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MINERAL ELEMENTAL COMPOSITION OF *SYZYGIUM POLYANTHUM* (WIGHT). WALP

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Abstract

Analysis of elemental composition of *Syzygium polyanthum* (Wight) Walp cultivars used by malay ethnic group as *Ulam* and traditionally for treatement of various ailments in Peninsular Malaysia. The elemental composition was determine using Inductively coupled plasma-mass spectrometry (Icp-Ms) and Neutron activation analysis (NAA) techniques. Standard reference material was used. Concentration of the following element Ca, Mg, Mn, Na, K, Fe, ZN, Co, Cu, Cr, Ni, V, Al, Ba and Pb were determined. Values are significantly difference at ($pd<0.05$). Presence of the elemental Ca, Mg, Mn, Na, K, Fe, ZN, Co, Cu, and Cr in the examined plant parts are responsible for lowering effects of glucose; making them to be hypoglycemic. The study is the first of its kind to present profile of trace elemental composition of *Serai Kayu* and *Serai Kayu Hutan* despite its acceptability by the malay populace. The findings of the study should be utilised in the development of herbal product to avioid over exploitation of the plants in Peninsular Malaysia.

Key words : Elemental, *Syzygium polyanthum*, Medicinal plants.

Introduction

Medicinal plants serve as food contribute significantly to the well being of human as a results of they contain all the essential nutrients neeeded by human (Subramanian *et al.,* 2012). Since the ancient time man has been utilising plants as a source of food and health care system to his self and his domesticated animals, and as the only source that provides oxygen to both man and animal. Certainly, the great civilizations of the ancient Chinese, Indians and North Africans provided written evidence of man's ingenuity in utilizing plants for the treatment of a wide variety of ailments. In order to satisfy the curiosity and willingness to understand the way environment and plant are interacting to help man survive, the field of ethnobotany is becoming pronounced in the globe (Ong *et al.,* 2011; Abdulrahman *et al.,* 2018b). Many countries have adopted plants as the only source of their medical care due to the large costly price of modern medicine (Jouad *et al.,* 2001). Accessibility and cheapness of the medicinal traditional system are one of the main ideas that make man depend on the plant. World Health Organisation (WHO) in 2013 documented that about (80%) of the world population largely depend on the traditional medicinal system to treat their various ailments and improve their health status (Kala *et al.,* 2004). It is estimated that 70-80% of people worldwide rely on traditional herbal medicine to meet primary health care need, also used for income generation for livelihood improvement (Abdulrahman *et al.,* 2018b). There are approximately 250, 000 species of plants available globally, however, only 1% of tropical species

