Asian Journal of Chemistry Vol. 21, No. 9 (2009), 7205-7210

Determination of Trace Elements of *Mimosa pudica* from Different Parts by Microwave Digestion-Atomic Absorption Spectroscopy

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The stem, leaf and flower of *Mimosa pudica* were digested with HNO_3:$HClO_4$ (4:1) and the contents of thirteen trace elements such as Zn, Fe, Cu, Mn, K, Ca, Mg, Ni, Cd, Pb, Cr, Co, Al, Se and As from different parts were determined by atomic absorption spectrophotometry. The relative standard deviation of the method is between 1.21 and 3.05 % and the recovery ratio by standard addition is between 97.2 and 103.1 %. The experimental result shows that the content of K, Mg, Ca, Fe and Mn which are beneficial to the human body in *Mimosa pudica* is high. The order from high to low of the additive weight (μg g^{-1}) for the five kinds of elements in different parts is as follows: leaf > flower > stem. The content of the heavy metal trace elements Cr, Cd, Pb and As which are harmful to the human body in *Mimosa pudica* is lower, but the content of copper was high. The results provided scientific data for the further discussion of the relationship between the content of trace elements in *Mimosa pudica* and their relativity of medicine efficacy and development and the application of the resource.

Key Words: Microwave digestion, Atomic absorption spectrometry, *Mimosa pudica*, Trace elements.

INTRODUCTION

Mimosa pudica L. (Leguminosae) is a Chinese medical herb[1], popularly named as a sensitive or shy plant[2]. The whole plant of *Mimosa pudica* has been used as a traditional Chinese medicine for the treatment of neurasthenia, insomnia, traumatic injury, pulmonary tuberculosis, *etc.*[3]. *Mimosa pudica* mainly grows on the hillside, jungle, glade and roadside of the east of China, south of China and the southwest of China. In previous papers[4-9], we have reported glycopyranosyl flavone, phenolics from *Mimosa pudica*. But so far, there is not any report about the research on the trace elements in Hainan *Mimosa pudica*.

Trace elements are the essential parts for human health and the prevention of diseases, so in recent years people pay increasingly important attention to the research of trace element distribution in medicinal plants[10-12]. The most important analytical

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methods used in the determination of the trace element contents in plant samples are as follows: the atomic absorption spectrophotometry[13-16], electromagnetic coupling plasmatic emitting spectrometry[17-19], electromagnetic coupling plasma[20,21] and the atomic fluorescent spectrometry[22,23], *etc.* The microwave digestion-atomic absorption spectroscopy method is a new technique in sample digestion[24]. This paper is just about how to use microwave digestion-atomic absorption spectroscopy method to determine, analyze and evaluate the contents of trace elements in Hainan *Mimosa pudica*. It also provides reference data for the further development of natural resources.

EXPERIMENTAL

Spectr AA 220 flame atomic absorption spectrometer (FAAS American Varian Company), Spectr AA 220Z graphite oven atomic absorption spectrometer (GFAAS American Varian Company), PE3030 Hydride atomic absorption spectrometer (American PE Company) and enclosed here is the China-made Hollow Cathode Light (Wiglass Beijing Instrument Corporation Ltd). MARS-5 Microwave digestion device (American CEM Company) and enclosed here is the RTP-300 -Plus temperature controller. FAAS air speed is 6.0/(L min^{-1}), acetylene running speed is 1.5/(L min^{-1}), Zn using deuterium light without background; GFAAS: Air-carriage speed is 3.0/(L min^{-1}), AC horizontal Saiman background correction. The Instrument working condition can be seen from the following Table-1.

TABLE-1
WORKING CONDITIONS OF THE INSTTRUMENT

Trace element	Determination method	Determination wavelength (nm)	Slit width (nm)	Light electric current (mA)
Zn	FAAS	213	0.5	2.0
Cr	FAAS	248	0.2	2.0
Fe	FAAS	589	0.2	6.0
Mn	FAAS	285	0.5	2.0
Cu	FAAS	766	1.0	2.0
Ni	FAAS	232	1.0	4.0
Mg	GFAAS	193	0.5	2.0
K	GFAAS	283	0.5	3.0
Ca	GFAAS	228	0.5	1.0
As	Hydride AAS	357	0.5	8.0
Pb	GFAAS	460	0.5	2.0
Cd	GFAAS	309	0.5	3.0
Co	GFAAS	240	0.5	2.0

The Hainan *Mimosa pudica* is picked from SanYa city, Hainan Province, PR China. This kind of plant is identified as Hainan *Mimosa pudica* by Professor Shiman Huang of Hainan University. The sample is air-dried and then ground to powder by agate mortar. Later, the powder is screened through the 100-hole sieve for use.

