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REGULAR ARTICLE

The proximate compositions and mineral contents of *Neptunia oleracea* Loureiro, an aquatic plant from Malaysia

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Abstract

This study was carried out to assess the availability of lesser known aquatic plant *Neptunia oleracea* Loureiro in Sibu Central native market throughout the year in order to determine the availability market price, edible part's, i.e., weight, diameter, length and the composition of proximate and minerals content of *N. oleracea*. The bunch's weight, number of individual shoot and their weight were significantly higher ($p \leq 0.05$) in April compared to October. *N. oleracea* was offered to customer in bunches of 106.91-149.41 g. Each individual young shoot varied in length, diameter and weight as 32.00-33.43 cm, 6.11-6.16 mm and 8.4-9.71 g, respectively. The proximate and mineral compositions of *N. oleracea* categorizing as moisture content > crude protein > crude fiber > ash > crude fat and K > P > Ca > Na > Mg > Mn > Zn > Cu, respectively. Moisture content was significantly higher in April (83.75±0.55%) and October (86.26±0.62%). However with respect to mineral content, calcium (348.00±14.93 and 381.42±9.00 mg/100g), phosphorous (395.67±26.50 and 405.92±43.67 mg/100g), copper (2.58±0.29 and 2.97±0.12 mg/100g) and Ca/P (0.88±0.09 and 0.95±0.11) were significantly lower in April than those observe in October ($p \leq 0.05$). Thus, the edible parts of *N. oleracea* provide good sources of crude protein, crude fiber, ash, calorie and mineral such as potassium.

Key words: Aquatic plant, Mineral contents, *Neptunia oleracea*, Proximate composition, Young shoot

Introduction

Aquatic plants are normally found growing in association with free-standing water level at or above the surface of the soil. In some instances, the plants may merely be growing near the water. They are conspicuous plants dominating diverse natural and man-made wetlands from small ditches, ponds, irrigation canals, sewage lagoons, streams, rivers, water reservoirs, shallow lakes, and marshes to swamps (Muta Harah et al., 2005). These diverse plant groups can be separated into four categories based on their habit of growth: floating unattached, floating attached, submersed, and emergent (Pancho and Soerjani, 1978). Taxonomically they are aquatic angiosperms, pteridophytes (ferns), and bryophytes (mosses, hornworts, and liverworts) (Cook et al., 1974) and also include algae (Nather Khan, 1990). Based on their behavior, colonization characteristic and effects to the natural and man-made water bodies, they are often considered as noxious aquatic plants or weeds. Despite being noxious aquatic plants, a number of studies (Taylor and Robins, 1968; Cook et al., 1974; Pancho and Soerjani, 1978; Nather Khan, 1990; Lim et al., 1968) have reported several of them as being useful. In China, India, and Japan, aquatic plants, e.g., water chestnut (*Trapa* spp.) and lotus (*Nelumbo nucifera* Gaertn.) are cultivated crops for their seeds (Edwards, 1980). *Ipomoea aquatica* Forssk. is one of the few aquatic plants cultivated as a green vegetable (Edwards, 1980). A survey conducted in Sarawak, East Malaysia recorded 43 species belonging to 29 families and of which 19 species are used as vegetables (Muta Harah et al., 2005). Aquatic plants, e.g., yellow velvet leaf (*Limnocharis flava* (L.) Buch) and water mimosa (*Neptunia oleracea* Loureiro) grow profuse in wetland habitats although considered as weeds, they are gathered from the wild

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by the local people of Sarawak (Saupi et al., 2009). Both yellow velvet leaf and water mimosa other than for own consumption as leafy vegetables also offered for sale at native markets locally known as Tamu. Leafy vegetables such as *L. flava* and *N. oleracea* are commonly consumed in rural areas but sold in the local native markets to the urban people. Despite being weed, the young shoots of *N. oleracea* are locally gathered as vegetable and eaten raw or cooked.

This paper highlights the availability of *N. oleracea* known by local names in Malaysia as keman air, keman gajah, daun tangki or kangkung puteri (Halimatul Saadiah, 2003; Samy et al., 2005; Muta Harah et al., 2005; Ong, 2008) in one of the native markets at Sibu, Sarawak, East Malaysia and its nutritional status through the proximate composition and the mineral contents of the edible parts.