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have been studied for their medicinal properties. In the present contemporary world that makes people be conscious of their well-being; people are now looking for plants-based product to replace the expensive and synthetic product available all over the market (Ahmad *et al.,* 2017). The demand of the product from plants source as a natural product will continue to increase because of their ability to cure and improve health status (Lokhande *et al.,* 2009; Khandaker *et al.,* 2015). The products obtained from this plants parts (natural product) have no any side effect when consumed by children and adult when compared to the synthetic chemical drugs (Kala *et al.,* 2004). *Syzygium* is a genus of flowering plants belongs to the family of Myrtaceae and is widely grown throughout Malaysia and other South Asian countries (Moneruzzaman *et al.,* 2011). Some of the edible species of Syzygium are planted throughout the tropics worldwide (Moneruzzaman *et al.,* 2012). *Syzygium polyanthum* is a tree or shrub with approximately 20-50 meters tall, glabrous or greenish brown bark (Soh and Parnell, 2015). The traditional *Ulam* are generally cultivated at home and found in abundance in the market. The Malay people from Peninsular Malaysia are in the habit of taken *Ulam* (traditional vegetables) every day in their meal. More than one hundred (120) species of *Ulam* have been reported to be found in Peninsular Malaysia ranging from small trees (shrubs) to large ones. Among the preferred *Ulam* in Malaysia is *Syzygium polyanthum* that has been taking for ages and are widely distributed all over Asian countries (Ahmad *et al.,* 2017). *Syzygium polyanthum* cultivar is locally called *Serai Kayu* and *Serai Kayu Hutan* among the malay ethnic people in Malaysia (Abdulrahman *et al.,* 2018a). Whilst in Indonesia, it is named as Indonesian laurel or Bay leaf. The plant parts of these plants are widely used in cooking as a result of scent colour, flavour and odour. It is frequently used as flavour or spices to the dishes like vegetable, fish, meat, rice and many other types of food. This plant plays an important role in the preparation of one of the favourite meals in Malaysia called *nasi kerabu* and *kerabu perut* or consumed raw of leaves as *Ulam* (Abdulrahman *et al.,* 2018a). The plant is believed to cure a diverse number of ailments like hypertension, diarrhea, diabetes, endometriosis and many more diseases. In order to maintain good health, human body requires a number of minerals. Mineral elements, essential to human body are found in different part of the plants obtained from the cultivated environment (Subramanian *et al.,* 2012). Biochemical process is influenced in human body by macro and micro elements. Research on the elements on the medicinal plants utilised by the community will give a highlight on the contents of the macro and micro elements in the plants parts. Minerals in plants are divided into macro and micro traced minerals (Subramanian *et al.,* 2012). The macro and micro elements play a significant role treating a number of ailments in human body. Compounds naturally occurring in plants are termed as Phytochemicals. Any compounds or chemical that have biological activity (Lokhande *et al.,* 2009; Haidu *et al.,* 2017). Medicinal plants are consider naturally to have diverse number of elements which are off medicinal value to our body (Baþgel and Erdemoðlu, 2006). Some of the essential elements needed by our body include iron, zinc, calcium, and copper (Narendhirakannan *et al.,* 2005; Lokhande *et al.,* 2009). Thderefore, it is necessary to provide an insight of the mineral contents of medicinal plants consumed as food or as medicine. This present study aim at providing the level of mineral elemental composition in *Serai Kayu* and *Serai Kayu Hutan*.

Materials and Methods

Herbarium Deposition and Taxonomic Identification

Herbarium specimens were prepared for the collected sample of Serai Kayu and Serai Kayu Hutan from home gardens and natural habitat. The collected plants were identified in the field by a Botanist in the Universiti Sultan Zainal Abidin (UniSZA), after which the identified herbarium specimen was further taken to the University of Malaya (UM), Universiti Kebangsaan Malaysia (UKM) and Universiti Sultan Zainal Abidin (UniSZA) for further identification, and finally deposited at the respective Herbarium.

Mineral Element Analysis

Inductively coupled plasma-mass spectrometry (Icp-Ms)

The dried samples of the leaf, bark and root of *Serai Kayu* and *Serai Kayu Hutan* were oven dried for 24 hours at 60 ºC, then grounded to powder using grinding machine; 2.0g of each of the sample were weighed and digested in the 3:7 v/v mixture of perchloric acid and nitric acid using polyethylene plugged bottle (10 mL). the mixture was heated until it dissolved at 120 ºC, then filtered with filter paper and the volume was adjusted to 25 mL (deionized water). The digested sample was kept at 4 °C until analysis. The following elements; Ni, Cu, and Pb were determined from the digested samples using ICP-MS (Germany) instruments with the following conditions; viewing height (mm) 12, wavelength nm RF Power (W) 1450, spray chamber; cyclonic, nebulizer; modified lichte, nebulizer flow (L/min) 0.8, plasma torch Quartz, fixed, 3.0 mm injector tube, plasma gas flow (L/min) 13, auxiliary gas flow (mL/min) 0.7, sample aspiration rate (mL/min)

2.0 and sample pump rate (rpm) 25.