The standard solution for each element is obtained by dilution from the National Standard Solution with the concentration of 1000 μg mL^{-1} (National Standard Material Research Center). HNO_3 and $HClO_4$ are first-class purification reagent, the experimental water is super-class purified water and the other reagents are all analytical purification reagents.

Pre-treatment of the sample and the microwave digestion: Put the sample of *Mimosa pudica* beforehand (its leaf, stem and flower) under the infrared light to be dried to constant weight. Weigh precisely the sample powder for 1 g each and put them in the inner bowl of the microwave digesting vessel. And then put 10 mL HNO_3-$HClO_4$ (4:1) liquid mixture in each of them. Slightly shake the mixtures for 0.5 h and add 5 mL water in each of them and put them in the microwave digesting instrument. Then digest them according to the procedure given in Table-2. After the digestion, cool them to the room temperature and take out the inner bowl and move the digested solution to another place and get settled in the 25 mL bottle. In the meantime, prepare a blank solution for comparison.

TABLE-2
PROCEDURE OF MICROWAVE DIGESTION

Digestion procedure	Power (W)	Temperature rising time (min)	Controlled pressure (kPa)	Temperature (ºC)	Time duration (min)
1	600	10	340	100	3
2	600	5	689	150	5
3	600	5	1033	180	5

RESULTS AND DISCUSSION

Comparison of the sample treatment: The method of the sample treatment is the source of error in the determination of the plant sample. This paper uses the standard material and compares the different methods of ashing and microwave digestion and finds out its different influence of the determination results. Determine them for three times on average and it shows that the trace elements are lost mainly when using ashing method and its recycling rate is relatively low. This experiment tried three kinds of systems, that is, HNO_3/$HClO_4$, HNO_3/H_2SO and H_2SO_4/$HClO_4$, with the HNO_3/$HClO_4$ (4:1) system being the best, while the other two systems can easily carbonize the sample.

Recycling rate experiment: Weigh precisely the above dried sample powder with constant weight, respectively. And add the compared solution with suitable amount of trace element in each of them and then digest them and determine them according to the method used and calculate its recovery rate. The experimental result can be seen in Table-3. The sample-added recovery rate is between 97.2-103.1 %, which shows that this method is correct and dependable.

TABLE-3
RESULT OF RECOVERIES

Element	*Mimosa pudica* (leaf)		*Mimosa pudica* (flower)		*Mimosa pudica* (stem)	
	Added amount (μg mL^{-1})	Recovery rate (%)	Added amount (μg mL^{-1})	Recovery rate (%)	Added amount (μg mL^{-1})	Recovery rate (%)
Zn	20.0	101.2	20.0	100.1	20.0	101.0
Fe	50.0	101.6	50.0	101.4	50.0	99.9
Ni	50.0	97.2	50.0	99.5	50.0	98.5
Mn	20.0	100.9	20.0	100.6	20.0	100.1
K	50.0	101.2	50.0	101.2	50.0	101.1
Ca	20.0	99.8	20.0	99.8	20.0	99.3
Co	50.0	101.5	50.0	102.2	50.0	103.1
Mg	50.0	101.2	50.0	100.5	50.0	101.1
Cr	5.0	98.8	5.0	99.9	5.0	98.2
Cu	5.0	98.7	5.0	97.9	5.0	98.4
Cd	5.0	101.2	5.0	100.2	5.0	101.1
Pb	5.0	99.2	5.0	99.5	5.0	99.3
Zn	50.0	101.6	50.0	98.6	50.0	101.2

Determination result: The experiment uses the atomic absorption spectrometer to determine the different trace element and it adopts different atomic methods. Among them, the flame atomic absorption method is used in determining Zn, Fe, Cu, Mn, K, Ca, Mg and Ni; graphite oven method is used in determining Cd, Pb, Cr and Co; hydride atomic absorption method is used in determining As. Thirteen kinds of trace elements in Hainan *Mimosa pudicac* is presented in Table-4. The RSD (relative standard deviation) of this method is between 1.21-3.05 %, which shows that this method is accurate and effective.

