescence Technique. J. Radioanaly and Nucle. Chem., 2000; 245: 611-614.

ISSN PRINT 2319-1775 Online 2320-7876

 UGC CARE Listed (Group -I) Journal Volume 12, Iss 1, January 2023

7. Richardson, DHS, Shore, M, Hartree, R. and Richardson RM. The use of X-ray fluorescence spectrometry for the analysis of plants, especially lichens, employed in biological monitoring. Science of the total environment. 1995; 176:97-105.
8. Viksna, A, Lindgren, ES. and Standzenieks, P. Analysis of pine needles by XRF scanning techniques. X-Ray Spectrom., 2001; 30:260-266.
9. World Health Organization. Quality Control Methods for Medicinal Plant Materials, WHO Offset Publication. WHO Geneva, 1998.
10. Ajasab, AMO, Bellob, MO, Ibrahimb AO, Ogunwandea IA. and Olawore NO. Heavy trace metals and macronutrients status in herbal plants of Nigeria. Food Chem. 2004; 85: 67-71.
11. Shirin, K, Imad, S. Shafiq, S. and Fatima, K. Determination of major and trace elements in the indigenous medicinal plant Withania somnifera and their possible correlation with therapeutic activity. J. Saudi Chem. Soc. 2010; 14:97-100.
12. Abou-Arab, AAK and Donia, MAA. Heavy metals in Egyptian spices and medicinal plants and the effect of processing on their levels. Journal of Agricultural and Food Chemistry, 2000; 48:2300-2304.
13. Queralt, I, Ovejero, M, Carvalho, ML, Marques, AF and Liabrés, JM. Quantitative determination of essential and trace element content of medicinal plants and their infusions by XRF and ICP techniques. X-Ray Spectrometry, 2005;34:213-217.
14. Kalny, P, Fijałek, Z, Daszczuk, A and Ostapczuk, P. Determination of selected microelements in polish herbs and their infusions. Science of the Total Environment. 2007; 381:99-04.
15. Özcan, MM, Ünver, A, Uçar, T and Arslan, D. Mineral content of some herbs and herbal teas by infusion and decoction. Food Chemistry, 2008; 106:1120-1127.
16. Arpadjan, S, Çelik, G, Taskesen, S and Güçer S. Arsenic, cadmium and lead in medicinal herbs and their fractionation. Food and Chemical Toxicology, 2008; 46:2871-2875.
17. Brima., EidI and Siddeeg SM. Pilot Study of Trace Elements in the Infusion of Medicinal Plants Used for Diabetes Treatment, International Journal of Analytical Chemistry, 2022; Article ID 3021396. https://doi.org/10.1155/2022/3021396.

ISSN PRINT 2319-1775 Online 2320-7876

 UGC CARE Listed (Group -I) Journal Volume 12, Iss 1, January 2023

18. Lokhande, RS, Singare, PU, Andhele, ML, Acharya, R, Nair, AGC and Reddy, AVR. Analysis of mineral content of some medicinal plants by NAA and AAS techniques. Radiochemistry, 2009; 51:321–325.
19. Patnaik PS, Ramanaiah M and Ramaraju B. Quantitative Determination of Essential and Trace Element Content of Some Medicinal Plants by ICP-MS Technique. Research J. Pharm. and Tech.2019; 12(4): 1595-1600.
20. Fu Z.H., Xie M.Y., Zhang Z.M. and Guo L., Determination of inorganic elements in plantago by ICP-AES. Spectroscopy and Spectral Analysis. 2004; 24(6):737-740.
21. Rehnberg GL, Hein, JF, Carter, SD, Linko, RS and Laskey JW. Chronic ingestion of Mn_3O_4 by rats: tissue accumulation and distribution of manganese in two generations. Journal of Toxicological Environmental Health. 1982; 9(2):175-188.
22. Tokalıoğlu Ş. Determination of trace elements in commonly consumed medicinal herbs by ICP-MS and multi variateanalysis. Food Chemistry. 2012; 134(4): 2504-2508.
23. Swanson CA. Iron intake and regulation: implications for iron deficiency and iron overload. Alcohol, 2003; 30(2):99-102.
24. Sullivan K., Vitamins and Minerals: A Practical Approach to a Health Diet and Safe Supplementation. Harpers Collins, 2002.
25. Krupanidhi, S, Sreekumar, A and Sanjeevi, CB. Copper and biological health. Indian Journal Medical Research. 2008;128(4):448-461.
26. Phipps, T, Tank, SL, Wirtz, J, Brewer, L, Coyner, A, Ortego LS and Fairbrother, A. Essentiality of nickel and homeostatic mechanisms for its regulation in terrestrial organisms, Environmental Reviews, 2002; 10(4): 209-261.
27. Araya, M, Pizarro, F, Olivares, M, Arredondo, M, Gonzalez, M and Mendez, M. Understanding copper homeostasis in humans and copper effects on health. Biological Research, 2006; 39(1):183-187.
28. Mocchegiani, E, Giacconi, R and Malavolta, M. Zinc signaling and subcellular distribution: emerging targets in type 2 diabetes. Trends in Molecular Medicine, 2008; 14(10):419-428.

ISSN PRINT 2319-1775 Online 2320-7876

 UGC CARE Listed (Group -I) Journal Volume 12, Iss 1, January 2023

29. Plum LM, Rink L and Haase H. The essential toxin: impact of zinc on human health. International Journal of Environmental Research and Public Health. 2010; 7(4):1342-1365.
30. Prasad AS, Zinc: An antioxidant and anti-inflammatory agent: Role of zinc in degenerative disorders of aging. Journal of Trace Elements in Medicine and Biology, 2014; 28(4):364-371.