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RESEARCH ARTICLE

Nutritional and Potential Trace Elements Assessment in Few Edible Tuber Crops from Two Blocks of Kandhamal district of Odisha

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Study Area: Kandhamal Odisha, India
Coordinates: 83.30°- 84.48°N; 19.34° - 20.54°E

Key words: *Dioscorea* spp., Mineral elements, XRF technique

Abstract

Six different tuber crop species namely *Dioscorea bulbifera, Colocasia esculenta, D.glabra, D.tomentosa, Maranta arundinacea,* and *Ipomoea batatas* were collected and analyzed to find out the presence of different elements. The result clearly revealed that the different varieties of tuber crops constitute the rich source of mineral elements in different concentrations. Six species were tested for detection of 20 mineral elements and 19 mineral elements were detected by X-Ray Fluorescence (XRF) analysis and Cobalt was not present in any of the tested species. The result indicated that six elements viz, Phosphorus, Sulphur, Chlorine, Potassium, Calcium and Iron were detected in all the six tested species. The highest of 83.51% potassium was detected in *D.glabra*, maximum of (29.82%) calcium in *I. batatas* and highest of 7.001% iron in *D.bulbifera*. The trace elements fall intolerable limits for human consumption.

Introduction:

Roots and tubers contain carbohydrates that provide more dietary energy in comparison to cereal grains and are therefore both nutritionally and economically important. Tubers are sourced from diversified plant sources. Approximately 836 million tons of tuber crops are produced annually in the world. Asian countries lead in producing 33% root and tuber crops. Different species are consumed as tubers but cassava, potatoes, and sweet potatoes consist of 90% of total worldwide yield and directly provide more than 25% available energy in 17 countries in the world (FAOSTAT; www:faostat3.fao.org). These crops are important because of the longer period of storage under the ground. Major tuber crops are potato (*Solanum tuberosome* L), sweet potato (*Ipomea batatas* (L.) LAM., arrowroot (*Maranta arundinacea* L.), Colocasia, yam (*Dioscorea* species), cassava (*Manihot esculenta* Crantz.) and elephant foot yam (*Amorphophallus* Sps.). Tuber crops are considered important crops because of their withstanding ability in tolerable limits (Plucknett, 1983; Parida & Sarangi, 2021). Most of the countries in the world depend on root and tuber crops as the staple food and the energy supply within the population varies depending on the country from 0 to 56%. The main producer of root and tuber crops in Asia. Nutritional content varies with variety, location, soil type and other microenvironmental parameters including cultivation practices. According to research data, it was estimated that 80% of the tribal people of India depend on forest products including wild edible tuber species to get nutrient supplements as well as avoid food scarcity and also a source of income (FAO, 2004; Edison *et al*., 2006). Tubers having nutritional properties have been studied from time to time in different parts of India by several researchers (Sujatha & Renuga, 2013; Kumar *et al*., 2012; Kumar, 2015).

Protein content in tuber crops is very less and ranges from about 1 to 2% on the basis of dry weight. Some root and tuber crops contain vitamin C and some yellow varieties contain beta-carotene. Calcium, magnesium and copper deficiencies are common in developed and developing countries. Literature data revealed that over 60% of the world's population are iron deficient, both zinc and iodine-deficient is 30% and 15% selenium. About 22 mineral elements are required by human beings for their wellbeing. Therefore, mineral malnutrition can be solved by supplemented fortified food, by choosing dietary diversification plant sources rich in minerals. Besides these benefits of the tuber crops as supplementary food, these simultaneously can be analyzed for their heavy metal composition because vegetables, leafy vegetables and tuber crops also are not only the source of nutrients but also contain toxic metals from contaminated soil, water and also from the air. Heavy metals are toxic in very trace amounts in both elemental and soluble salt forms because of biological

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half life cycles and accumulation capability in different organs causing different health problems. There is no mechanism of elimination of these trace elements from the body.

Both essential (Fe, Zn. Mn, Cr, Cu) and non-essential (Cd and Pb) heavy metals in high amounts in the soil, water and atmosphere can cause consequential problems to live organisms (Pickering & Owen, 1997; Alloway, 1990). Heavy metals are accumulated easily in the root and tuber crops and metal uptake is dependent on the forms of the chemical of the metal in the soil. Edible tuber crops can accumulate high concentrations of heavy metals in the contaminated soil. Data revealed from the literature revealed that vegetables absorb these metals from highly contaminated soils. X-ray fluorescence (XRF) analysis provides useful elemental information of the specimens without any complicated specimen sample preparation. .