TABLE-4
ANALYTICAL RESULTS OF SAMPLES (μg g^{-1})

Element	*Mimosa pudica*(leaf)		*Mimosa pudica* (flower)		*Mimosa pudica* (stem)	
	Average value	RSD (%)	Average value	RSD (%)	Average value	RSD (%)
Zn*	31.4	2.56	38.9	1.87	26.1	3.01
Fe*	238	3.05	216	1.93	202	2.69
Ni*	5.12	2.56	6.92	2.24	3.26	2.37
Mn*	74	2.23	68	2.46	55	2.78
K*	10900	1.21	10278	1.66	9635	1.55
Ca*	7798	2.05	7524	2.14	7108	2.26
Co*	0.26	1.31	–	–	0.18	2.11
Mg*	1583	1.88	1356	1.83	1125	2.03
Cr**	1.48	2.07	1.36	2.04	1.88	2.25
Cu**	28.34	2.05	12.348	2.28	21.66	2.21
Cd**	0.027	2.23	0.021	2.21	0.016	2.23
Pb**	3.76	1.79	3.23	1.58	2.12	1.85
As**	0.056	2.15	0.036	2.04	0.081	2.34

*The essential trace element, **Heavy metal and arsenic salt.

This experiment uses the atomic absorption spectrometer method to determine the trace elements in Hainan *Mimosa pudica*. Among them, the flame atomic absorption method is used in determining Zn, Fe, Cu, Mn, K, Ca, Mg and Ni. The flame atomic absorption method and deuterium light method without background are used in determining Zn with a good analytical result. The contents of Cd, Pb, Cr, Co are low, so the graphite oven method is used in determining them and this has a very good result. While the determination of As is done by using hydride atomic absorption method, because this method is highly sensitive with less external interference and is much better than graphite atomic absorption method in accuracy and precision[25].

The digesting decomposing methods of the plant samples are many, such as dry ashing digestion, wet digesting, high-pressure jar digesting, high-pressure microwave digesting, *etc.*[26]. The method of microwave digesting has the advantages of less sample amount, fast digesting, reagent-saving, less loss of the trace element and less pollution of the environment.

This experiment determined the 13 trace elements in the Hainan *Mimosa pudica*, including the 8 kinds of essential trace elements, that is, Zn, Fe, Ni, Mn, K, Ca, Mg, Co. While Cr, Cu, Cd, Pb and As all belong to harmful heavy metals, which can cause accumulative poison if absorbed by human body. Although copper is the essential element in human body, it is harmful if taken excessively. This experiment shows that there are rich trace elements in the Hainan *Mimosa pudica*. And it has a high content of the useful trace elements, like K, Mg, Ca, Fe, Mn. The overall content ($\mu g\ g^{-1}$) order of this 5 kinds of trace elements in each part is as follows (from high to low): leaf > flower > stem. The content distribution of Zn and Ni is as follows (from high to low): flower > leaf > stem; No Co has been determined in the flower part. While the content of the harmful heavy metals like Cr, Cd, Pb, As are relatively low. But the content of the harmful element Pb is slightly higher in the leaf part, reaching 3.76 $\mu g\ g^{-1}$, even so, it is still within the limit of the permitted amount of the heavy metals and arsenic salt. This experiment also shows that the content of the trace element Cu is relatively higher and its contend distribution order (from high to low) is leaf > stem > flower, which means that its cause of the high content maybe has something to do with its growing environment.

Mimosa pudica, as the most abundant plants with rich trace elements, is the precious plant in Hainan Province. The findings of this research provide the reference data for the development of this natural resource.

ACKNOWLEDGEMENTS

Our thanks go to all the people who give us help in any form. Here, we show our special thanks to the Analyzing and Testing Center of Southern Yangtze River University for making the atomic absorption spectrophotometer available. We also thank Prof. Shi-man HUANG of Hainan University for assistance in collecting the plant material.

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(*Received*: 28 January 2009; *Accepted*: 17 August 2009) AJC-7752