Materials and Methods

Observation of *Neptunia oleracea* and availability in Sibu native market

A year observation was conducted at Sibu native market, Sibu Central Market, Sarawak throughout 2009. On the basis of the market price, the origins of samples either cultivated or gathered from wild, consumption method and seller background, cross-sectional surveys with formal interviews were conducted. Five fresh bunches of the plant in the month of April and October (their availability was only in these two months) were purchased and recorded for details on edibles part. The diameter, length and weight of edible parts were also measured.

Sample preparation for analyses

Plant materials of fresh young edible green shoots of *N. oleracea* were purchased from Sibu native market in the two months. The moisture content of the samples was determined at 60°C until constant weight was obtained following method by Saupi et al. (2009). The dried matter obtained was ground to a fine powder and stored in air tight containers prior to further analysis for ash, crude protein, total crude fiber and total crude fat.

Proximate analysis

Moisture, ash, crude protein, crude fat and crude fiber were determined using the methods of AOAC (2000). Ash was determined by combustion at 500°C in muffle furnace for 6 hours (method 930.05, AOAC, 2000). The percentage of crude protein content was estimated by multiplying the sample percentage of nitrogen content obtained using Kjeltec Auto Distillation 2200 Foss by a factor 6.25 (method 984.13, AOAC, 2000). The crude fat was extracted using Soxhtec 2055 Foss and quantity of lipid was determined gravimetrically (method 991.36, AOAC, 2000). Crude fiber content was determined by the Fibertec 2010 Foss with repeated treatment of 1.25% sulfuric acid (H_2SO_4) (w/v), followed by 1.25% potassium hydroxide (KOH) (w/v) and then washed by water (method 993.19, AOAC, 2000). The gross energy in kJ/100 g dry matter was determined by bomb calorimeter (Model AC-350 Leco) using benzoic acid as a standard.

Mineral analysis

The ash obtained from the determination of ash analysis was placed in porcelain crucible. Few drops of distilled water were added and followed by 2 mL concentrated hydrochloric acid (HCl). 10 mL of 20% HNO_3 were added evaporated on the hotplate. The sample was filtered through Whatman filter paper No.2 into 100 mL volumetric flask (method 922.02, AOAC, 2000). The mineral elements Na, K, Ca, Mg, Cu, and Zn concentration were determined by atomic absorbance spectrophotometer (AA800 Perkin-Elmer, Germany) (method 975.03, AOAC, 2000). P was determined by colorimetrically using UV-VIS spectrophotometer (Murphy and Ridley, 1967).

Statistical analysis

Statistical analysis was performed using the Microsoft Office Excel 2007. T-test was used to determine the significant different ($p \leq 0.05$) between bunch's fresh weight, number of shoot per bunch, a single shoot's weight, diameter and length, proximate composition and mineral contents for April and October.

Results and Discussion

Availability of *Neptunia oleracea*

The availability of *N. oleracea* is shown in Table 1. *N. oleracea* was traded by women of Melanau ethnic origin only in April and October. Plants were collected from the wetland area in Sibu District, a day before being marketed. Plants offered for sale is in bunch comprising young leaves with part of stems. A bunch varies from 12–15 shoots per bunch (April) to 21–32 shoots per bunch (October) with price tag of RM1.00 for both months. The mean weight of *N. oleracea*'s bunch in April and October were 149.41±18.35 g and 106.91±3.81 g respectively. Comparison of means of bunch's weight and number of shoots per bunch between two months showed there was a significant difference ($p \leq 0.05$).

Table 1. *Neptunia oleracea* in Sibu Central Market in April and October 2009.

	April	October
Bunch's price (RM)	1.00	1.00
Bunch's fresh weight (g)	149.41±18.35[a] (133.75-170.23) n = 5	106.91±3.81[b] (102.34-110.52) n = 5
Number of shoot per bunch	13.88±1.30[b] (12–15) n = 5	26.40±4.22[a] (21–32) n = 5
A single shoot's weight (g)	8.40±4.40[b] (2.72-22.68) n = 68	9.71±5.17[a] (1.54-22.67) n = 132
A single shoot's diameter (mm)	6.11±1.60[a] (3.70-10.78) n = 68	6.16±1.36[a] (3.49-9.87) n = 132
A single shoot's length (cm)	33.43±7.02[a] (19.50- 52.50) n = 68	32.00±5.81[a] (18.20- 45.30) n = 132

Mean values in the column sharing a common letter are not statistically significant according to T-test (p≤0.05), ± standard deviation (SD).

