Original Article

Journal of Medicinal Herbs and Ethnomedicine 2016, 2: 26-35
http://scienceflora.org/journals/index.php/jmhe/
doi: 10.19071/jmhe.2016.v2.3117

Mineral content of five indigenous leafy vegetables from bintulu market, Sarawak Malaysia

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Received: 05.10.2016
Accepted: 06.12.2016
Published: 22.12.2016

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ABSTRACT

Indigenous leafy vegetables commonly consumed by local people in Bintulu, Sarawak, Malaysia. Most people consumed this group of vegetable without knowing the nutrient contents and its importance to the health. Five indigenous leafy vegetables, *Scorodocarpus borneensis*, *Pangium edule*, *Gnetum gnemon*, *Dracaena gracilis,* and *Helminthostachys zeylanica* were selected and analyzed to determine their mineral contents. The vegetables were bought from Bintulu native market and mineral elements were analyzed using standard method of Association of Official Analytical Chemists. The result showed that *S. borneensis* and *D. gracilis* contain high concentration of P, *P. edule* contains high Ca, Cu and Mg, *H. zeylanica* had highest Zn, Fe, K and Na and *G. gnemon* showed high Mn. The principal component analysis (PCA) result performed three distinct groups with respect to the nutrient elements. Group A: *G. gnemon* and *H. zeylanica* which contains K, Na, Fe, Mn and Zn. Group B: *S. borneensis* and *D. gracilis* with high P content and Group C: *P. edule* with high Ca, Cu and Mg. The study of mineral contents of the indigenous leafy vegetables can help to improve the efficiency of nutrient intake by local people and further information is required to enable the vegetables to be introduced as new crops.

KEY WORDS: Health, indigenous leafy vegetables, local people, mineral contents, nutrition

INTRODUCTION

Indigenous leafy vegetables have been exploited traditionally by various ethnics and indigenous groups in Malaysia. It was believed that the hunter-gatherers were the first to recognize the plants from their surrounding during the search for edible plants by trial and error methods (Binu, 2010; Samy *et al*., 2014). The knowledge on this group of vegetables has been passed over generations by the elders from mouth to mouth thus local people gain benefits tremendously from its uses (Samy *et al*., 2009; Shaffiq *et al*., 2013). Indigenous vegetables can be defined as native plant species which originate from a certain area or were introduced from other place from a long time through natural processes or human selection (van Rensburg *et al*., 2007). Sarawak, the largest state in Malaysia with vast tropical rainforest area covering approximately 8.7 million ha provides wide variety of native plant species that can be exploited as foods (Shaffiq *et al*., 2013). Malaysian includes indigenous leafy vegetables in their daily diets as source of nutrients, flavor, therapeutic, and source of income (Det *et al*., 2013).

The importance of the indigenous leafy vegetables as source of nutrients has been proved by many studies worldwide such as in Ghana (Glew *et al*., 2010), Kenya (Onyango *et al*., 2013), Nigeria (Aworh, 2015), Southern Thailand (Kongkachuichai *et al*., 2015), and West Papua (Lense, 2012). The indigenous vegetables contain protein, fat, carbohydrate, vitamins, and mineral nutrients that are required for body metabolism and health (Nazarudeen, 2010; Binu, 2010). Deficiencies in mineral nutrients can lead to improper body and immune function, directly and indirectly (Ong, 2006). Health disorder such as anemia, rickets, stunted growth, low birth weight, and birth defects are closely related to implication of iron, zinc, iodine, and other nutrient deficiencies (Akhtar *et al*., 2013; Nazar and Usmanghani, 2015). Meanwhile, efficient intake of the elements such as P can protect people from disease affecting cardiovascular system, kidneys, and bones (Anavi, 2013). Mineral nutrients cannot be synthesis by animals, therefore, must be provided from plants, and its composition was different depending on the vegetables consumed (Achikanu *et al*., 2013).

Native people tend to consume various indigenous leafy vegetables that can be easily collected from the wild and their surroundings. However, they seldom acknowledge the nutritional values and potential contribution of the plants to their health and livelihood (Det *et al*., 2013). The information of mineral nutrients in different type of indigenous leafy vegetables consumed can provide a guideline for efficient nutrient intake. The aim of this study is to record the mineral elements various indigenous leafy vegetables consumed by communities in Bintulu, Sarawak, Malaysia.

