Research Journal of Applied Sciences, Engineering and Technology 6(19): 3536-3539, 2013
DOI:10.19026/rjaset.6.3557
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: October 30, 2012 Accepted: December 23, 2012 Published: October 20, 2013

Research Article

Determination of the Elemental Composition of the Pulp, Seed and Fruit Coat of Black Velvet Tamarind (*Dialium guineense*) using Instrumental Neutron Activation Analysis

[1, 2]D.O. Ofosu, [4]N.S. Opata, [2, 4]O. Gyampo and [2, 3]G.T. Odamtten
[1]Biotechnology and Nuclear Agricultural Research Institute, Ghana Atomic Energy Commission, P.O. Box LG 80, Legon-Accra, Ghana
[2]School of Nuclear and Allied Sciences, University of Ghana, Legon, P.O. Box AE 1, Kwabenya, Accra, Ghana
[3]Department of Botany, University of Ghana, Legon, P.O. Box LG 55, Legon-Accra, Ghana
[4]National Nuclear Research Institute, Ghana Atomic Energy Commission, P.O. Box LG 80, Legon-Accra, Ghana

Abstract: This study sought to provide data on the mineral composition of the fruit pulp, outer coat and seed of *Dialiu guineense* in an attempt to widen the sources of minerals for the rural population of sub-Saharan Africa. The elemental composition of the pulp, seed and fruit coat of black velvet tamarind (*Dialium guineense*) was determined using Neutron Activation Analysis. The fruit pulp contained manganese (23.40±1.57μg/g), chlorine (205.40±37.59 μg/g), calcium (5671.00±2132.30 μg/g), sodium (332.95±8.76 μg/g) and potassium (6190.00±711.85 μg/g). The seed and fruit coat contained all these minerals except potassium and sodium respectively. The fruit pulp can serve as a good source of macrominerals for humans while the fruit coat and seed could be ground and incorporated in various meal formulations of livestock as mineral supplements.

Keywords: *Dialium guineense*, macrominerals, mineral deficiency

INTRODUCTION

It has been reported that millions of people in Sub-Saharan Africa are affected by mineral deficiency (UNICEF, 2009; UNICEF and TMI, 2004). Minerals known to be essential to a healthy body include calcium, phosphorous, cobalt, copper, fluorine, iodine, iron and sodium. The role of these minerals in body metabolism is of prime importance. Their deficiency causes diseases, whereas their presence in excess may result in toxicity to human life (Hashmi *et al*., 2007).

Wild edible fruits are being investigated for their potential use as food supplements, especially in treating vitamin and mineral deficiency, in the Sahelian region to increase the quality of daily food for the rural population (Glew *et al*., 2005; Okafor, 1981; Getahun, 1974). Examples of well known wild edible fruit species in Africa include baobab (*Adansonia digitata*), jackalberry (*Diospyros mespiliformis*), sycamore fig (*Ficus sycomorus*), tamarind (*Tamarindus indica*), shea tree (*Vitellaria paradoxa*; = *Butyrespermum parkii*) and black velvet tamarind (*Dialium guineense*) (Lamien-Meda *et al*., 2008).

Black velvet tamarind *(Dialium guineense),* a forest tree, is well known in many localities especially in West Africa. Small black velvet fruits are characteristic of the genus. The tree grows to about 20 m in height, 0.8 m in diameter, low-branching, rarely straight, bearing a compact densely leafy crown but is often shrubby (Okegbile and Taiwo, 1990; Burkill, 1985; Keay *et al*., 1964).

The extracts from the leaves and seed coat have been reported to be very rich in Vitamin C (Maduako, 1988). Proximate analysis of the pulp showed that it contained 17.75% moisture, 4.76% protein, 10.00% crude fat, 5.00% crude fibre, 2.5% ash and 59.99% carbohydrate (Arogba *et al.*, 1994; Ajiwe and Umoru, 1988).

There is limited information in the literature about the mineral composition of the various components of the fruits of *Dialium guineense* except for a partial account by Adepoju (2009). This study therefore, sought to provide data on the mineral composition of the fruit pulp, outer coat and seed of *D. guineense* in an attempt to widen the sources of minerals for the rural population of sub-Saharan Africa.

