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Trace metals in tropical yam species: *Dioscorea* spp.

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Four common species of *Dioscorea*; *D. piscatorium*, *D. wallichiani*, *D. hispida* and *D. alata* were analysed for the trace metals using the technique of Instrumental Neutron Activation Analysis (INAA). A total of sixteen elements were detected some of which are classified as either toxic or essential to humans. Zn was found to have the highest concentration ranging from 16 to 52 ppm.

INTRODUCTION

The primary agent of transfer of trace metals to the human body is food. In view of the serious impact of trace metals on the human body, it is important to continously monitor the diet. Such data are particularly useful in evaluating the safety of the diet.

Dioscorea is a family of yam commonly available in the forest of tropical countries such as Malaysia. It is a staple diet amongst the forest natives. Incidences of food poisoning from eating yam have been quite common. Before they are consumed, these yams are immersed in running water for a day or two. Doing so not only helps to clean the yam but also removes toxic substances. They are then boiled and eaten.

The purpose of this study was to analyse some trace metals in *Dioscorea* that may be hazardous to mankind. Four common species of *Dioscorea* were selected: *D. piscatorium*, *D. wallichiani*, *D. hispida* and *D. alata*.

MATERIALS AND METHODS

Metal analysis was carried out using instrumental neutron activation analysis (INAA), a technique well known for its sensitivity, accuracy and the ability to analyse many elements simultaneously.

Samples of *Dioscorea* were obtained from the forest with the help of the natives. The samples were then cleaned with distilled water. The skin of each yam was peeled to expose the flesh which was then sliced. These slices were then sun-dried to remove water before being ground. Five yams of each species were analysed. The dried powder was placed in separate vials (2/5 dram) for a total of 20 samples. An additional two vials were filled with Reference Material; NBS Coal Ash (SRM 1632a). The net weight of the contents of each vial was between 200 and 500 mg. All vials were then heat-sealed and placed inside an aluminium cylindrical container before being transferred into the reactor.

An Atomic Energy Unit research reactor TRIGA MKII with thermal flux of 4×10^{12} n/cm^2/s was used to irradiate the samples and standard reference material. After 10 h of irradiation, the aluminium container was transferred from the reactor core and left to cool for at least 2 weeks. The activities of the *Dioscorea* samples and standard materials were then measured with a γ-ray detection system. This consisted of a horizontal hyperpure germanium detector coupled to a 4096 channel pulse height analyser. The counting system has an energy resolution of 1·90 keV (FWHM) for the 1332 keV γ-ray of ^{60}Co. The presence of trace elements in the samples was deduced from the detection of γ-rays originating from the respective radioisotopes (Lederer & Shirley, 1978). The method of comparison (Ibrahim, 1987) was used to calculate the concentration of each element. If m_s is the mass of the trace element in the standard sample, then the mass of the trace element in the unknown sample is given by

$$m_x = m_s A_x / A_s$$

where A_x and A_s are the activity rate per unit mass of the unknown sample and standard sample, respectively.

RESULTS AND DISCUSSION

The trace elements obtained from the neutron activation analysis of four *Dioscorea* species are shown in Table 1. The concentration of elements is expressed in ppm (dry weight) or as otherwise stated.

Analyses showed that the method of neutron activation analysis as a means of detecting trace elements is reliable and accurate. The analyses of trace elements in coal ash by INAA have shown good agreement with the certified values (Ibrahim, 1992).