Materials and methods:

Study area: six tuber crop samples were collected randomly from villages of Raikia and G.Udayagiri blocks of Kandhamal district of Odisha to analyze the mineral composition of the tuber crops. The district lies at 300-1100-meter altitude with ~8,021 km² area.

Plant identification: the tuber crops specimens were brought for thorough study and identification. The characters of the plant specimens were identified after verifying the characteristics of the following "The Botany of Bihar Orissa" (Haines, 1921-1925) and "The Flora of Orissa" (Saxena & Brahmaam, 1994-1996) and also following the recent monographs.

Macro and Micronutrient analysis: the six different collected tubers were washed separately with distilled water to remove mud and dust particles. One gm. of this raw sample was taken and different elements present in the selected six types of tubers were investigated quantitatively by using X-ray Fluorescence (XRF) technique, which is a non-destructive and effective method for elemental analysis. XRF technique was carried out at Advanced Testing and Calibration laboratory in Centurion University of Technology and Management.

Results and Discussion:

Six tuber specimens were analyzed for quantification of elements and were depicted in Table 1. Out of 92 naturally occurring chemical elements, 28 elements are essential for human life. Major or quantity elements present in the body of human beings are calcium, phosphorus, sodium, potassium, Sulphur, chlorine and magnesium. Essential trace elements having specified biochemical functions are iron, cobalt, chlorine, sulfur, Cu, Zn, Mn, Mo, I and Se. Elements like Br, Si and Sr are not reported for any biochemical function. Strontium is known to promote calcium uptake and utilization in the body at a moderate dietary level of strontium. The higher dietary level shows rachitogenic action i.e. rickets producing action (Nielsen, 1999). Rubidium (Rb), Tin (Sn) is having very little evidence for their benefits in biological action in mammals. Samarium (Sm), Europium (Eu), Erbium (Er) and Rhenium (Re) have not been reported for the biological activity in mammals. Bromine (Br) is one of the essential elements for the development of tissue in human beings.

The results of XRF analysis clearly revealed that the different varieties of tuber crops constitute the rich source of mineral elements (Table 2). Six species viz. *D.bulbifera, C.esculenta, D.glabra, D.tomentosa, M.arundinacea* and *I.batatas* (Kandamula) was tested for the detection of 20 mineral elements. It was observed that a maximum of 19 mineral elements (Fig.-1 to Fig.-6) was detected by X-Ray Fluorescence (XRF) analysis except for Cobalt (Co) which was not found in any of the tested species. These identified elements were Silicon (Si), Phosphorus (P), Sulphur (S), Chlorine (Cl), Potassium (K), Calcium (Ca), Titanium (Ti), Manganese (Mn), Iron (Fe), Copper (Cu), Zinc (Zn), Tin (Sn), Samarium (Sm), Europium (Eu), Erbium (Er), Rhenium (Re), Rubidium (Rb), Strontium (Sr) and Bromine (Br) (Table-2). It was observed that Cobalt was not detected in all these tested varieties. The result also indicated that six elements viz., P, S, Cl, K, Ca and Fe were present in all the six tested species (Table-2).

Silicon was present in all the species except *D.tomentosa. C.esculanta* shown to contain a minimum amount of silicon with 1. 057% and maximum silicon were estimated with about 9.73% in *D.bulbifera*. Europium (Eu) was only detected in *D.tomentosa* with 1.13%. Tin (Sn) was present only in *C.esculanta* with 0.2% only. Cu was detected only in four species namely *C.esculanta, D.glabra, D.tomentosa* and *M.arundinacea* with 0.1, 0.17, 0.34 and 0.4% respectively. Only 0.38% of Br was detected in *D.glabra* and in the rest species, it was not detected. Zn was found in all the species except *Ipomea batatas* and varied between 0.06% in *C.esculanta* and 0.4% in *D.tomentosa*. Rhenium (Re) was not detected in I. batatas. Strontium (Sr) was detected only in *C.esculanta* with 0.04% only. Rubidium was detected in four species viz. *C.esculanta* with 0.23% and *D.glabra* with 0.8% while both *M.arundinacea* and *I.batatas* contained 0.2% only. Samarium (Sm) was detected in *D.bulbifera* and *I.batatas* 0.4 and 0.26% respectively. Europium was present only in *D.tomentosa* with1.13%. Erbium (Er) was detected in *C.esculanta, D.glabra* and *I.batatas* 0.46, 1.7 and 2.61% respectively. Three elements viz. Sm, Eu and Br were not detected in C.esculanta. In *D.bulbifera*, eight elements viz. Mn, Cu, Sn, Eu, Er, Rb, Sr and Br were found to be absent but the highest amount of silicon, sulphur, samarium, chlorine, iron was detected. In *D.glabra*, three elements viz. Ti, Sn, Er and Sr were also not detected. A maximum of 10 elements was found to be absent in *I.batatas* followed by nine elements in both *D.bulbifera* and *M.arundinacea*. Out of 20 mineral elements Cobalt was