MATERIAL AND METHODS

Sample collection and identification: *Dialium guineense* fruits were bought from the Akatsi market in the Akatsi District in the south eastern part of the Volta

Corresponding Author: D.O. Ofosu, Biotechnology and Nuclear Agricultural Research Institute, Ghana Atomic Energy Commission, P.O. Box LG 80, Legon-Accra, Ghana

Table 1: Nuclear data (IAEA-TECDOC-564) for the elements of interest

Element	Isotope (% Abundance)	Nuclide	Cross-section (barn)	Half-life	γ-Ray energy used (keV)
Al	^{27}Al (100)	^{28}Al	0.232	2.241 min	1.779.0
Br	^{79}Br (50.69)	^{80}Br	148±4	17.68 min	616.8
Ca	^{48}Ca (0.187)	^{49}Ca	1.1±0.2	8.72 min	3,084.4
Cl	^{37}Cl (24.23)	^{38}Cl	0.428±0.005	37.2 min	1,642.7
Co	^{59}Co (100)	^{60}Co	17±2	5.272 years	1,173.5, 1,332.5
Cu	^{65}Cu (30.9)	^{66}Cu	2.17±0.03	5.09 min	1,039.2
Fe	^{58}Fe (0.28)	^{59}Fe	1.15±0.02	44.5 days	192.3, 1,099.3
I	^{127}I	^{128}I	6.2±0.2	25.0 min	442.9
K	^{41}K (6.73)	^{42}K	1.46±0.03	12.38 h	442.9, 1,524.7
Mg	^{26}Mg (11.01)	^{27}Mg	0.0382±0.001	9.46 min	843.8, 1,014.4
Mn	^{55}Mn (100)	^{56}Mn	13.3±0.2	2.58 h	846.8
Na	^{23}Na (100)	^{24}Na	0.530±0.005	14.95 h	1,368.6, 2,754.0
V	^{51}V (99.75)	^{52}V	4.88±0.04	3.743 min	1,434.1

Table 2: Validation of elemental concentrations of samples in (mg/kg) using standard reference materials

(NIST) Standard Reference Material (SRM) 1547 peach leaves validation using NAA

Elements	This work	Reported value
	Concentration, mg/kg	Concentration, mg/kg
I	0.282±0.042	0.3
Mn	93.968±3.452	98±3
Cu	3.695±0.860	3.7±0.4
Cl	349.365±24.121	360±19
Al	224.574±2.149	249±8
Cd	0.026±0.004	0.026±0.003
Br	15.452±2.986	11
Na	46.529±1.444	24±2
K%	2.243±0.028	2.43±0.03
Mg%	0.400±0.019	0.432±0.008
Ca%	1.609±0.032	1.56±0.02

Region of Ghana. This is the main source of the *D. guineense* fruits in Ghana. After the collection, the fruit samples were taken to the Ghana Herbarium GC, Department of Botany and University of Ghana for identification. All fruits used in this research were ripe and without any visibly identifiable damage or blemish.

Sample preparation: Sample preparation was carried out in the sampling preparation room of the Ghana Research Reactor-1 Centre at the Ghana Atomic Energy Commission. The fruits were separated into their component fruit coat, pulp and seed. Each component was then pulverized in a vibrating disk mill. 200 mg of each sample was weighed into clean polyethylene films. The films were wrapped and heat-sealed. Three replicate sub-samples were prepared, packed into polyethylene irradiation vials and heat-sealed.

Standard reference material: The Standard Reference Materials (SRM) used (NIST 1547 Peach Leaves and NIST 1572 Citrus) were obtained from the US National Institute of Standard and Technology and were analyzed for internal quality control. The SRMs were treated the same way as the samples.

Sample irradiation, counting and analysis: The irradiation and counting of samples have been previously described by Serfor-Armah *et al*. (2010). The samples and the controls were irradiated at the Ghana Research Reactor-1 (GHARR-1) facility at the Ghana Atomic Energy Commission, Kwabenya, operating at 15 kW at a thermal flux of 5 X 10^{11} ncm^2/s^1. The samples were transferred into irradiation sites via pneumatic transfer systems at a pressure of 1.723 bars. The irradiation was categorized mainly according to the half-life of the elements of interest. The nuclear data of the elements of interest are shown in Table 1 (IAEA, 1990).

The counting of the induced radioactivity was performed by a PC-based γ-ray spectrometry. It consists of an n-type HPGe detector coupled to a computer-based Multichannel Analyzer (MCA) via electronic modules. The relative efficiency of the detector is 25% and its energy resolution of 1.8 keV at a γ-ray energy of 1,332 keV of ^{60}C.