A single shoot vary in mean weight, mean diameter and length for both months, which were 8.40±4.40 g and 9.71±5.17 g in weight, 6.11±1.60 mm and 6.16±1.36 mm in diameter and, 33.43±7.02 cm and 32.00±5.81 cm in length respectively for April and October. Only means of shoot's weight showed significantly difference. Most of the portions of plants traded were still intact with white spongy structures. Based on interviews on the traders and consumers, young leaves and portion of stems that are young and soft was selected for consumption either raw or blenched as salad or cooked as most other common leafy vegetables. The indigenous Melanau were identified as major consumers of *N. oleracea.* They consumed either the raw, blanched or cooked tender shoots comprised of leaves, spongy stems and young seedpods. This kind of consumption pattern is similar to the Malays in Peninsular Malaysia as reported by Rukayah (2002), Halimatul Saadiah (2003) and Samy et al. (2005).

Based on our repeated monthly visits, *N. oleracea* was available only in April and October. This was attributed to preference of other selected commodities being traded. For example May to September, Sibu native market was dominated by seasonal local fruits especially durian (*Durio zibethinus* L.) and endemic fruit dabai (*Canarium odontophyllum* Miq.). Thus, *N. oleracea* was not being the choice traded during local fruit season. After the end of fruits season in October, *N. oleracea* was sold out for all weekends of October.

The strategy of selling *N. oleracea* was different in the two months. The survey indicated that in April about 12–15 of shoots per bunch and almost double in October (21-32 shoots). Interestingly, the price of RM1.00 per bunch remained the same for both months. In term of the bunch's weight, for April was 149.41±18.35 g for each bunch, and for October the bunch was 106.91±3.81 g, 28% less weight than in April. Even the bunch weight in April was significantly higher than October but the number of individual shoots and their weight were different. Furthermore shoot's moisture itself has an effect on weight of shoot (Table 2).

Proximate composition and mineral contents

Comparatively based on the percentage of the dry matter per 100 g, young shoots of *N. oleracea* have relatively high crude protein content when compared to ash, crude fat, and crude fiber (Table 2). Moisture content of young shoots of *N. oleracea* in October (86.26±0.62%) was significantly higher than in April (83.75±0.55%).

The nutritional composition of food is the estimation of the nutritive value of human food in its chemical form (Alli Smith, 2009). The comparison on proximate composition of *N. oleracea* shoots with others aquatic vegetables are shown in Figure 1. The trend nutritional composition of *N. oleracea* of both observed months is similar to those reported by Paisooksantivatana (1994), i.e., moisture > crude protein > crude fiber > ash > crude fat. These results suggests that *N. oleracea* is ranked as moisture rich plant due to their relatively high moisture content as this plant is an aquatic species.

However, the moisture content of edible parts in this study was lower than 89.40% as reported by Paisooksantivatana (1994). In view of the fact that it is a Leguminosae, the composition of crude protein was ranked after moisture. Most of the legume plants are good sources of protein which consisted nitrogen-organic compound complexes (Hazra and Som, 2005). Nevertheless, crude protein analyzed from this study was 3.01-3.23% (50% less) compared to 6.4% reported by Paisooksantivatana (1994). Compared to others Malaysian aquatic leafy vegetables, protein content of *N. oleracea* in this study was high with value of 0.28-3.10% (Rukayah, 2002; Saupi et al., 2009). The crude protein in this study was similar to the other leafy legume, *Sesbania* sp. (4.8%) as reported by Lyimo et al. (2003). The crude protein of edible *N. oleracea* was 6.54-7.02% of the recommended dietary allowance (RDA) (Institute of Medicine, 2005a) and the traditional leafy vegetables have proved inadequate and low in cost in providing solution to the protein requirements of the ever increasing world population (Alofe et al., 1996; Achinewhu et al., 1995). Hence, this wild vegetable could be considered as a good protein supplement.

Crude fiber was defined as the residue remaining as well as lignin; hemicelluloses and cellulose after acid and alkaline extraction of a defatted sample (deMan, 1999). Fibers are mainly found in cereals, legumes, nuts and vegetables which helps the body to remove toxic materials faster (Ong, 2008). In this present study, crude fiber of edible portion was 2.30-2.66% and it was 55% higher than reported by Paisooksantivatana (1994). It was also above the range of aquatic leafy vegetables (1.00–1.60%) but within the range of terrestrial vegetables (0.60-4.70%) (Rukayah, 2002). Referring to the present data, nutritionally, one serving of 100 g of *N. oleracea* provides relevant quantities of the total fiber (9.20-10.64% RDA) (Institute of Medicine, 2005a). The available fibers in *N. oleracea* could contribute to the intake of dietary fiber through consumption of the plant and this form allows consumption of many micronutrients and bioactive compounds which provide their own nutritional benefits.