MATERIALS AND METHODS

Plant Description and Morphological Observation

Five indigenous leafy vegetables *Scrodocarpus borneensis* Becc. (sindu), *Pangium edule* Reinw (kepayang), *Gnetum gnemon* L. (sabong), *Dracaena gracilis* L. (sabong kura), and *Helminthostachys zeylanica* L. (paku tongkat langit) were purchased from Bintulu native market. The detail of plant botanical descriptions and methods of plant consumption of these leafy vegetables were evaluated from different previous studies. The methods of plant consumption for vegetable purposes were recorded based on interviewed with local seller. The plant samples were bought from Bintulu native market to observe their morphological characteristic. The morphological characteristics of selected leafy vegetables such as leaf shape, shape of leaf apex, leaf margins, and leaf arrangement were identified while petiole length, petiole diameter, blade length, and blade width were recorded and measured using ruler and digital vernier caliper.

Sample Collection for Mineral Analysis

All the samples were brought to the Nutritional Laboratory, UPM Bintulu Sarawak Campus for further analyses. The inedible portion was discarded while the edible portion was washed with tap water and rinsed with distilled water. The residual moisture on the leaves was evaporated at room temperature (±27°C). The raw samples were dried overnight at 60°C until the weight become constant. The dried sample was milled and sieved through 1 mm stainless steel sieve to obtain homogenized powder sample. Each sample was labeled with five replications. The dried powdered samples were used for the analysis.

Mineral Content Analysis

Total mineral content was determined using dry-ashing methods (Association of Official Analytical Chemists [AOAC], 1990). About 1 g of the dried sample was weighed and placed into the crucible and incinerated in the muffle furnace (Pyrolabo, France) at 300°C for 1 h. The temperatures were raised to 520°C, and ashing continues for 4-5 h. All ash samples were changed to white color, removed from the furnace, and cooled in the desiccators. Then, a few drops of distilled water were added into the samples followed by 2 ml of concentrated HCl and evaporated to dry using hot plate. The samples were filtered through Whatman filter no. 2. Total potassium (K), sodium (Na), calcium (Ca), phosphorus (P), magnesium (Mg), manganese (Mn), iron (Fe), zinc (Zn), and copper (Cu) were quantified using atomic absorption spectrophotometer (Perkin-Elmer AAnalyst 800, Germany). Total P content was determined using blue development method (Murphy and Riley, 1962) and quantified using UV-VIS spectrophotometer (Perkin-Elmer, Germany).

Statistical Analysis

Data obtained were analyzed using statistical analysis software 9.3. Mineral nutrients were compared using one-way analysis of variance. A significant difference between means was evaluated using Duncan multiple range test at significant level $P \leq 0.05$. The relationship between indigenous vegetables and nutrient contents was analyzed using PCA by XLSTAT statistical software (2013, Addinsoft).

RESULTS AND DISCUSSIONS

Plant description and Morphological Characteristics

The detail information on the vegetables selected are presented in Table 1 and Figure 1 whereas the consumption method preferred by local people in Bintulu was presented in Table 2. All the selected vegetables distributed widely in Southeast Asia and grown wild up to 40 m except for *H. zeylanica* which is herbaceous plant that grows up to 40 cm only. The consumption and preparing method of the vegetables that were collected from various studies and face to face interview with locals in Bintulu showed that the consumption methods are different based on locality and the selected vegetable can be consumed as variety of dishes.

The selected indigenous vegetables showed different morphology of leaf which help to distinguish each of the species (Table 3). *S. borneensis* and *G. gnemon* shared similar characteristics in leaf shape, leaf margins, and leaf arrangement whereas *P. edule*, *D. gracilis,* and *H. zeylanica* have different characteristics with one another (Figure 1). However, all the vegetable species showed similar characteristic on adaxial and abaxial leaf

Table 1: Scientific name, vernacular name, characteristics and preparation methods of the indigenous vegetables from previous studies