RESULTS AND DISCUSSION

NIST Standard Reference Material (SRM) 1547 peach leaves were validated using NIST Standard Reference Material (SRM) 1572 Citrus Leaves (Table 2). The elements in the samples (fruit coat, pulp and seed) were detected using Instrumental Neutron Activation Analysis (INAA) and concentrations were calculated on dry weight basis in triplicate.

The mean elemental composition of the fruit coat, pulp and seed showed the presence of manganese, chloride, calcium, sodium, magnesium and potassium in varying quantities (Table 3). The fruit pulp contained all the minerals of interest in this study; the seed contained all but potassium while the fruit coat lacked sodium.

The results obtained in this present study are comparable to the study by Adepoju (2009) on the pulp of *D. guineense*. However, owing to the difference in methods used in assessing the mineral composition, the present study gave relatively higher values.

Manganese and magnesium were highest in the seed (574.20±94.17 µg/g and 4401.00±321.27 µg/g, respectively) as compared to 23.40±1.57 µg/g and 910.10±174.74 µg/g in the pulp. Dara (1993) asserts that a daily intake of 2.5 to 5 mg of manganese contributes to the well-being of cells. Manganese

Table 3: Elemental composition of the fruit coat, pulp and seed of *D. guineense*

	Concentration (μg/g)		
Element	Fruit coat	Pulp	Seed
Manganese	88.81±14.83	23.40 ± 1.57	574.20±94.17
Chlorine	203.3±37.20	205.40±37.59	131.90 ± 46.66
Calcium	5428±2040.93	5671.00±2132.30	5954.00±2238.70
Sodium	ND	332.95 ± 8.76	365.58 ± 11.05
Magnesium	874.2±167.85	910.10±174.74	4401.00±321.27
Potassium	5.64 ± 0.85	6190.00±711.85	ND
Aluminium	136.1±21.64	161.40±25.66	275.40±43.51
Vanadium	0.42±0.08	0.46±0.09	1.19±0.16

ND-not detected

deficiency causes diseases and excess of it is known to cause poisoning of the central nervous system. Absorption, ingestion, inhalation or skin contact may cause manganic pneumonia (Underwood, 1997). Magnesium is a very important micronutrient required for bone formation and aids enzyme action and nerve heartbeat functions (Witney and Rolfes, 2005). Calcium was present in all three parts of the fruit (coat, pulp and seed) in varying concentrations; it was highest in the seed (5954.00±2238.70 μg/g) and least in the fruit coat (5428±2040.93 μg/g). Calcium is a very important mineral and very essential in human diet. It plays a role in the formation of bones and is also essential for blood clotting and muscle contraction (Wardlaw and Smith, 2006). Its presence in the pulp albeit low is advantageous to the consumer. For adults, daily calcium intake of 1,000 mg is required. In children, this intake is higher. If calcium is taken in low quantities or if it does not meet the body's requirements, the risk of rickets and osteomalacia may increase.

Chlorine, aluminium and vanadium are found in varying amounts in all three parts of the fruit of *D. guineense* analysed. Chlorine is an essential electrolyte located in all body fluids responsible for maintaining acid/base balance, transmitting nerve impulses and regulating fluid in and out of cells (Anonymous, 2012). Aluminium is thought to be involved in the action of a small number of enzymes such a succinic dehydrogenase and daminolevulinate dehydrase (involved in porphyrin synthesis). However, the body has a hard time ridding itself of excess aluminium (Anonymous, 2012).

Raisins have been reported to contain a similar mineral profile (Ghrairi *et al*., 2013). However, the levels of these minerals in this present study are higher than the results for raisins. Recent studies in Ghana have shown that the Volta clam (*Galatea paradoxa*) mantle contains these same elements which were found suitable for human consumption based on the WHO Safety Reference Standards (Serfor-Armah *et al*., 2010).

CONCLUSION

Calcium, chlorine, magnesium, phosphorus, potassium and sodium are macrominerals required by the body to function properly. Their presence in the pulp of the fruit of *Dialium guineense* (which is the portion that is normally eaten) and in the seed (except potassium) is an indication that *D. guineense* can be a good source of these macronutrients. The seeds of *D. guineense* can be ground and added to the meals of malnourished children to add up to the nutrient requirements. The fact that more than one fruit of *D. guineense* is consumed at a time will mean that these minerals will accumulate in the body. The fruits of *D. guineense* are thus recommended as snacks in the Sahelian region of Africa.