Table 2. Proximate composition of shoots of *Neptunia oleracea*.

Composition (% dry matter) of 100 g edible portion	April	October	p-value
Moisture content (%)*	83.75±0.55[b]	86.26±0.62[a]	0.03
Ash content (%)	1.07±0.01[a]	1.05±0.04[a]	0.36
Crude fat (%)	0.44±0.24[a]	0.25±0.01[a]	0.16
Crude fiber (%)	2.66±0.16[a]	2.30±0.14[a]	0.07
Crude protein (%)	3.01±0.30[a]	3.23±1.52[a]	0.43
Gross energy (kJ)	261.02±7.48[a]	257.78±11.29[a]	0.40

Mean values of three replicates in the row with a common alphabet are not statistically significant according to T-test ($p \leq 0.05$), ± standard deviation (SD), *value expressed as % wet weight.

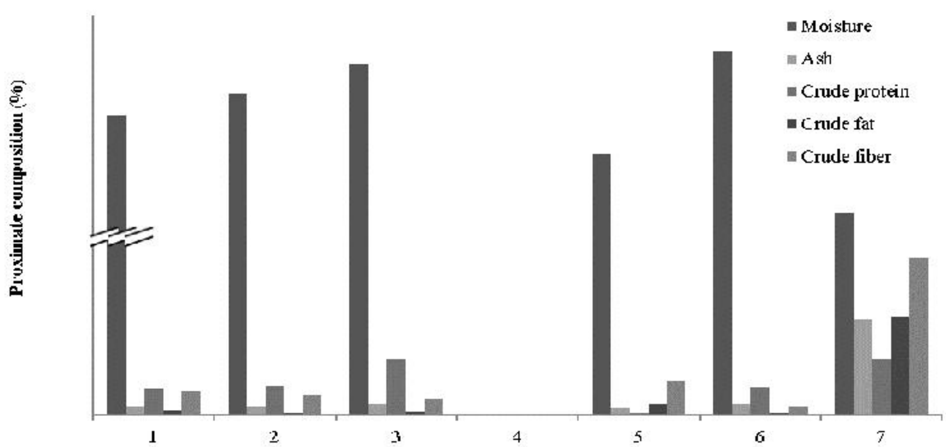

Figure 1. Comparison of proximate composition in *Neptunia oleracea* Loureiro edible parts with others aquatic vegetables. 1 (*Neptunia oleracea* present study, April), 2 (N. oleracea present study, October), 3 (*N. oleracea*, Paisooksantivatana (1994)), 4 (*N. oleracea*, Abulude (2005)), 5 (*Limnocharis flava*, Saupi et al. (2009)), 6 (Ipomoea aquatica, Samy et al. (2005); Rukayah (2002) and 7 (*I. aquatica*, Umar et al. (2007).

The ash content is an index of inorganic minerals in biota (Fleck, 1981; Hassan and Umar, 2006). The ash content (dry weight basis) of *N. oleracea*'s shoot (1.03-1.05%) was comparable to 1.70% recorded by Paisooksantivatana (1994). Similar results have also been reported for other local leafy legumes, *Sesbania grandiflora* (L.) Pers. where ash was 1.80%. This was comparable with other Malaysians leafy vegetables (0.90-2.50%) (Rukayah, 2002).

Vegetables usually contain very low fat content at which mostly ranges from 0.10 to 0.20% (deMan, 1999; Hazra and Som, 2005). However, this present study showed that *N. oleracea* possessed crude fat content of 0.25-0.44% comparatively higher than those obtained by Paisooksantivatana (1994). Others studies on edible legume plant, *S. grandiflora* possessed values of five times higher than *N. oleracea* (Rukayah, 2002). Hence a comparison could be made with other studies, the plants were still within the range of aquatic and terrestrial of common consumable leafy vegetables in Malaysia (0.20-1.80%). One serving of 100 g of *N. oleracea* provides relevant quantities of the total fat (0.83-1.47% RDA) (Institute of Medicine, 2005a).