Scientific name (Family)	Vernacular name	Distribution	Plant characteristics	Consumption method
S. borneensis Becc. (Olacaceae)	Bawanghutan (Malay), kesindu (Iban), kayo kesindo (Kelabit)	Peninsular Thailand, Peninsular Malaysia and Borneo Island (Lim, 2012)	Grow up to 40 m tall (Kubota *et al.*, 1994; Lim, 2012)	Cook as vegetables or seasoning in foods like garlic (Kubota *et al.*, 1994; Lim, 2012)
Pangium edule Reinw (Flacourtiaceae)	Kepayang (Malay, Iban), Poyang (Bidayauh- Bau)	Peninsular Malaysia, Indonesia, Papua New Guinea and Borneo Island (Lim, 2013)	Grow up to 18-40 m tall and has many branches (Lim, 2013)	Young leaves used in the preparation of meat called 'kasam' (Lim, 2013)
Gnetum gnemon L. (Gnetaceae)	Melinjau or belinjau (Malay), sabong (Iban), dedah (Bidayuh)	Cambodia, Vietnam, Thailand, Borneo Island and Peninsular Malaysia (Lim, 2012)	Grows up to 15-20 m tall. And commonly found in an area near the river and stream (Lim, 2012; Det*et al.*, 2013)	Cook as vegetables for various dishes
D. gracilis L. (Agavaceae)	Sabongkura (Iban)	Africa and Asia (Chen, 2000)	The detailed information is limited due to little studies of *Dracaena* in Asia (Chen, 2000)	Young leaves are commonly used as vegetables (Chai, 2000)
H. zeylanica L. (Ophioglossaceae)	Tongkatlangit (Malay), sutar (Iban)	Peninsular Malaysia, Borneo Island, South Sumatra and Kalimantan (Fitrya *et al.*, 2010; Chotimah *et al.*, 2013)	It is small fern grows about 20-40 cm in deciduous forest and moist area (Ismail, 2000; Joshi, 2011)	Boiled or blanched and prepared as Malay dish called 'kerabu' (Ismail, 2000)

S. borneensis: *Scorodocarpus borneensis, P. edule*: *Pangium edule, G. gnemon*: *Gnetum gnemon, D. gracilis*: *Dracaena gracilis, H. zeylanica*: *Helminthostachys zeylanica*

Table 2: The consumption method of indigenous leafy vegetables obtained from local seller around Bintulu native market

Indigenous leafy vegetables	Consumption method
S. borneensis	The leaves are cut, washed and stir fried with shrimp paste
P. edule	The leaves are soaked and boiled in the water first to remove the poisonous chemical, then chopped finely and mixed with the fish
G. gnemon	Young leaves are cut, washed and stir fried with bamboo or coconut shoots and anchovies
D. gracilis	The leaves are washed, chopped finely and stir fried with shrimp paste, onion, chili and anchovies
H. zeylanica	The leaves and soft stems are cut and stir fried with shrimp paste, onion, chili and anchovies

S. borneensis: *Scorodocarpus borneensis, P. edule*: *Pangium edule, G. gnemon*: *Gnetum gnemon, D. gracilis*: *Dracaena gracilis, H. zeylanica*: *Helminthostachys zeylanica*

Table 3: The morphological observation on the selected indigenous leafy vegetables

Leaf structure	*S. borneensis*	*P. edule*	*G. gnemon*	*D. gracilis*	*H. zeylanica*
Leaf shape	Oblong-elliptic	Cordate	Oblong-elliptic	Lanceolate	Linear-elliptic
Shape of leaf apex	Acuminate	Acuminate	Caudate	Caudate	Acuminate
Leaf margins	Entire	Lobed	Entire	Entire	Serrate
Type of leaf	Simple	Simple	Simple	Simple	Palmately-compound
Leaf arrangement	Alternate	Alternate	Opposite	Opposite	Opposite
Leaf surface	Smooth at adaxial and abaxial	Smooth at adaxial and abaxial	Smooth at adaxial and abaxial	Smooth at adaxial and abaxial	Smooth at adaxial and abaxial
Blade color	Young leaves are reddish and older leaves are light green color	Green and glossy	Light green	Young leaves are yellowish green and older leaves are green	Green
Petiole length (cm)	1.00-2.00	9.90-16.90	0.90-1.10	0.50-3.10	1.00-1.50
Petiole diameter (cm)	0.40-1.00	0.60-0.75	0.10-0.15	0.40-0.50	0.40-0.50
Blade width (cm)	3.80-5.90	11.00-15.70	3.60-5.70	2.50-3.80	2.80-3.40
Blade length (cm)	8.90-13.40	15.20-21.00	9.70-15.00	5.60-6.80	4.80-5.90

S. borneensis: *Scorodocarpus borneensis, P. edule*: *Pangium edule, G. gnemon: Gnetum gnemon, D. gracilis: Dracaena gracilis, H. zeylanica: Helminthostachys zeylanica*

surface. *S. borneensis* have unique blade color which is young leaves tend to develop in reddish color, might be influenced by the anthocyanin pigment in leaves. *P. edule* have the largest leaves which characterized by the longest or largest petiole length, petiole diameter, blade width, and blade length ranged from 9.9 to 16.90 cm, 0.60 to 0.75 cm, 11.0 to 15.7 cm, and 15.2 to 21.0 cm, respectively.