REFERENCES

Adepoju, O.T., 2009. Proximate composition and micronutrient potentials of three locally available wild fruits in Nigeria. Afr. J. Agric. Res., 4(9): 887-892.

Ajiwe, V.I.E. and U.P. Umoru, 1988. Basic data of some Igala feeding stuffs. Proceeding of 13th Annual Conference of Chemical Society of Nigeria, Bauchi, Nigeria.

Anonymous, 2012. Retrieved from: http://www.connectedearth.net/experiencinglife/Biology/Chemistry/elements.html, (Accessed on: 17 October, 2012).

Arogba, S.S., A.A. Ajiboro and I.J. Odukwe, 1994. A physico-chemical study of Nigerian velvet tamarind (*Dialium guineense* L) fruit. J. Sci. Food Agric., 66(4): 533-534.

Burkill, H.M., 1985. The useful Plants of West Tropical Africa. 2nd Edn., Kew Royal Botanical Gardens, Richmond, UK, 3: 858.

Dara, S.S., 1993. Environmental Chemistry and Pollution Control. 1st Edn., S. Chand and Co. Ltd., New Delhi, India, pp: 184-205.

Getahun, A., 1974. The role of wild plants in the native diet in Ethiopia. Agro-Ecosystems, 1: 45-56.

Ghrairi, F., L. Lahouar, E.A. Amira, F. Brahmi, A. Ferchichi, L. Achour and S. Said, 2013. Physicochemical composition of different varieties of raisins (*Vitis vinifera* L.) from Tunisia. Ind. Crop. Prod., 43: 73-77.

Glew, R.S., J. Dorothy, L.T. Chuang, Y.S. Huang, M. Millson and R.H. Glew, 2005. Nutrient content of four edible wild plants from West Africa. Plant Foods Hum. Nutr., 60: 187-193.

Hashmi, D.R., S. Ismail and G.H. Shaikh, 2007. Assessment of the level of trace metals in commonly edible vegetables locally available in the markets of Karachi city. Pak. J. Botany, 39(3): 747-751.

IAEA (International Atomic Energy Agency), 1990. Practical Aspects of Operating Neutron Activation Laboratory, IAEA, Vienna, pp: 197.

Keay, R.W.J., C.F.A. Onochie and D.P. Stanfield, 1964. Nigerian Trees. Department of Forest Research, Ibadan, pp: 25-27.

Lamien-Meda, A., C.E. Lamien, M.M.Y. Compaoré, R.N.T. Meda, M. Kiendrebeogo, B. Zeba, J.F. Millogo and O.G. Nacoulma, 2008. Polyphenol content and antioxidant activity of fourteen wild edible fruits from Burkina Faso. Molecules, 13: 581-594.

Maduako, A.U.C., 1988. Determination of the ascorbic acid content of velvet tamarind. Proceeding of 13th Annual Conference of Chemical Society of Nigeria, Bauchi, Nigeria.

Okafor, J.C., 1981. Woody plants of nutritional importance in traditional farming systems of the Nigerian humid tropics. Ph.D. Thesis, University of Ibadan, Ibadan, Nigeria.

Okegbile, E.O. and E.A. Taiwo, 1990. Nutritional potentials of velvet tamarind (*Dialium guineense* Wild). Niger. Food J., 8: 115-121.

Serfor-Armah, Y., C.M. Amoah, G.T. Odamtten, N.S. Opata and E.H.K. Akaho, 2010. Determination of elemental and nutrient composition of water, clam mantle and shell of the Volta clam (*Galatea paradoxa*) using neutron activation analysis. J. Radioanal. Nucl. Ch., 286(1): 39-45.

Underwood, E.J., 1977. Trace Elements in Human and Animal Nutrition. 4th Edn., Academic Press Inc., New York.

UNICEF, 2009. Investing in the Future: A United Call to Action on Vitamin and Mineral Deficiencies. ISBN: 978-1-894217-31-6.

UNICEF and TMI (The Micronutrient Initiative), 2004. Vitamin and Mineral Deficiency: A Global Progress Report. Retrieved from: siteresources. worldbank.org/NUTRITION/Resources/.../Bangladesh.p.

Wardlaw, G.M. and A.M. Smith, 2006. Contemporary Nutrition. 5th Edn., McGraw and Hill, USA.

Witney, E. and S.R., Rolfes, 2005. Understanding Nutrition. Thompson Learning Inc., New York, USA.