Neutron Activation Analysis (NAA)

Collected samples of the leaf, bark and root of *Serai Kayu* and *Serai Kayu Hutan* were oven dried for 24 hours at 60 ºC, then grounded to powder using grinding machine; 0.15-0.20g of each of the sample and 100 µL of standard solution were weighed into vials (polyethylene) respectively and immediately exposed to neutron irradiation in Triga MK-II reactor. The elements are detected from the leaf, bark and root of *Serai Kayu* and *Serai Kayu Hutan* using Instrumental Neutron Activation Analysis (INAA) respectively. Detection of element was through short-live radionuclides such V, Al, Ca, Mg and V required 1 minute irradiation, followed by 20 minutes cooling and 5 minutes counting times; while as Na and K, irradiation time of 1 minute was followed by 24 hours cooling and 20 minutes counting times. long-live radionuclides element example As, required 7 hours irradiation, then 3-5 days cooling and 2 hours counting times; while Ba, Cr, and Fe, Co and Zn requires 6 hours irradiation, followed by 20-30 days cooling and 1 hour counting times. The experiments were carried out in three replicates (Mat *et al.,* 2006).

Data Analysis

A simple descriptive analysis was used to determine the percentage and frequencies of the ethnobotany data. The data from mineral analysis was analyzed using Statistical Analysis System (SAS) software (University version 9.4). One way repeated ANOVA procedure was carried out and means were subjected to post hock Duncan's Multiple Range Test (DMRT) due to significant difference. The mean difference was significant at $p \leq 0.05$ level.

Results and Discussion

Voucher numbers of the collected specimen were given in the deposited herbarium of Universiti Sultan Zainal Abidin (UniSZA), Universiti Kebangsaan Malaysia (UKM) and Universiti Malaya (UM) (Table 1). Previously, Mat *et al*., (2006) and Khandaker *et al*., (2015) have reported submission of collected medicinal plants parts to the registered herbarium for identification and deposition. Traditionally the plants is reported to be used in tratement of various ailments by malay ethnic grouop in Peninsular Malaysia (Table 2). Previously Abdulrahman *et al*., (2018b) reported the plants as *ulam*. Reference standard material with biological origin analysed for quality control and validation of the method. The study observed most of the elements contents are found within or below of the accepted certified values. Relatively small standard deviation was reported (Table 3). In this context Lokhande *et al.,* (2009) reported similar pattern of results in studies of mineral content analysis of some medicinal plants. The ability of medicinal plants to healed depend on the Micro and macro nutrients; which are responsible for the functional and structural properties of the plants.

Studies revealed the plant parts contain different element composition as Ca, Mg, Mn, Na, K, Fe, ZN, Co, Cu, Cr, Ni, V, Al, Ba and Pb (Table 3). The results revealed the calcium content in the leaves of *Serai Kayu Hutan* to be highest among the examined parts at 10150 mg/kg, followed by the leaves of *Serai Kayu* at 7700 mg/kg and the root of *Serai Kayu* have the least concentrations of the calcium contents at 49 mg/ kg (Table 3). Calcium is the sole responsible for the maintainance of the nerve and muscle (Lokhande *et al.,* 2009). Mat *et al.,* (2006) reported calcium as engine for the activation of enzymes in the body, for dietary vitamin B absorption and synthesis of synthesis of the neurotransmitter acetylcholine. The magnesium contents was found to be between 1610 to 810 mg/kg in the *Serai Kayu* examine parts respectively (Table 3). Simailarly *Serai Kayu Hutan* was found in the range of 1280 to1030 mg/kg respectively (Table 3). Magnesium is one of the major cofactor in transportation of glucose and enzymes carbohydrate oxidation mechanisms in cell membrame. It is involved in binding activity, insulin secretion, glucose phosphorylation reactions (Sium *et al.,* 2006). Mat et al. (2006) reported magnesium as a sole responsible for the relesded of hormone responsible for the control blood glucose level in human. Manganese concentration was found between 46.8 to 10.8 mg/kg in both *Serai Kayu* and *Serai Kayu Hutan* respectively (Table 3). Manganese is an elements required in human body for biochemical process take place (Narendhirakannan *et al.,* 2005). It sole responsible for the elimination of nervous irritability and fatique (Mat *et al.,* 2006; Sium *et al.,* 2016). Previously, is reported as a good sources of antioxadants against free radicals (Koh *et al.,* 2014). Deficient of this particular element may end up in altering lipid and carbohydrate metabolism, impaired glucodse tolerance and insulic sectration and abnormalities in skeleton (Nicoloff *et al.,* 2004; Koh *et al.,* 2014). Sodium was found to be in high amount with highest concentration from the bark of *Serai Kayu* 2,170, followed by the bark of Serai Kayu Hutan 91.5 and the least concentrations was recorded from the root of *Serai Kayu* 131 mg/kg respectively (Table 3). Sodium is on of the essential elements required for the maintainance of life, deficient results to impairment function of the body (Lokhande *et al.,* 2009). The highest concentration of potassium was recorded in the leaves of *Serai Kayu*