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not present in any of the either tested species. Besides cobalt other three elements viz. Sm, Eu and Br were not detected in *C.esculanta*. Seven elements were not detected in both *D.glabra*, and *D.tomentosa*. Other 12 elements present in *D.glabra* were Si, P, S, Cl, K, Ca, Fe, Cu, Zn, Er, Re, Rb and Br while other 12 elements viz. P, S, Cl, K, Ca, Mn, Fe, Cu, Zn, Sm, Eu, Re and Rb were detected in *D.tomentosa*.

Table-1: Names in various forms and family of Tuber crop specimen samples for detecting elemental analysis

Odia	Common	Botanical name	Family
Saru	Taro	*Colocasia esculanta*	Araceae
Pita Alu	Bitter yam	*Dioscorea bulbifera*	Dioscoreaceae
Taragaialu	Asiatic bitter yam	*D. tomentosa*	Dioscoreaceae
Saraga Aalu	Wild yam	*D. glabra*	Dioscoreaceae
Kandamula	Sweet potatoes	*Ipomoea batatas*	Convolvulaceae
Palua	Arrow root	*Marantaar undinacea*	Marantaceae

Elemental analysis has shown that the presences of different types of elements having an important role in the treatment of various ailments are present in all the six studied plants. Nutritional analysis of a few green leafy vegetables has also been studied (Mohanty *et al.*, 2020) and showed variation in elemental composition. Minerals like Ca, k, Mn are responsible to repair worn-out cells, strong bones and teeth, red blood cell productions and other important mechanisms of cells and are essential for disease prevention. Potassium is required to transmit the messages and regulation of contractions of muscles and *D.glabra* contains the highest potassium followed by *D.bulbifera* and *D.tomentosa*. *C.esculenta* contains the highest potassium followed by *M.arudinacea* and I. batatas. Elements such as P, S, K, Ca, Mn, Cu, and Zn are reported to be essential in the regulation of blood sugar level in the human body and production of insulin. In the biosynthesis, storage, and secretion of insulin zinc has a vital rolein the maintaining structural integrity of insulin. Calcium is an essential component for skeletal muscle and adipose tissue. A low level of calcium concentration is required for optimal insulin-mediated functioning. Many research works have shown that calcium supplementation might reduce the risk for type II diabetes. In this study highest of 83.51% potassium was detected in *D. glabra*, maximum of (29.82%) calcium in *I.batatas* and highest of 7.001% iron in *D.bulbifera*. Literature data revealed that recommended dietary Allowance (RDA) of iron for women is 18mg/day in between 11 to 50 years of age and 10 mg/day for men above 19 years. Zinc is important for the production of hormones. RDA is 15 mg/day for zinc for people above 11 years of age (NRC, 1980). But excess amount of zinc inhibits absorption and utilization of iron and copper. National Research Council recommended daily dietary zinc intake of 0.5 to 1.0 mg/day for infants, 1.0 to 2.5 mg/day for children and 2 to 3 mg/day above 11 years of age (NRC, 1980). Daily intake of iodine is much higher than recommended daily dose for all age group (Pennington *et al.*, 1986) as it is an essential component of thyroid hormones and its deficiency cause goiter. Manganese is known for carbohydrate metabolism and also functions as co factor and safe dose is 0.5 to 1.0, for infants, 1.0 to 3 mg/day for infants and up to 10 years of children respectively and 2.5 to 5 mg/day for adults (Hurley & Keen, 1987). Plant based foods especially cereals contain 10 to 100 mg/kg and are the best sources of Mn (Kazantzis, 1981). Dietary manganese is nontoxic (Ulrich, 19799). It has been reported that high molybdenum intake above 0.5 mg can balance Cu deficiencies (Golden *et al.*, 1985). Dietary safe dose falls in between 0.15 mg to 0.5 mg. for adults and above this recommended dose it can compromise copper balance and more than 10 to 15 mg/day is reported to be associated with gout (Koval'skii *et al.*, 1961).