Mineral Content

The trend of mineral contents for the vegetables studied was comparatively different with one another (Table 4). All the vegetables studied were from different species, so the composition of each mineral element in the species were different. In general, all the macronutrients in plants such as K, P, Ca, Mg, and Na showed higher composition than micronutrients such as Fe, Zn, Cu, and Mn. In this study, K content was present in the highest concentration for all the vegetables whereas Zn and Cu were among the lowest micronutrient contents in the plants.

The concentration of K was observed to be the highest in *H. zeylanica* (1808.53 mg/100 g) and *G. gnemon* (1777.80 mg/100 g) with each value was approximately two times higher than those obtained in *S. borneensis* (918.80 mg/100 g). Different values, however, were recorded by Hoe and Siong (1999) which showed the concentration of K in *G. gnemon* and *H. zeylanica* was two to three times lower than the result obtained in this study. A similar result was also reported for *P. edule*. The variation showed in both studies might be due to the different developmental stages of the plants (Gupta *et al*., 2005). By considering the importance of K to the health, high concentration was recommended in dietary intake for adults as compared to other elements and suggested to be at 4700 mg/day (Joshi, 2011; Anavi, 2013). K is important for heart, bone, and kidney hence an adequate intake of this mineral has potential to reduce the risks of coronary heart disease, stroke, and formation of kidney stone (Anavi, 2013; Weaver, 2013). Imbalance of K in the body can lead to the condition known as hypokalemia and hyperkalemia which have adverse effect to the health (Pohl *et al*., 2013). People with chronic kidney disease commonly have hyperkalemia, thus the intake of *G. gnemon* and *H. zeylanica* in their daily diet should be avoid because K content in these vegetables was higher than the recommended dietary allowance (RDA) (Pohl *et al*., 2013).

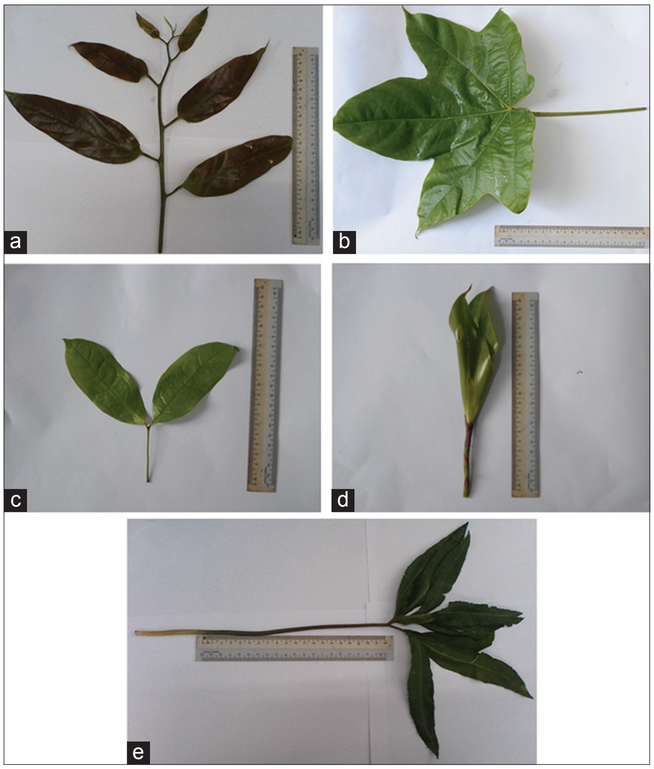

Figure 1: The edible parts of indigenous leafy vegetables: (a) *Scorodocarpus borneensis*, (b) *Pangium edule*, (c) *Gnetum gnemon*, (d) *Dracaena gracilis,* and (e) *Helminthostachys zeylanica*

H. zeylanica was observed to have 594.90 mg/100 g of Na which was significantly four to eight times higher than those in other indigenous leafy vegetables with value ranged of 75.97-158.52 mg/100 g and this result was similar to the study done by Chotimah *et al*. (2013) which demonstrated that *H. zeylanica* contains highest Na compared to other vegetables. The RDA for Na was suggested to be at 2300 mg/d for a healthy person and