Table 1: Voucher numbers of deposited specimen in respective Herbarium.

S.No.	Specimen	Herbarium NO
1	*Syzygium polyanthum* (*Serai Kayu*)	UniSZA 00395
2	*Syzygium polyanthum* (*Serai Kayu Hutan*)	UniSZA 00396
5	*Syzygium polyanthum* (*Serai Kayu*)	UM-KLU 49443
6	*Syzygium polyanthum* (*Serai Kayu Hutan*)	UM-KLU 49444
7	*Syzygium polyanthum* (*Serai Kayu*)	UKMB 40352
8	*Syzygium polyanthum* (*Serai Kayu Hutan*)	UKMB 40353

Note: S/N; Serial number, UniSZA; Universiti Sultan Zainal Abidin, UM-KLU; University of Malaya.
UKMB; Universiti Kebangsaan Malaysia.

Table 2: Traditional Medicinal used of the plant parts used in the study.

Species	Parts of the plant	Traditional usage
Serai Kayu	Leaves	Asthma, Cancer, Diabetes, Endometriosis, Postpartum, Hypertension, Ulcer, Fever, Skin Diseases, Ulam
	Bark	Skin Diseases, Cancer
	Root	Hypertension, Ulcer, Fever,
Serai Kayu Hutan	Leaves	Hypertension, Diabetes, Diarrhea, Postpartum, Fever, Ulcer, Cancer, Skin diseases
	Bark	Diarrhea, Ulcer, Fever,
	Root	Diabetes, Diarrhea, Postpartum, Fever, Ulcer, Cancer, Skin diseases

Hutan (Table 3). Potasium is also responsible for the activation of enzymes especially coenzyme responsible for the muscle function and normal growth in the body (Subramanian *et al.,* 2012). The concentration of the iron the present study was found to be between 231 to 50.7 mg/kg in both *Serai Kayu* and *Serai Kayu Hutan* respectively (Table 3). The concentrations of the iron in the examine plant parts revealed the plants as a source of iron can be used to compensate iron defciency. Iron is the sole responsible of oxygen transfer from the lungs to tissue cells and is also associated with hemoglobin (Lokhande *et al.,* 2009). Iron has been reported as the most prevelent deficient essential element in human (Sium *et al.,* 2016). The concentration of cobalt in *Serai Kayu* parts was between 0.13 to 0.10 mg/kg respectively (Table 3). Similarly low ammount was also reported in *Serai Kayu Hutan* parts 0.41to 0.10 mg/kg respectively (Table 3). The studies revealed both the examine plants parts can not be used as agood source of cobalt. *Serai Kayu* and *Serai Kayu Hutan* was reported to have the concentration of cupper between 157 to 2.98 mg/kg respectively. Highest concentration of chromium was reported from *Serai Kayu Hutan* bark at 3.55 mg/kg (Table 3). Choromium is essential elements with many biological activity in human that helps in glucose homeostasis (Lokhande *et al.,* 2009; Sium *et al.,* 2016). It also regulates blood glucose level and insulin by activating insulin signal pathway, thereby improving insulin sensitivty (Lokhande *et al.,* 2009; Sium *et al.,* 2016). Lokhande *et al.,* (2009) reported chromium as major elements in the treatments of diabetes. Deficiency in chromium may caused artherosclerotic disease (Lokhande *et al.,* 2009). The concentration of Nickel in both *Serai Kayu* and *Serai Kayu Hutan* was found to be between 9.47 to 1.95 mg/kg respectively (Table 3). The result obtained show significant difference among the treatment. Nickel are known to be toxic in nature. Presence of trace amounts in the examine parts of the plant sample might be as result of industrial activities and automobile (Lokhande *et al.,* 2009).

