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Determination of Major, Minor and Trace Elements in *Cochlospernum tictorium* A. Rich by Instrumental Neutron Activation Analysis (INAA)

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Abstract: *A total of 26 elements (major, minor, trace and ultra-trace) were detected and determined in Cochlospernum tictorium A. Rich. using INAA. Ca, Sr, Ba, Rb and Fe are found at higher concentrations in the range of 33.40 – 796ppm followed by Ce, La, Nd, Br and Zn in the range of (6.78 – 24.20ppm) while Au, Lu, Sc, Co, Cr, Cs, Sm, Eu Tb, Hf, Th, As, Ta, W, Hg and U are in traces and at ultra-trace levels. Nutritional, medicinal and toxicological implications were discussed.*

Key words: *Major, minor, trace, ultra-trace elements, INAA and C. tinctorium A. Rich*

I. Introduction

Cochlospernum tinctorium A. Rich is a member of Cochlospermaceae family and a widely distributed shrub in the West African sub-region and grows abundantly in uncultivated farmlands [1, 2]. The plant has been claimed to cure many diseases in the areas where it flourishes. They include: the use of the root decoction as fever remedy in Ghana, for the treatment of piles, pneumonia, burns, bruises, veneral diseases, stomach disorders, antidote to snake venom, purgative, mensural troubles, urethral discharges, reduced labor difficulty and bark decoction for the treatment of hernia [1, 2]. Other uses to which the plant is put in to includes management of epilepsy [3], flavoring of food in Nigeria, coloring agent for shea butter leaves as fodder for animals, stems as binding materials and root decoction as beverage, liniment, lotions and eye bath or drops [1]. Some studies elsewhere [4 – 8] have justified the medicinal use of the plant and its phytochemical analyses have revealed the presence of alkaloids, flavonoids, saponins and tannins [8 – 10].

Normally the efficacy of therapeutic plants as curatives is often accounted for in terms of their organic constituents not elemental components, though chemical elements may take part in the medicinal uses of plants. In addition to that, there is the need to know the effects of increased exposure of man to abnormal amounts of trace metals [11].

However, the role of inorganic elements in animal and plant metabolism has long been established, but the effect and influences of these elements on administration of medicinal plants has relatively received little attention [12 – 13]. Therefore, it is pertinent to provide adequate biological input information relating the effects or biological changes due to long term and low level exposure to both trace and ultra-trace levels of toxic metals. To obtain such input information, it is necessary to look at the total exposure from all pathways, including air, food, water and dust. One must determine the total absorption and residual concentration in the various parts of the body and then determine the biochemical reactions taking place in the body at the potential binding sites (Metallo-enzymes and nucleic acids) [10, 14]. One such important pathways is the consumption of medicinal plants indiscriminately without due regard to possible side effects. It is thus important to determine the elemental contents of medicinal plants for pharmacological assays and their probable role in the curative process [12].

Therefore to the knowledge of these researchers there has not been any work done on the comprehensive elemental composition and the possible role the elements play in the therapeutic uses of the plant.

The method of instrumental neutron activation analysis (INAA) was used in the determination of the elemental composition of the leaves of C. tictorium A. Rich. INAA is based on the fact that whenever neutrons from their sources (nuclear reactions) are allowed to impinge on a sample of any ordinary material, some neutrons will be captured by some nuclei of constituent elements of the material and become excited. On returning to the ground state, γ-rays are emitted. The resultant nuclei are usually radioactive and have a unique half-life, mode of decay and energy for the emitted radiation(s) during decay. In most cases the radioactive nuclei undergoes β-decay which is accompanied by emission of γ-rays. Because the energies of the prompt γ- and β-rays are discrete and distinctive for each radioisotope, therefore multi-element INAA becomes feasible with the use of a resolution semi-conductor. Apart from high sensitivity of many elements by the method, INAA is not influenced by the chemical state of the elements under investigation. For these reasons, the method has been applied for the studies of several medicinal plants [13 – 15].

II. Materials and Methods

Fresh leaves of C. tinctorium A. Rich were collected from Zaria and its environs (Northern Nigeria) in polythene bags. The samples were thoroughly washed with distilled water, air dried and then oven dried at 60^o. The dried samples were then grinded and pulverized using pestle and mortar and then submitted for INAA with TRIGA research reactor and its associated spectrometer at Atominstitut, Vienna, Austria.