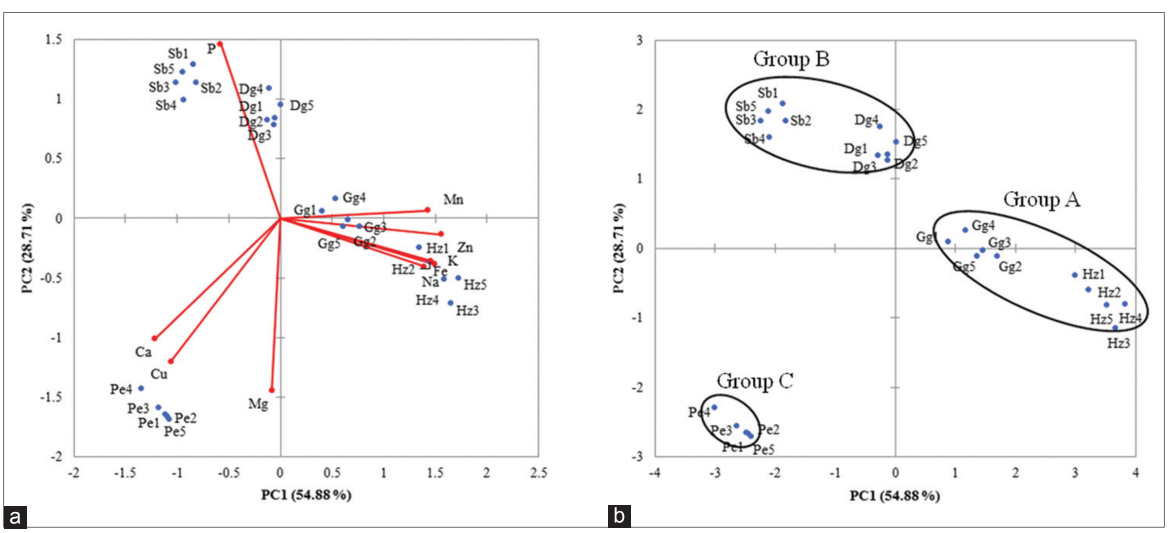

Figure 2: (a) Score plot of all the five indigenous leafy vegetables against PC1-PC2, (b) Score plot that showed three distinct groups. Group A: *Gnetum gnemon* and *Helminthostachys zeylanica* which contains high K, Na, Fe, Mn, and Zn. Group B: *Scorodocarpus borneensis* and *Dracaena gracilis* with high concentration of P. Group C: *Pangium edule* that contains high Ca and Cu and Mg

the indigenous leafy vegetables studied can only supply approximately 3.3-25.86% of Na, somehow relatively low than that recommended (Chotimah *et al.*, 2013). Na is essential to maintain plasma volume, acid-base balance, transmission of nerve impulses and normal cell function, but the excessive intake of Na can cause high blood pressure, cardiovascular disease, and stroke (WHO, 2012; Whelton *et al.*, 2012). By considering the low concentration of Na recorded, the consumption of all these vegetables can be suggested to the patient with high blood pressure, cardiovascular disease, and stroke.

Furthermore, the Na/K ratio in all the leafy vegetables studied showed the value <1 which is accordance to recommended ratio for the prevention of high blood pressure. This result was similar to other studies which recorded the value of Na/K ratio was <1 (Oulai *et al.*, 2014; Caunii *et al.*, 2010). These two elements interact with another and the effect between these relations are larger in reducing blood pressure and hypertension than the effect of K and Na alone (Perez and Chang, 2014; Sacks *et al.*, 2001). Higher K intake is related to the reduction of blood pressure in hypertensive population only (Perez and Chang, 2014; Aburto *et al.*, 2013).

P. edule favorably a good source of Ca because it contains the highest concentration with the value of 466.66 mg/100 g when compared to other indigenous leafy vegetables studied. This followed by *D. gracillis* (256.10 mg/100 g) and *S. borneensis* (241.41 mg/100 g) which had significantly two times lower than *P. edule*. A similar result recorded by Hoe and Siong (1999) which showed that *P. edule* contains high Ca compared to other elements. Ca contents in the indigenous vegetables studied were comparatively higher than commercialized leafy vegetables such as *Brassica juncea, Lactuca sativa,* and *Brassica oleracea* (Ng *et al.*, 2012; Caunii *et al.*, 2010). From the study, *P. edule* was beneficial to humans as source of Ca because Ca was required for the healthy bone and teeth, helps in nerve regulation and muscle function. Nevertheless, Ca deficiency may cause rickets in children and osteomalacia in adults (Soetan *et al.*, 2009). The concentration of Ca analyzed in *P. edule* was slightly lower than that had been recommended to adults and children based on RDA 1300 mg/day and 700 mg/day, respectively, (Sawka, 2005).