Litle trace of vanadium was observed in the following study 0.4 to 0.1 mg/kg in both *Serai Kayu* and *Serai Kayu Hutan* respectively. Vanadium has been proven to be siurces of antidiabetic (Narendhirakannan *et al.,* 2005). Its affects many aspects of metabolism like glycolysis, glycogen synthesis, glucose transport and glucose oxidation homeostasis (Lokhande *et al.,* 2009; Sium *et al.,* 2016). Serai Kayu Hutan root was found to contain high concentration of aluminium at 393 mg/kg (Table 3). All order examine parts are found to be low. The hight concentration in the root is attributed to the botanical structure, soil mineral composition where the plant grow (Lokhande *et al.,* 2009). All the examine parts were found to significantly contain amount of barium (Table 3). Abundance barium in the examined parts should be utilised in drugs preparation (Lokhande *et al.,* 2009; Sium *et al.,* 2016). Deficien in barium results in negative consequencies in the body (Narendhirakannan *et al.,* 2005).

Table 3: Concentrations of element in the leave, bark and root of *Serai Kayu Hutan* and *Serai Kayu.*

	Plant Parts (mg/kg)					
EL	HKL	KL	HKB	KB	HKR	KR
Ca	10150 ± 0.1^{a}	7700 ± 0.1^{b}	6300 ± 0.1^{d}	7360 ± 0.1^{c}	3510 ± 0.0^{e}	49 ± 0.1^{f}
Mg	1280 ± 0.0^{b}	1610 ± 0.0^{a}	1120 ± 0.0^{e}	1120 ± 0.0^{c}	1030 ± 0.0^{d}	810 ± 0.0^{e}
Mn	46.8 ± 2.4^{a}	35.6 ± 1.8^{b}	28.6 ± 1.5^{d}	27.17 ± 1.4^{e}	29.9 ± 1.5^{c}	10.8 ± 0.6^{f}
Na	362 ± 18^{d}	649 ± 33^{b}	91.5 ± 4.6^{f}	2170 ± 110^{a}	449 ± 23^{c}	131 ± 7.0^{e}
K	12280 ± 0.1^{a}	10008 ± 0.1^{b}	8330 ± 0.1^{d}	8930 ± 0.0^{c}	3270 ± 0.0^{f}	5700 ± 0.1^{e}
Fe	50.7 ± 2.6^{f}	93.8 ± 4.7^{d}	163 ± 9.0^{b}	97.3 ± 4.9^{c}	231 ± 12^{a}	88.7 ± 4.5^{e}
ZN	17.4 ± 0.9^{d}	13.8 ± 0.7^{e}	66.2 ± 3.4^{b}	67 ± 3.4^{b}	74.2 ± 3.8^{a}	45.4 ± 2.3^{c}
Co	$0.10 \pm 0.0^{b,c}$	0.10 ± 0.0^{c}	0.21 ± 0.0^{b}	0.10 ± 0.0^{c}	0.41 ± 0.0^{a}	0.13 ± 0.0^{c}
Cu	2.98 ± 0.59^{f}	10.7 ± 2.1^{e}	33.5 ± 4.5d	85.9 ± 6.3^{c}	107 ± 16^{b}	157 ± 2a
Cr	0.51 ± 0.0^{b}	0.9 ± 0.0^{a}	3.55 ± 0.2^{a}	0.69 ± 0.0^{a}	1.20 ± 0.0^{a}	0.9 ± 0.0^{a}
Ni	1.95 ± 0.4^{d}	$3 \pm 0.4^{b,c}$	3.71 ± 0.8^{b}	$2.67 \pm 0.4^{c,d}$	9.47 ± 1.8^{a}	$2.65 \pm 0.5^{c,d}$
V	0.1 ± 0.0^{b}	0.20 ± 0.0^{b}	0.20 ± 0.0^{b}	0.1 ± 0.0^{b}	0.4 ± 0.0^{b}	0.1 ± 0.0^{a}
Al	33.4 ± 1.7^{e}	93.2 ± 4.7^{b}	55.2 ± 2.8^{c}	93.2 ± 4.7^{b}	393 ± 20^{a}	4 ± 2.1^{d}
Ba	28.5 ± 1.5^{c}	37.9 ± 1.9^{a}	27.1 ± 1.4^{d}	6.30 ± 0.3^{f}	22.6 ± 1.2^{e}	36 ± 1.8^{b}
Pb	0.11 ± 0.0^{f}	1.72 ± 0.3^{d}	0.95 ± 0.0^{e}	3.25 ± 0.0^{b}	4.49 ± 0.57^{a}	1.9 ± 0.3^{c}