The INAA analysis was undertaken using two (2) irradiation regimes; short and long irradiations. For short irradiation about 200 mg of the well grinded and pulverized leaf samples were weighed in to polyethylene (PE) vials measuring 30 mmx5 mm diameter. The PE vial was carefully sealed with a heat sealing equipment in the Chemistry Laboratory at Atominstitut. The sealed samples were irradiated after each were held by a rabbit measuring 120x25 mm diameter and then tightly held in place for 60 seconds [10, 12 and 7]. After irradiation the samples were then removed from the rabbit and counted for 60 seconds in appropriate geometry using a high rate γ-spectroscopy system. The counting system consist of HPGe detector having efficiency of 14 % and FWHM and of 2.1Kev for 11732 Kev γ-line, an ORTEC 673 gated integrator amplifier, an ADC (Canberra 8713) and a loss free count (LFC) system. The capability of LFC system has been previously described elsewhere [18 – 20].

In the long irradiation regime, bout 400 – 500mg of the sample was weighed in to PE – container which was also heat sealed. This was then packed in a tube measuring 100x200 mm (diameter) and placed in a dry in a dry irradiation tube within the reactor.

These samples together with SRM (NBS 1573 Tomato leaves and NBS Spinach) were irradiated in the irradiation tube of TRIGA MARK reactor for 10 hours at a flux of $1.5x10^{12}\ s^{-1}cm^{-2}$. After decay for three (3) days, the samples and the SRMs were counted for 30 minutes. Subsequent measurements were repeated two (2) weeks and a month there after.

III. Results and Discussion

Table 1 below shows the average concentrations of elements analyzed in C. tinctorium A. Rich and standard reference materials (SMRs). The elements determined are As, Au, Ba, Br, Ca, Ce, Co, Cs, Eu, Fe, Hf, Hg, La, Lu, Nd, Rb, Sc, Sm, Sr, Ta,Tb, Th, U, W and Zn.

Table 1: Concentration of major, minor and ultra-trace elements in C. tinctorium A Rich leaves in ppm unless otherwise stated.

Element	Concentration				
	C. tinctorium	SRM 1570 (Spinach)		SRM1573 (Tomato)	
		Measured	Certified	Measured	Certified
Al	_	1000.00±1.10	_	_	_
As	45.00±14.0 ppb	_	_	24100.00±1.90	_
Au	2.72±4.33 ppb	_	_	_	_
Ba	475.00±1.50	_	_	60.90±7.30	55.0±9.0
Br	9.27±0.32	46.00±7.70	_	16.00±0.60	_
Ca	0.796±2.40%	_	_	2.41±0.05	3.9±0.5
Ce	6.78±1.92	_	_	1.10±7.80	_
Cl	_	6660.00±0.80	_	_	_
Co	0.581±2.70	_	_	496.00±2.80 ppb	_
Cr	1.25±6.76	_	_	3.50±2.91	3.90±0.5
Cs	0.146±9.80	_	_	79.90±16.40	_
Eu	0.147±3.60	_	_	20.10±7.30	_
Fe	630.00±1.90	_	_	589.0±11.00	550.00±140.0
Hf	0.946±1.40	_	_	190.00±5.30 ppb	_
Hg	77.40±25.00 ppb	_	_	_	_
K	_	2.96±2.30 %	1.40±0.14	_	_
La	10.30±0.40	_	_	532.00±3.20	_
Lu	22.50±6.02	_	_	9.50±28.00 ppb	_
Mg	_	6188±20.60	_	_	_
Mn	_	163.00±0.30	165.0±9.0	_	_
Na	_	1.37±0.30 %	_	_	_
Rb	33.40±2.20	_	_	17.20±3.40	17.0±3.0
Sb	_	_	_	70.80±23.00	_

Sc	0.224±1.10	_	_	157.00±1.30	_
Sm	0.805±0.59	_	_	61.60±2.39 ppb	_
Sr	65.8±8.00	_	_	50.40±8.10	46.0±12.0
Ta	68.20±15.80 ppb	_	_	20.00±27.10 ppb	_
Tb	0.168±9.40	_	_	_	_
Th	1.12±1.40	_	_	185.00±5.40ppb	_
U	0.832±10.20	_	_	_	_
V	_	2.30±28.10	_	_	_
W	54.90±18.60 ppb	_	_	_	_
Zn	24.20±2.10	_	_	59.50±1.30	61.50±5.0