The study revealed that *S. borneensis* (343.86 mg/100 g) and *D. gracilis* (342.69 mg/100 g) had significantly one to two times higher concentration of P compared to *H. zeylanica, P. edule,* and *G. gnemon* with values ranged from 176.26 to 240.02 mg/100 g. In general, the range of concentration of P recorded from these plants was similar to other indigenous leafy vegetables studied in the other literatures (Odhav *et al.*, 2007). The result suggests that *S. borneensis* and *D. gracilis* can serve as an alternative source of P; however, the value was four to five times lower than RDA. The RDA for adult, lactating, and pregnant women was 700 mg/d (Sawka, 2005). P was fundamental for cellular metabolism and skeletal mineralization and inadequate intake of P can cause osteoporosis especially among women (Heaney, 2004). However, P intake among patient with end-stage renal disease should be concern because of the imbalance in phosphate homeostasis can cause hyperphosphatemia and hypophosphatemia, thus there is the need to maintain P concentration within the recommended range (Covic and Rastogi, 2013). A daily intake of 800-1000 mg is recommended for patients undergo hemodialysis (EBPG expert group on hemodialysis, 2007).

Ca/P ratio recorded in *P. edule* and *H. zelanica* were <1, thus these two vegetables might be have more benefits than other vegetables because the diet is considered good if the Ca/P ratio is <1 (Oulai *et al.*, 2014). A similar result was also recorded by Hoe and Siong (1999) which showed that these two vegetables have Ca/P ratio <1. Ca and P interact in the body and them response to form calcium phosphate which was essential for bone formation and maintenance (Heaney, 2004). Calcium phosphate is required for the formation of hydroxylapatite, a mineral compound in osseous tissue (Lee *et al.*, 2014). A study by Lee *et al*. (2014) showed dietary Ca/P ratio was positively correlated to bone mass density.

Magnesium content in *P. edule* was demonstrated to be the highest (266.42 mg/100 g) when compared to other vegetables with its value was approximately three times higher than those in *S. borneensis* (91.10 mg/100 g) and similar result was also recorded by Hoe and Siong (1999) which showed the higher value of Mg in *P. edule* compared to *S. borneensis*. The RDA of this element for adults was around 300-420 mg/day; depending on the age. Mg content in *P. edule* almost meets the minimum recommended value while other vegetables contains in moderate amount. In the body, Mg is important as cofactor in many enzymatic reactions, glucose metabolism, and insulin homeostasis (Song *et al.*, 2004; Barbagallo *et al.*, 2003). Hence, the deficiency of Mg can cause Type 2 diabetes mellitus (He *et al.*, 2006; Lopez-Ridaura *et al.*, 2004). *P. edule* and other leafy vegetables studied can be suggested to the patient with diabetes to overcome hypomagnesemia (Song *et al.*, 2004; Barbagallo *et al.*, 2003).

G. gnemon was recorded the highest content of Mn followed by *H. zeylanica* with the value 9.67 mg/100 g

Table 4: Mineral contents of the five indigenous leaf vegetables (mg/100 g)

Mineral elements	Plant species				
	S. borneensis	*P. edule*	*G. gnemon*	*D. gracilis*	*H. zeylanica*
K	918.80±30.31[d]	1157.25±38.76[c]	1777.80±30.20[a]	1359.50±36.65[b]	1808.53±53.53[a]
Na	75.97±8.18[c]	101.87±5.57[c]	158.52±6.93[b]	124.96±8.87[bc]	594.90±32.89[a]
Ca	241.41±24.77[bc]	466.66±6.71[a]	204.90±3.34[cd]	256.10±9.37[b]	183.95±4.27[d]
P	343.86±14.38[a]	179.82±7.74[c]	240.02±14.49[b]	342.69±2.79[a]	176.26±17.86[c]
Mg	91.10±2.63[e]	266.42±9.47[a]	224.60±6.65[b]	123.60±4.53[d]	162.37±6.87[c]
Mn	4.26±0.21[d]	4.36±0.17[d]	9.67±0.35[a]	7.19±0.25[c]	8.53±0.37[b]
Fe	2.67±0.26[c]	3.04±0.53[c]	4.99±0.20[c]	8.40±0.47[b]	67.61±4.61[a]
Zn	1.41±0.16[c]	1.72±0.17[c]	3.09±0.12[b]	3.19±0.12[b]	4.72±0.23[a]
Cu	2.47±0.11[b]	7.42±0.21[a]	0.67±0.03[e]	1.35±0.12[d]	1.86±0.11[c]
Na/K ratio	0.08±0.01[b]	0.09±0.01[b]	0.09±0.01[b]	0.09±0.01[b]	0.32±0.02[a]
Ca/P ratio	0.70±0.05[c]	2.50±0.11[a]	0.86±0.05[bc]	0.75±0.03[c]	1.09±0.13[b]
Trend	K>P>Ca>Mg>Na>Mn>Cu>Fe>Zn	K>Ca>Mg>P>Na>Cu>Mn>Fe>Zn	K>P>Mg>Ca>Na>Fe>Mn>Zn>Cu	K>P>Ca>Mg>Na>Fe>Mn>Zn>Cu	K>Na>Ca>P>Mg>Fe>Mn>Zn>Cu