Umar et al. (2007) stated that the calorific values of most vegetables are low within the range of 125.00-209.00 kJ/100g. The result showed that *N. oleracea* was high in energy value of 257.82±3.17 kJ/100g. It was recorded 50% higher than Paisooksantivatana (1994) (134.00 kJ/100g) but lesser than compared in other legumes vegetable, *S. grandiflora* (343.09 kJ/100g) (Rukayah, 2002). However, the value was about one and half times higher than those recorded in Malaysia leafy vegetables (109.00-155.00 kJ/100g) as reported by Rukayah (2002).

Shoots of *N. oleracea* contains potassium, sodium, calcium, magnesium, phosphorous, copper, zinc and manganese in varying concentration with potassium having the highest concentration (Table 3). The concentration of calcium, phosphorous and copper was significantly lower in April when compared to those in October.

The mineral composition in edible parts of *N. oleracea* was compared with other leafy vegetables (Figure 2 and Figure 3). Minerals play a major role in the functioning of the physiological activities and reproduction in inorganic elements (Fleck, 1981; Hazra and Som, 2007). The inorganic elements were resulting from ash content (Fleck, 1981). Both observed months showed similar trend of macro and micro minerals composition, i.e., K > P > Ca > Na > Mg and Mn > Zn > Ca respectively. The trend was different when compared to *N. oleracea* in Nigeria was K > Na > Ca > Na > Mg and Zn > Cu (Abulude, 2005). According to the present data, nutritionally, one serving of 100 g of N. oleracea provides relevant quantities of the minerals K (68.69-70.40% of the recommended dietary allowance; RDA), Na (14.82-16.76% RDA), Ca (34.80-38.14%), Mg (46.67-50.25% RDA), P (56.52-57.80% RDA) and Zn (94.82-95.73% RDA) (Institute of Medicine, 1997, 2001, 2005b).

The mineral concentration in edible parts of *N. oleracea* showed that potassium is relatively high when compared with other elements (3309.50-3228.33 mg/100g). Nevertheless, this value did not exceed the recommended intake which is 3-4 g daily (Fleck, 1981). Fresh vegetables are one of the major dietary sources of potassium (K) and it facilitated reactions of enzymes in protein and carbohydrate metabolism (Insel et al., 2002). In comparison with a study done by Abulude (2005) in Nigeria, it was eight times higher in K content (820 mg/100g). K content (dry weight basis) in this plant was five times higher than those reported in Malaysian leafy vegetables with the values ranged 78-708 mg/100g (Rukayah, 2002; Samy et al., 2005). The value was similar to those of *I. aquatica* grown in Nigeria (5458.33 mg/100g) and local *L. flava* (4202.50 mg/100g) as reported by Umar et al. (2007) and Saupi et al. (2009). In comparison to others local edible leafy legume, *S. grandiflora* (356 mg/100g), *N. oleracea* purchased from Sibu Central Market had high of K content. Plants generally have higher content of K than Na (deMan, 1999). A similar trend was also observed for sodium (Na) (222.50-251.33 mg/100g) which is slightly lower than Nigerian *N. oleracea* (320.00 mg/100g) but much higher when compared to others leafy vegetables available in Malaysia (3.00-65.00 mg/100g) (Rukayah, 2002). Hassan and Umar (2006) noted that K/Na in diet is an important factor in prevention of hypertension and arteriosclerosis, with K depresses and Na enhances blood pressure. The ratio of K/Na (13.24-7.07) in edible parts of *N. oleracea* was six times higher (2.65) than reported by Abulude (2005). This suggests the shoots of *N. oleracea* provide a good combination of K and Na.

