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Mineral Compositions of *Datura*: A Traditional Tropical Medicinal Plant

S. Bhattacharjee,* S. Kar, and S. Chakravarty

Analytical Chemistry Division, National Metallurgical Laboratory, Jamshedpur, India

ABSTRACT

Mineral compositions of leaf, seed, and flower of *Datura metel*, a tropical medicinal plant, have been ascertained in detail. *Datura metel* leaves have been found to be minerally richer than its seeds or flowers. The studied *datura* variety has been found to be a cobalt- and nickel-tolerant plant and a probable phytomonitor for these elements in soil.

Key Words: Mineral compositions; *Datura metel*; Phytomonitor.

*Correspondence: S. Bhattacharjee, Analytical Chemistry Division, National Metallurgical Laboratory, Jamshedpur 831007, India; Fax: 0657-2270527; E-mail: santanu@ nmlindia.org.

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INTRODUCTION

Datura Linn. (family: *Solanaceae*), a genus of poisonous herbs, is distributed over tropical and warm temperate regions of the world. About ten species of *datura* are found, of which *D. innoxia*, *D. metel*, and *D. Stramonium* are most important drug plants.[1]

Datura has long been known as a medicinal plant and as a plant hallucinogen all over the world. Pre-historic use of *datura* in medicinal and ceremonial rituals could be observed in aboriginal North America stretching from South Western United States to Southern Mexico and Guatemala.[2] It has been proposed that aboriginal rock paintings in two areas of North America were produced by shamans under the hallucinogenic effect induced by the decoctions of *datura* species.[3] Ceramics of ancient Nazca, an extinct people that lived on the south coast of Peru from 100 to 800 AD suggest that *datura* species was used as a plant hallucinogen.[4] *Datura stramonium* has been traditionally used as antihelmintic, antiparasitic, and repellent in central Italy.[5]

In ancient India *datura* had a very special place in *Ayurveda* as mentioned in the works of Charaka and Sushruta. All parts of the plant namely, leaves, flowers, seeds, roots, etc., were used for a wide range of medication though many of them were esoteric in nature. These included treatment of leprosy, rabies, insanity, etc.[6] *Datura stramonium* may also be used in the treatment of Parkinson's disease.[7] The extract of *datura*, however, is a potent poison and its indiscriminate use may lead to delirium and acute poisoning that may eventually lead to death even.[8,9]

The principal alkaloid of *datura* is scopolamine, which is used as a pre-anaesthetic in surgery and childbirth, in opthalmology and in the prevention of motion sickness. It also contains hyoscyamine, atropine, and norhyoscyamine. The leaves also contain vitamin C while the seeds contain a fixed oil with a disagreeable odor and taste. The fatty acid components of the oil are solid fatty acid, oleic acid, α- and β-linoleic acid, and caproic acid. The seeds also contain alantoin.[10]

Datura is a heavy metal tolerant plant that can grow at ease in metal polluted sites. The hyperaccumulative nature of *datura* has been exploited for the recovery of toxic heavy metals from contaminated groundwater[11] and in-situ bio-remediation of soils contaminated with organic pollutant.[12] Metal binding in *datura* cells has been studied in some detail using X-ray absorption spectrometry (XAS).[13–15]

It was observed with interest and intrigue during the literature search that no attempt was made to document endogenic mineral composition of *datura* species which is quite relevant as well as important especially in view of its heavy metal hyperaccumulative nature and its usage in medicinal formulation. An attempt has been made in the present communication to provide an exhaustive mineral composition of *datura* leaf, seed, and flower with the objective of bridging the existing knowledge gap as mentioned above.

MATERIALS AND METHODS

Datura species used in the present work belonged to *D. metel* variety. Nine healthy plants grown in the wild were collected from within an approximately 2500 sq. ft. plot. All of them had leaves and seeds while only two of them had flowers. Thus, sample size for datura leaf and seed was nine while it was two for flower. Intentionally, the sample size was restricted to this set of nine plants only as all of them were grown under the same environment. Plants were collected in late February. Five soil samples were also collected from the same plot for determining average soil mineral compositions. All soil and plant samples were demoisturized at 105°C and mineral compositions reported in this article were all on dry basis.

Quality Control

Each demoisturized plant sample was crushed in an agate mortar as fine as possible. Each sample was analyzed three times independently for its mineral composition. For each mineral five replicate measurements were taken in AAS ICP-OES. The mean value of five replicates was accepted only if the RSD was less than 1%. Therefore, three independent measurements for each mineral in each sample resulted into three such means the average of which was accepted as the mineral composition for that sample if the RSD was less than 3%. For soil samples also same protocol was followed.

Dissolution of the Sample

Each powdered demoisturized sample was dissolved in HCl-HNO_3-$HClO_4$ tri-acid mixture following standard practice.[16]

Instrumental

Copper (Cu), cobalt (Co), nickel (Ni), iron (Fe), manganese (Mn), zinc (Zn), sodium (Na), potassium (K), calcium (Ca), were determined by GBC 908 AA atomic absorption spectrometer, magnesium (Mg), phosphorus (P), and aluminum (Al) were determined by Shimadzu GVM 1014 P simultaneous ICP-OES and qualitative measurements were carried out by Shimadzu ICPS 1000 III sequential ICP-OES.