Values are means of five replicates±standard error (SE). Means with different letter within rows indicate significant difference between plant samples using DMRT at $P\leq 0.05$, *S. borneensis: Scorodocarpus borneensis, P. edule: Pangium edule, G. gnemon: Gnetum gnemon, D. gracilis: Dracaena gracilis, H. zeylanica: Helminthostachys zeylanica*

Table 5: Eigen analysis of the correlation matrix loadings of the significant principal components (PCs)

Variables	PC1	PC2
P	−0.3486	**0.8794**
K	**0.8961**	−0.2302
Ca	**−0.7309**	−0.6089
Mg	−0.0487	**−0.8680**
Na	**0.8365**	−0.2431
Zn	**0.9353**	−0.0814
Fe	**0.8729**	−0.2144
Mn	**0.8586**	0.0391
Cu	−0.6356	**−0.7215**
Eigenvalue	4.9390	2.584
Variability (%)	54.878	28.714
Cumulative (%)	54.8778	83.592

The most significant loading are highlighted in boldfaced

and 8.53 mg/100 g, respectively. The similar result was also obtained by Hoe and Siong (1999) which showed the higher contents of Mn in *G. gnemon* compared to *H. zeylanica*. The Adequate Intake of Mn was approximately 3 mg/day for adult males and females, relatively lower than the values recorded for all the vegetables studied (Sawka, 2005). However, the excessive Mn content in these vegetables cannot pose any risk or adverse effect to human health because its concentration was relatively lower than the tolerable upper intake levels (UL) (11 mg/d) (Sawka, 2005). Mn is required for the body to regulate and binds to enzyme in the body such as arginase, superoxide dismutase, and pyruvate carboxylase (Crossgrove and Zheng, 2004). Risk cause by inadequate intake of Mn appears to be low but Mn toxicity can affect central nervous system similar to Parkinson's disease (Sawka, 2005).

H. zeylanica contains 67.61 mg/100 g of Fe and the value recorded showed significantly 8-25 times higher compared to *P. edule, S. borneensis, D. gracillis,* and *G. gnemon* with the value of 3.04 mg/100 g, 2.67 mg/100 g, 8.40 mg/100 g, and 4.99 mg/100 g. Studies by Hoe and Siong (1999) and Chotimah *et al*. (2013) revealed similar result which suggests that *H. zeylanica* was a rich source of Fe. According to RDA, 8-18 mg of Fe per day (depending on age) is sufficient to meet the requirement for adults and *D. gracillis* was observed to meet the recommended value. It can provide adequate intake of Fe for body metabolism because it is component of hemogolobin, protein, enzyme, and myoglobin (Sawka, 2005). However, accordance to UL (45 mg/day) excessive Fe content was found in *H. zeylanica* and this can cause health problem if consumed regularly. Fe toxicity can cause health problem such as astherosclerosis, autoimmunity disease, Parkinson's disease, diabetes, fibrosis, and others (Brewer, 2007).

Zinc content in all the indigenous leafy vegetables studied were ranged from 1.41 to 4.72 mg/day with the highest has been observed in *H. zeylanica* (4.72 mg/100 g) and the lowest was in *S. borneensis* (1.41 mg/100 g). The value obtains from this result was similar with other indigenous leafy vegetables from various studies (Gupta *et al.*, 2005; Asaolu *et al.*, 2012). The RDA for Zn is suggested at 8 mg/day and 11 mg/day for adult females and males, respectively (Sawka, 2005), thus the indigenous leafy vegetables studied can provide approximately 18-59% Zn for females and 13-43% for males. Zn concentration in this study was lower than the UL (40 mg/day) so the dietary intake of all these vegetables cannot possess any harmful effect to the health (Sawka, 2005). Zn is required in many body functions such as metabolic activity of body's enzyme, cell division and protein and DNA synthesis (Bhowmik and Chiranjib, 2010). Its deficiency can affect immune system, anemia, asteriosclorosis, and deficiency among pregnant women can cause decrease of fetal brain cells (Chasapsis *et al.*, 2012).