Basgel *et al.,* (2006) reported according to the WHO, there is no per Recommended Daily Allowance (RDA) of mineral elements in unprocessed medicinal plants excepts for lead, cadimium and arsenic at 10, 0.3 and 1.0 mg/kg respectively. The following study found all the enlisted elements by the WHO are below the RDA in both the examined parts of *Serai Kayu* and *Serai Kayu Hutan* respectively. The RDA of processed medicinal plant; Ca and Mg 800 mg/day and K 4700 mg/day. Essential elements were known to be very important in maintain the good health of human; as some of them were part of respiration as a component of haemoglobin, they were also used in maintaining normoglycemia for diabetes patient. Narendhirakannan *et al.,* (2005) reported micro and macro elements as antioxidants responsible for the treatments of diabetes. The unwanted or toxic element in both the examined parts of *Serai Kay* and *Serai Kayu Hutan* were found to be below the RDA of processed medicinal plants. The study have established presence of various elements such as chromium, manganese, copper, vanadium, potassium, zinc, iron, nickel, and sodium in significant amount of the leaves of the plants accounts for its hypoglycemic activities and treatement of order diseases by the traditional herbalist (Table 2). Moreover, the data present here of the individual examined parts will serve as bench mark for herbal preparations.

Conclusion

Presence of elemental composition in the examined plant parts Ca, Mg, Mn, Na, K, Fe, ZN, Co, Cu and Cr are responsible with lowering effects of glucose; making them to be hypoglycemic. Though, relationship between micro elements and diabetes is complex, the action may be as result of complex interaction of many compounds in the plant parts. The study is the first of its kind to present profile of trace elements composition in *Serai Kayu* and *Serai Kayu Hutan* a parts respectively despite acceptability of the plants by malay ethnic group as *ulam* (food). The findings of the study should be utilised in the development of herbal product to avioid over exploitation of the plants in Peninsular Malaysia.

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References

Abdulrahman, M.D., A.M. Ali, H. Fatihah, M.M. Khandaker, and N. Mat (2018a). Morphological and anatomical Studies of *Syzygium polyanthum* (Wight) Walp.(Myrtaceae). *Malayan Nature J.,* **70(3):** 309-322.

Abdulrahman, M.D., A.M. Ali, H. Fatihah, M.M Khandaker, and N. Mat (2018b). Traditional medicinal knowledge of Malays in Terengganu, Peninsular Malaysia. *Malayan Nature J.,* **70(3):** 349-364.

Ahmad, W.W., N. Jamal, U. Rahmat, N. Ramli, N. Muhammad, and L. Noordin (2017). Evaluation of *Syyium polyanthum* Leaves Methanol Extract as Antihypertensive Agent in Rat. *Int. J. Cardiology,* **249:** 265.

Basgel, S. and S. Erdemoðlu (2006). Determination of mineral and trace elements in some medicinal herbs and their infusions consumed in Turkey. *Sci. Total Environ.,* **359(1-3):** 82-89.