Table 1. Concentrations of trace elements in four different species of *Dioscorea* in ppm (dry weight) or as otherwise stated

Element	*D. piscatorium*	*D. wallichiani*	*D. hispida*	*D. alata*
As	0·13 ± 0·02	0·23 ± 0·09	—	—
Br	0·31 ± 0·07	1·6 ± 0·3	1·2 ± 0·2	14 ± 2
Ce	—	0·79 ± 0·15	0·83 ± 0·11	0·46 ± 0·10
Co	0·06 ± 0·01	0·20 ± 0·02	0·15 ± 0·01	0·05 ± 0·01
Cr	0·99 ± 0·17	1·3 ± 0·2	0·6 ± 0·1	0·70 ± 0·13
Cs	0·11 ± 0·01	0·14 ± 0·02	0·06 ± 0·01	—
Eu	0·034 ± 0·007	0·027 ± 0·007	0·019 ± 0·004	0·017 ± 0·004
Fe (%)	0·013 ± 0·002	0·039 ± 0·002	0·024 ± 0·002	0·015 ± 0·002
K (%)	0·11 ± 0·02	0·63 ± 0·07	0·94 ± 0·10	1·7 ± 0·2
La	0·12 ± 0·03	1·2 ± 0·2	0·40 ± 0·07	0·18 ± 0·09
Na (%)	—	0·012 ± 0·001	0·013 ± 0·001	0·23 ± 0·02
Rb	20 ± 1	18 ± 1	39 ± 3	7 ± 1
Sm	0·008 ± 0·004	0·12 ± 0·02	0·05 ± 0·01	0·03 ± 0·01
Sr	—	12 ± 2	10 ± 2	5 ± 1
Th	0·04 ± 0·01	0·26 ± 0·02	0·14 ± 0·01	0·15 ± 0·03
Zn	49 ± 4	18 ± 2	16 ± 2	52 ± 4

A total of 16 trace elements were detected: As, Br, Ce, Co, Cr, Cs, Eu, Fe, K, La, Na, Rb, Sm, Sr, Th and Zn. Generally, the concentration of each element was of the same order in all four species. The only element with a wide range of concentration values was bromine (Br) with concentration ranges from 0·31 ppm in *D. piscatorium* to 14 ppm in *D. alata*. The trace metal with the highest concentration was zinc (52 ppm) in *D. alata*, while the lowest concentration was samarium (0·008 ppm) in *D. piscatorium*.

Arsenic was present at concentrations of 0·13 and 0·23 ppm in *D. piscatorium* and *D. wallichiani*, respectively. Bromine and arsenic are classified as toxic elements while elements such as cobalt, chromium, iron and zinc are dietary essentials for human beings (Tanner & Friedman, 1977). These elements cause some physiological effects on man and hence, insufficient and excess amounts of these elements may cause physiological problems (Sherif *et al.*, 1979). Zinc was present in high concentrations of 16 ppm in *D. hispida* C to 52 ppm in *D. alata*. Another element with high concentration was rubidium (Rb) with concentrations ranging from 7 ppm in species *D. alata* to 39 ppm in *D. hispida*. Analysis also revealed the presence of lanthanides (Ce, Eu and La) in the samples.

Table 2 compares the concentrations of some trace elements present in *Dioscorea* with those in carrots and potatoes (Al-Jobori *et al.*, 1992). The concentrations of iron, bromine and strontium are lower in *Dioscorea* than in potatoes and carrots while zinc is relatively higher. The concentrations of Na, K, Cr, Co and Rb are of the same order.

In conclusion, the *Dioscorea* contain trace elements some of which are classified either as toxic or essential to humans. Further research is needed to ascertain the extent to which this staple diet has affected the health of the forest natives.

Table 2. Concentration (range) of some trace elements in *Dioscorea*, potatoes and carrots (units ppm or as otherwise stated)

Element	*Dioscorea*	Potatoes[a]	Carrots[a]
Na (%)	0·012–0·23	0·014–0·17	0·65–3·6
K (%)	0·11–1·7	2·08–3·05	1·99–2·87
Fe	0·015–0·039	21·6–77	68·5–177
Cr	0·6–1·3	0·19	0·04
Co	0·05–0·20	0·17–0·75	0·14–1·09
Zn	16–52	3·8–20·9	9·1–16·9
Br	0·31–14	3·30–28·0	13·3–30·9
Rb	7–39	2·97–46·3	2·7–5·7
Sr	5–12	—	37·9–46

[a] Data taken from Al-Jobori *et al.* (1992).

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