Copper content in *P. edule* recorded the highest value (7.42 mg/100 g) and this result corresponding with the study done by Hoe and Siong (1999) which recorded that *P. edule* had higher concentration of the elements as compared to *H. zeylanica* and *S. borneensis*. Cu concentration obtained in *P. edule* (7.42 mg/100 g), *H. zeylanica* (1.86 mg/100 g), *S. borneensis* (2.47 mg/100 g), and *D. gracilis* (1.35 mg/100 g) was approximately two to eight times higher than RDA (0.9 mg/day) while *G. gnemon* (0.67 mg/100 g)was slightly lower than the value (Sawka, 2005). The UL for this element was reported at 10 mg/day, thus these vegetables considered safe to consume without possess any adverse effect to the health. Cu is a component of several metalloenzyme and its deficiency in human is rare (Sawka, 2005). Toxicity of Cu can cause astherosclerosis (Brewer, 2007).

Interrelationship of the Mineral Elements and Selected Indigenous Leafy Vegetables by PCA

To study the relationship among each of the nutrient elements and relationship that may exist between the indigenous leafy vegetables the dataset were analyzed using PCA. The eigenvalues and percentage of variation obtained from PCA were summarized in Table 5. The highest eigenvalue was recorded by PCA1 (4.94) which accounted the highest variability (54.88%). Based on Kaiser's rule only eigenvalue ≥1.0 are considered significant (Shin *et al.*, 2010), thus only PC1 and PC2 were used to explain the relationship exists. PC1 and PC2 axes showed total variability of 83.59%.

The factor loadings of the significant principal components (PCs) and its visualization were shown in Table 5 and Figure 3. By referring to PC1 axes there are positive correlations between K, Na, Zn, Fe, and Mn while at PC2 axes positive correlation exists between P and Mn. The distribution of five indigenous leafy vegetables studied is shown in the score plot PC1-PC2 (Figure 2a). The score plot revealed three distinct groups: Group A, B, and C (Figure 2b). Group A consists of *H. zeylanica* and *G. gnemon* which contains high K, Na, Fe, Mn, and Zn while Group B represent *S. borneensis* and *D. gracilis* with high concentration of P. Group C contains high Ca, Mg, and Cu and result showed that *P. edule* falls into this group.

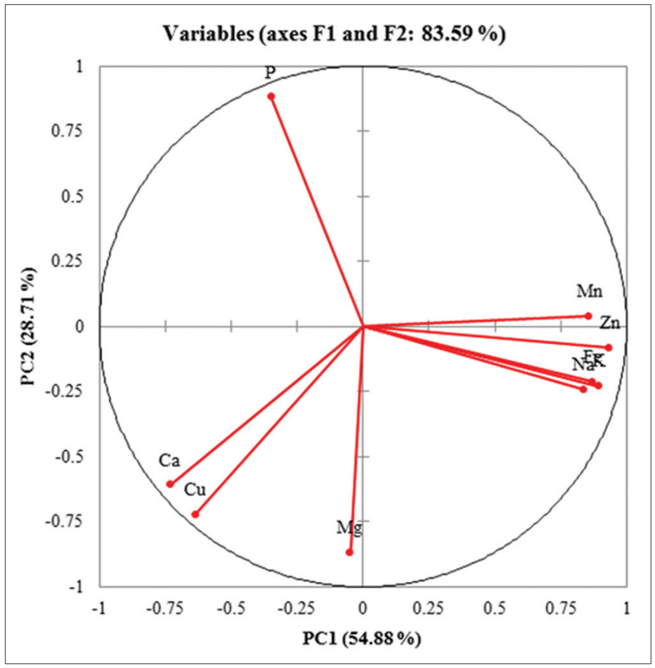

Figure 3: Loading plot of PC1-PC2 for nutrient contents of indigenous leafy vegetable

The PCA result suggested relationship exists between each of the nutrients content in the plant studied. The interaction between nutrients in plants was reported by Robson and Pitman (1983) and Malvi (2011) different types of indigenous leafy vegetables studied showed different interaction between the nutrients. Negative correlation was observed between Ca and K in *P. edule* where there was high concentration of Ca while lower concentration of K. This antagonistic relationship exists might be due to alkaline soils which normally contain high Ca than K (Mousavi, 2011). Besides, negative correlation also was observed in P and Zn for most of the indigenous vegetables studied because P interferes with Zn uptake, thus vegetables with high P showed lower concentration of Zn contents (Mousavi, 2011).

CONCLUSION

The study of nutrient contents in the indigenous leafy vegetables can help to improve the nutritional intake among local people. The results suggest that the indigenous leafy vegetables consumed by local people in the Bintulu are good sources of minerals especially *D. gracillis* that contains high concentration of P and moderate amount of other nutrients. Further information required for this species so that they can be commercialized as new food crops.

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