Table 2. Elements from six spp. of tuber crops by XRF method

Elements	Tuber crop species/Values (%)					
	D.b	*C.e*	*D.g*	*D.t*	*M.a*	*I.b*
Silicon (Si)	9.73	1.057	1.25	-	5.99	2.85
Phosphorus(P)	5.5	3.69	6.77	4.2	5.5	4.25
Sulphur(S)	3.75	1.7	3.13	3.81	3.42	3.2
Chlorine (Cl)	8.62	0.35	2.37	4.8	5.04	3.14
Potassium(K)	37.76	65.25	83.51	67.88	63.97	51.21
Calcium (Ca)	25.81	25.18	0.77	16.16	13.49	29.82
Titanium (Ti)	1.08	0.17	-	-	-	-
Manganese (Mn)	-	0.46	-	0.03	0.93	0.96
Iron (Fe)	7.001	1.05	0.77	0.73	1.1	1.64
Cobalt (Co)	-	-	-	-	-	-
Copper (Cu)	-	0.1	0.17	0.34	0.2	-
Zinc (Zn)	0.23	0.06	0.2	0.4	0.35	-
Tin (Sn)	-	0.2	-	-	-	-
Samarium (Sm)	0.4	-	-	0.26	-	-
Europium (Eu)	-	-	-	1.13	-	-
Erbium (Er)	-	0.46	1.7	-	-	2.61
Rhenium (Re)	0.1	0.02	0.01	0.07	0.03	-
Rubidium (Rb)	-	0.23	0.08	0.2	-	0.2
Strontium (Sr)	-	0.04	-	-	-	-
Bromine (Br)	-	-	0.38	-	-	-

D.b-D. bulbifera, C.e- C. esculanta, D.g-D. glabra, D.t-D. tomentosa, M.a-M.arundinacea,I.b-I. batatas

Conclusively, Tuber crops have the potentiality to be sustainable crops because of their use in food, medicine and other industrial uses. This study will help for developing newer fortified foods and also will give the insight to meet the needs of the industry in the upcoming years for sustainable development to preserve the raw tubers as well as the processed products rich in nutrients that will help the tribe to generate their livelihood. The study shows that the mineral composition of tuber crops may contribute to awareness about the presence of an excessive amount of trace elements and toxic metals in finding out suitable soil resources to cultivate these tuber crops for the fulfilment of nutritional requirements. Essential trace elements present in six tuber crops were analyzed using the XRF method to fall within the tolerable limits for human consumption.

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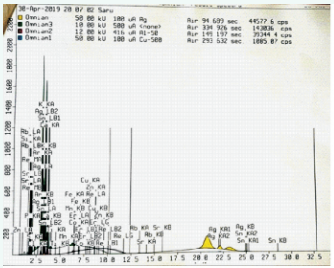

Figure-1: XRF spectra of *C.esculanta*

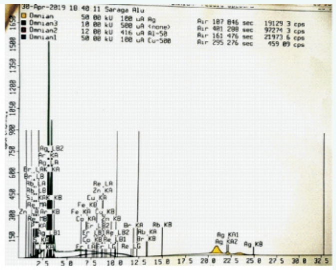

Figure-2: XRF spectra of *D.glabra*

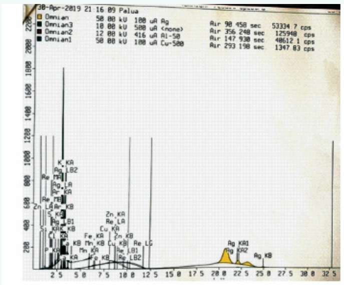

Figure-3: XRF spectra of *M.arundinacea*

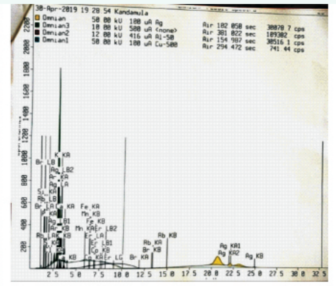

Figure-4: XRF spectra of *I.batatas*

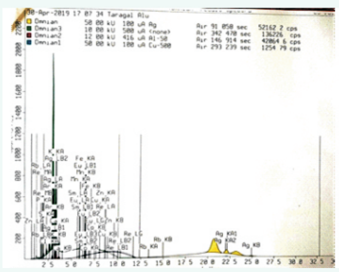

Figure-5: XRF spectra of *D.tomentosa*

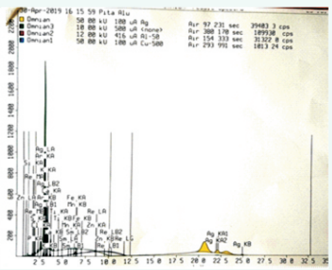

Figure-6: XRF spectra of *D.bulbifera*

Further studies can be taken to find out the relationship between elements content of soil sample with the tuber crop species.

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