Reagents

All the reagents used were of AR grade, 18 MΩ ASTM grade 1 water was used for making the solutions. Calibration standards were prepared from Johnson-Mathey specpure materials.

Statistical Analysis

Robust Z-score statistic was employed to assign a representative value for each mineral in leaf and seed category. Z-score statistic is generally employed to a data set that has wide variations within. Presence of extreme values do not influence the final decision greatly in Z-score statistic, which otherwise would bias the conventional normal distribution statistics of mean and standard deviation. In robust Z-score statistic mean is replaced with median and each data point is assigned a normalized score, a Z-score, which qualifies the deviation of the data point from the median value. Z-score of a data point beyond a critical value entails the point as an outlier. The details of Z-score analysis may be obtained elsewhere.[17] The appropriateness of employing Z-score statistics in the present study has been justified in the results and discussion section. Recently Z-score statistic was used to find out the mineral compositions of some common spices.[18] Since there were only two flower samples, mineral compositions for the flower reported were only arithmetic mean.

RESULTS AND DISCUSSION

Mineral compositions of *datura* leaf, seed, and flower have been shown in Table 1. Both mean and median values calculated after Z score screening (removal of outliers) along with standard deviation (SD) have been given in Table 1. For most of the elements median and mean are quite close to each other thus indicating the closeness of the independent measurements. However, in case of Co in leaf and seed substantial deviations could be observed between mean and median. Deviations were also observed for Na in seed, Al in leaf and seed. In such cases, median is

Table 1. Mineral composition of *datura* leaf,[a] seed,[a] and flower.[b]

Element	Statistic	Leaf	Seed	Flower
Cu(mg/kg)	Median	12.7	11.7	
	Mean	12.5	11.9	14.1
	SD	2.7	1.99	
Co(mg/kg)	Median	19.6	n.d.[c]	
	Mean	25.4	2.0	n.d.
	SD	18.0	3.6	
Ni(mg/kg)	Median	8.2	10.2	
	Mean	8.3	10.0	n.d.
	SD	1.6	3.92	
Mn(mg/kg)	Median	73.7	13.4	
	Mean	77.6	13.9	20.2
	SD	22.3	4.73	
Zn(mg/kg)	Median	67.6	34.8	
	Mean	66.8	36.2	47.4
	SD	11.5	8.18	
Fe(g/kg)	Median	0.8	0.30	
	Mean	0.9	0.31	0.3
	SD	0.35	0.22	
Na(g/kg)	Median	0.6	n.d.	
	Mean	0.56	0.13	0.7
	SD	0.24	0.21	
K(g/kg)	Median	36.5	26.5	
	Mean	37.9	25.6	41.3
	SD	8.56	4.74	
Ca(g/kg)	Median[a]	29.9	2.4	
	Mean	30.0	2.45	6.1
	SD	4.02	0.88	
Mg(g/kg)	Median	11.6	3.95	
	Mean	11.5	4.02	6.2
	SD	1.38	0.40	
P(g/kg)	Median	2.8	3.5	
	Mean	2.79	3.62	3.65
	SD	0.69	0.77	
Al(g/kg)	Median	2.5	n.d.	
	Mean	3.94	0.2	n.d.
	SD	2.29	0.25	

[a]Median values reported calculated after excluding the outliers through Z-score statistic for an independent sample size of nine.
[b]Arithmetic mean of two values.
[c]n.d = not detected.

preferred over mean. These deviations also vindicate the choice of employing Z-score statistic in the present work for describing representative mineral compositions.

It may be seen from Table 1 that *datura* leaves are minerally richer than their seed and flower counterparts though P content has been found to be little higher in flower and seed and Cu and K contents are higher in flower. It was interesting to note that *datura* leaf and flower showed a significant accumulation of Na while it was not detectable in seed.

Datura is a known heavy metal tolerant plant and has been suggested as a bio-remediator of metal contaminated soils[12] and groundwater.[11] Heavy metal tolerant nature of *D. innoxia*, one of the species of *datura*, has been studied by two groups independently.[13–15] Though no literature could be obtained on a similar study on *D. metel*, its metal tolerant nature was apparent from Zn, Mn, Ni, Co, and Cu contents in *datura* plant parts used in the present study and shown in Table 1. Cobalt, however, could not be detected in *datura* seeds and flower while Ni was not detectable in *datura* flower. Occurrence of these metals in *datura* leaf follow the pattern Mn > Zn > Co > Cu > Ni.

Heavy metal contents in *D. metel* plant parts as reported in Table 1 were looked into more critically with respect to the concentration of these elements in the soil where these plants were grown and available literature on the normal and critical range of these elements in soils and plants. The relevant data have been shown in Table 2. It was noted with interest

Table 2. Literature data on normal and critical concentration range of a few heavy metals in soils and plants and their concentration in the experimental soil wherefrom studied *datura* plants were collected.