- Not determined

Ca, Ba and Sr concentrations are 0.796 %, 475.00 ppm and 65.80 ppm respectively. Ca is the element that is required in largest amounts in animal's diet. It is the element needed in bone formation in animals and it must be in proper proportion to that of phosphorus and is expressed as the calcium to phosphorus ratio (Ca/P). So, involvement of C. tinctorium A. Rich in human and animals' diet will surely alleviate Ca deficiency diseases [21]. Ba and its compounds are known to be highly poisonous and can cause death through ventricular fibrillation of the heart. This toxicity of Ba is related to its ability to substitute for Ca in muscle contraction and most edible plants have a common ratio Ba/Ca from 10^{-6} to 10^{-3} [13] while similar pattern of concentration of Sr is similar to that Ba and Ca.

Rb and Cs have concentrations of 33.40 ppm and 0.146 ppm respectively. These metals are radioactive, their isotopes are short lived and concentrations within tolerable limits [13].

Arsenic (As) concentration C. tinctorium A. Rich is 45.00 ppb and the metal is highly toxic when concentrations are high, but the concentration in the plant is within tolerable level. However, long term consumption of the plant may lead to the bioaccumulation of the element to toxic levels.

Br concentration is 9.27 ppm and it is normally in tissue cells of animals at low concentration. Its major role in acid/base regulation and maintaining osmotic balance [21] and therefore C. tinctorium A. Rich is a good source of it.

Co, Cr, Fe, Sc, and Zn have their concentrations 0.581, 1.25, 630.00, 0.224 and 24.20 ppm respectively. Co is essential in living organisms at <1.0 ppm level but at high concentration it is known to cause dermatitis, nausea/vomiting by local irritation in man. Cr is believed to be involved in insulin production and utilization, cholesterol, and protein metabolism and whose deficiency include nausea, vomiting, peptic ulcer, CNS disorder, Liver/kidney dysfunction and growth retardation. Iron is essential for human body in the production of hemoglobin and in oxygenation of red blood cells. It is needed for a healthy immune system and for energy production. Severe iron deficiency results in anemia and red blood cells that have a low hemoglobin concentration [22]. Zinc is involved in RNA and DNA synthesis, which influences cell division, repair and growth. Accordingly, zinc may help to prevent growth of abnormal cells associated with cancer. Zinc has been used to enhance wound healing and to prevent or treat impaired acuity of taste, smell and night vision. Lack of zinc in the body causes rapid egesting on the surface of wound which may delay quick healing [23]. Some these uses are inconformity with the local treatments to which C. tictorium A. Rich is put in to as claimed by the communities where it is grown [1 – 8].

Au, Hf, Hg, La, Ta, Lu Nd, Sm and W concentrations are 2.70 ppm, 0.946 ppm, 77.40 ppb, 10.30 ppm, 68.20 ppb and 54.90 ppb. The dermatological and rheumatoid action of C. tinctorium A. Rich may be associated with the presence of Hg while antiseptic and diuretic activity may be as a result of the presence of Au in the plant. However, presence of Hf, La, Ta, Sm, Nd and W may be an inherent property of the plant which may be related to soil type and pH conditions of the soil.

Moreover, the same table (Table 1) above shows results of determinations of certified reference materials SRM 1570 (Spinach leaves) and SRM 1573 (Tomato leaves) for comparison with that obtained for C. tinctrium A. Rich. It reveals that, for most of the elements, there is an agreement between the values obtained in the plant and the certified samples.

IV. Conclusion

The trace metal content in C. tinctrium A. Rich had been detected by INAA as it is one of the most powerful techniques for its rapid, non-destructive, accurate, precise and multi-element capability. Each of the determined elements has specific roles it plays in plants and animals and therefore, there is a need to determine the structures of the compounds that contains these elements. The different concentrations of the major, minor and trace elements in C. tinctorium A. Rich leads to the conclusion that it could have both medicinal and nutritional roles, though long term accumulation of the plant may lead to the bioaccumulation of the toxic metals.

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