Haidu, D., D. Párkányi, R.I. Moldovan, C. Savii, I. Pinzaru, C. Dehelean and L. Kurunczi (2017). Elemental characterization of Romanian crop medicinal plants by neutron activation analysis. *J. Aanal Meth. Chem.,* **2017:** 1-12.

Jouad, H., M. Haloui, H. Rhiouani, El J. Hilaly and M. Eddouks (2001). Ethnobotanical survey of medicinal plants used for the treatment of diabetes, cardiac and renal diseases in the North centre region of Morocco (Fez–Boulemane). *J. Ethnopharmacol.,* **77(2-3):** 175-182.

Kala, C.P., N.A. Farooquee and U. Dhar (2004). Prioritization of medicinal plants on the basis of available knowledge, existing practices and use value status in Uttaranchal, India. *Biodiver.Conserv.,* **13(2):** 453-469.

Khandaker, M.M., N. Mat and A.N Boyce (2015). Bioactive constituents, antioxidant and antimicrobial activities of three cultivars of wax apple *Syzygium samarangense*. *Res. J. Biotechnol.,* **10:** 1-15.

Koh, E.S., S.J. Kim, H.E. Yoon, J.H. Chung, S. Chung, C.W. Park and S.J. Shin (2014). Association of blood manganese level with diabetes and renal dysfunction: a cross-sectional study of the Korean general population. *BMC Endocrine disorders,* **14(1):** 24.

Lokhande, R., P. Singare, M. Andhele, R. Acharya, A. Nair and A. Reddy (2009). Analysis of mineral content of some medicinal plants by NAA and AAS techniques. *Radiochem.,* **51(3):** 321-332.

Mat, N., Z. Hamzah, M. Maskin and A.K. Wood (2006). Mineral uptake by Taro (*Colocasia esculenta*) in swamp agroecosystem following gramoxone® (paraquat) Herbicide spraying. *J. Nuclear Related Technol.,* **3:** 59-68.

Moneruzzaman, K.M., A.B.M.S. Hossain, O. Normaniza and A. N. Boyce (2011). Growth, yield and quality responses to gibberellic acid (GA_3) of Wax apple *Syzygium samarangense* var. Jambu air madu fruits grown under field conditions. *Afr. J. Biotechnol.,* **10(56):**11911-11918.

Moneruzzaman, K.M., A.I. Alebidi and A.M. Al-Saif (2012). Assessment of genetic diversity in three cultivars of *Syzygium samarangense* grown in Malaysia by using morphological and physiological parameters. *Res. J. Biotech.,* **7(3):** 1-7.

Narendhirakannan, R., S. Subramanian and M. Kandaswamy (2005). Mineral content of some medicinal plants used in the treatment of diabetes mellitus. *Biol. Trace Element Res.,* **103(2):** 109-115.

Nicoloff, G., K. Mutaftchiev, D. Strashimirov and C. Petrova (2004). Serum manganese in children with diabetes mellitus type 1. *Diabetol Croat,* **33(2):** 47-51.

Ong, H.C., R.M. Zuki and P. Milow (2011). Traditional knowledge of medicinal plants among the Malay villagers in Kampung Mak Kemas, Terengganu, Malaysia. *Stud. Ethno-Med.,* **5(3):** 175-185.

Sium, M., P. Kareru, J. Keriko, B. Girmay, G. Medhanie and S. Debretsion (2016). Profile of trace elements in selected medicinal plants used for the treatment of diabetes in Eritrea. *Scientific World J.,* **2016:** 1-7.

Soh, W.K. and J. Parnell (2015). A revision of *Syzygium* Gaertn.(Myrtaceae) in Indochina (Cambodia, Laos and Vietnam). *Adansonia,* **37(2):** 179-275.

Subramanian, R., S. Gayathri, C. Rathnavel and V. Raj (2012). Analysis of mineral and heavy metals in some medicinal plants collected from local market. *Asian Pacific J. Trop. Biomed.,* **2(1):** 74-78.