Heavy metal	Normal range in Soils[a] (mg/kg)	Critical soil total concentration[b] (mg/kg)	Experimental soil concentration[c] (mg/kg)	Normal range in plants[a] (mg/kg)	Critical concentration in plants[b] (mg/kg)
Co	0.5–65	25–50	88	0.02–1	15–50
Cu	2–250	60–125	32	5–20	20–100
Mn	20–10,000	1,500–3,000	740	20–1,000	300–500
Ni	2–750	100	253	0.02–5	10–100
Zn	1–900	70–400	77	1–400	100–400

[a]Reference: Alloway[19]

[b]Range beyond which toxicity is likely (Alloway,[19] Kabata Pendias and Pendias[20]).

[c]This work.

that Co content of the soil was significantly higher than the norm Co range observed in soils. This implied that the soil where *datura* plar had grown was cobalt rich. Also, cobalt content in the soil was mu higher than the critical soil total concentration, which could have a to effect on the growth of *datura* plant. Nickel content of the soil was al higher than the corresponding critical soil total concentration but with the normal range. It was indeed interesting to observe that in sp of the abundance of Co and Ni, all nine plants grown in this soil w quite healthy.

Comparison of Tables 1 and 2 clearly indicates that Co content *D. metel* leaves and Ni contents in both leaf and seed were mu above the normal Co, Ni range observed in plants. It was a cle testimony of the fact that in spite of the presence of cobalt and nick in the soil beyond critical level, *D. metel* had a healthy growth and had accumulated Co and Ni in the plant parts up to a level that w much above the normal range of these elements observed in the plan This further establishes that *D. metel* variety is tolerant to Co a Ni though it may not be strictly labeled as a hyperaccumulator as th call for a still higher level of accumulation. Normally to qualify a hyperaccumulator plant, metal concentration in its dry biomass mu be at least 100 times that of a normal plant grown on the same so For most of the metals this threshold concentration is 0.1%.[21] A example, *Thlaspi caerulescens*, a Zn hyperaccumulator plant, has be found to accumulate 51.6 g Zn/kg of dry weight in shoots and *Sebertia acuminata*, a hyperaccumulator plant of nickel has been found t accumulate 25% Ni by weight of dry bio-mass.[22] The present stud clearly indicates that *D. metel* can easily qualify as a phytomonit for these elements in soil even if not a true hyperaccumulator. Contr experiments are being carried out in the laboratory by growing *D. met* in cobalt and nickel contaminated soil to ascertain its Co and N accumulative property quantitatively which depends not only on tot metal concentration, but also on available metal concentrations i addition to other nutrients.

Qualitative analyses were carried out for a number of ultratrace elements such as titanium (Ti), vanadium (V), arsenic (As), molybdenum (Mo), antimony (Sb), gold (Au), lead (Pb), and bismuth (Bi) in *datur* leaf, seed, and flower using a sequential ICP-OES. It was interestin to observe that *datura* leaves contained all these elements except Pb which could be detected in flower, and some of the seeds. Seeds and flowers had shown presence of Ti though to a lesser extent as compared to leaves. Vanadium, As, Mo, Sb, and Au could not be detected in seeds and flowers.

CONCLUSIONS

Mineral compositions of leaf, seed, and flower of *Datura metel*, a tropical medicinal plant, have been reported. A total of 12 elements have been reported quantitatively that includes Cu, Co, Ni, Mn, Zn, Fe, Na, K, Ca, Mg, P, and Al. *Datura* leaves are minerally richer than their seed and flower counterparts. The leaves also contain Ti, V, As, Mo, Sb, and Bi in ultratrace quantity. *Datura metel* is a tolerant plant for Co and Ni and may be used as phytomonitor for these elements in the soil.

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Chemical Fractionation of Copper, Zinc, and Cadmium in Two Chinese Soils as Influenced by Rhizobia

Qiaoyun Huang,* Wenli Chen, and Xuejun Guo

State Key Laboratory of Agricultural Microbiology, Faculty of Resources and Environment, Huazhong Agricultural University, Wuhan, China

ABSTRACT

Red soil and Cinnamon soil were collected from Chenzhou of Hunan and Gongyi of Henan, respectively. Soils were treated with $Cu(NO_3)_2$, $Zn(NO_3)_2$ or $Cd(NO_3)_2$, respectively, for two weeks. *Rhizobium fredii* strain HN01 was inoculated into the two soils polluted with three heavy metals. Sequential extraction method was employed to investigate the forms of copper (Cu), zinc (Zn), and cadmium (Cd) in the examined soils with the absence and presence of rhizobia. Results showed that the total amount of solid-bound Zn decreased

*Correspondence: Qiaoyun Huang, State Key Laboratory of Agricultural Microbiology, Faculty of Resources and Environment, Huazhong Agricultural University, Shizishan, Wuhan 430070, Hubei Province, China; Fax: +86-27-87671033; E-mail: qyhuang@mail.hzau.edu.cn.

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