Calcium (Ca) is the essential of bones and teeth (Fleck, 1981; Hazra and Som, 2005). *Neptunia oleracea* has 348.00-381.42 mg/100g Ca content. Paisooksantivatana (1994) and Abulude (2005) reported that Ca content in *N. oleracea* was 387.00 and 320.00 mg/100g respectively. *Neptunia oleracea* purchased in October was 9.60% significantly higher than composed in April's samples. However, the value was slightly higher than recorded by Rukayah (2002) on Malaysian leafy vegetables with the values ranged from 53.00 to 290.00 mg/100g. The concentration of this element was also higher than recorded in *S. grandiflora*, 181 mg/100g and 230 mg/100g by Rukayah (2002) and Lyimo et al. (2003). Phosphorous generally found with calcium in the body contribute to the supportive structures of the body and daily requirement is 1000 mg (Fleck, 1981; Hazra and Som, 2005). The concentration of this element in *N. oleracea* was 405.92±43.69 mg/100g far greater than other studies (Paisooksantivatana, 1994; Rukayah, 2002; Abulude, 2005). Fleck (1981) and Hazra and Som (2005) reported that, legume one of the vegetables containing more than 100 mg of P and good sources of P. While, Ca/P ratio played important role on development of human being at least below for good absorption of both minerals (Raigón et al., 2008). Ca/P in *N. oleracea* was well below 1 (0.88-0.95) (Escudero et al., 1999). The value obtained in this study was comparable as reported by Rukayah (2002). Although responsible to the formation of chlorophyll or deep green colour in vegetables, primary function of magnesium (Mg) to human is as an activator of many enzyme systems (Fleck, 1981; Insel et al., 2002; Hazra and Som, 2005). Green leafy vegetables and legume products were good sources of Mg (Fleck, 1981). Mg obtained from *N. oleracea* was less about one and half times than those recorded in Nigerian *N. oleracea* with the value of 308.00 mg/100g (Abulude, 2005). However, the value (186.67±7.64 mg/100g) was below than daily requirement (200-700 mg per day) (Fleck, 1981).

Table 3. Mineral composition and concentration of edible parts of *Neptunia oleracea*.

Concentration (mg/100g) of edible portion	April	October	p-value
K	3309.50±93.04[a]	3228.33±68.77[a]	0.25
Na	251.33±24.54[a]	222.50±71.20[a]	0.27
Ca	348.00±14.93[b]	381.42±9.00[a]	0.04
Mg	201.00±27.22[a]	186.67±7.64[a]	0.26
P	395.67±26.50[b]	405.92±43.67[a]	0.05
Cu	2.58±0.29[b]	2.97± 0.12[a]	0.05
Zn	10.43±0.78[a]	10.53±1.36[a]	0.41
Mn	12.63±0.55[a]	14.23±1.14[a]	0.12
K/Na	13.24±1.14[a]	15.97±7.07[a]	0.28
Ca/P	0.88±0.09[b]	0.95±0.11[a]	0.04

Mean values of three replicates in the row with a common alphabet are not statistically significant according to T-test (p≤0.05), ± standard deviation (SD).

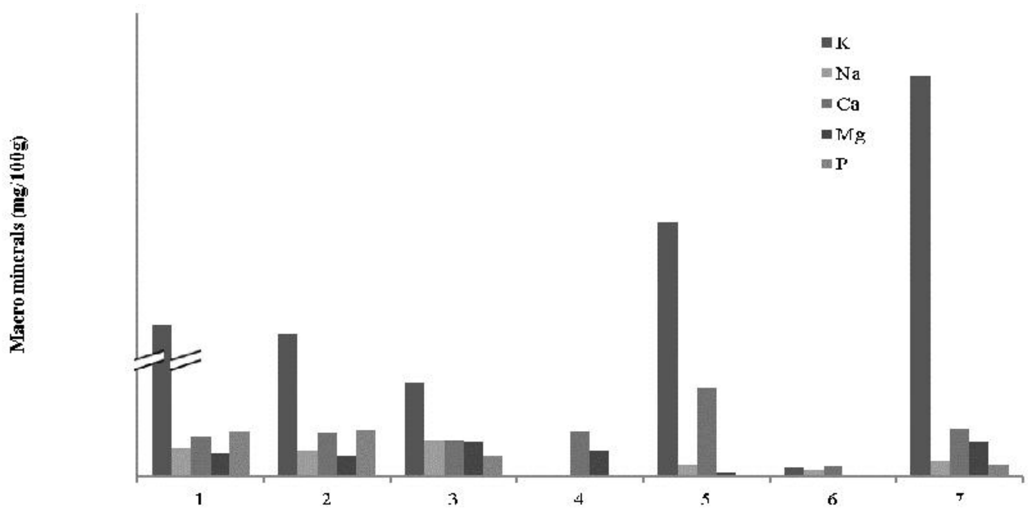

Figure 2. Comparison of macro mineral in *Neptunia oleracea* Loureiro edible parts with others aquatic vegetables. 1 (*Neptunia oleracea* present study, April), 2 (*N. oleracea* present study, October), 3 (*N. oleracea*, Paisooksantivatana (1994)), 4 (*N. oleracea*, Abulude (2005)), 5 (*Limnocharis flava*, Saupi et al. (2009)), 6 (*Ipomoea aquatica*, Samy et al. (2005); Rukayah (2002)) and 7 (*I. aquatica*, Umar et al. (2007)).

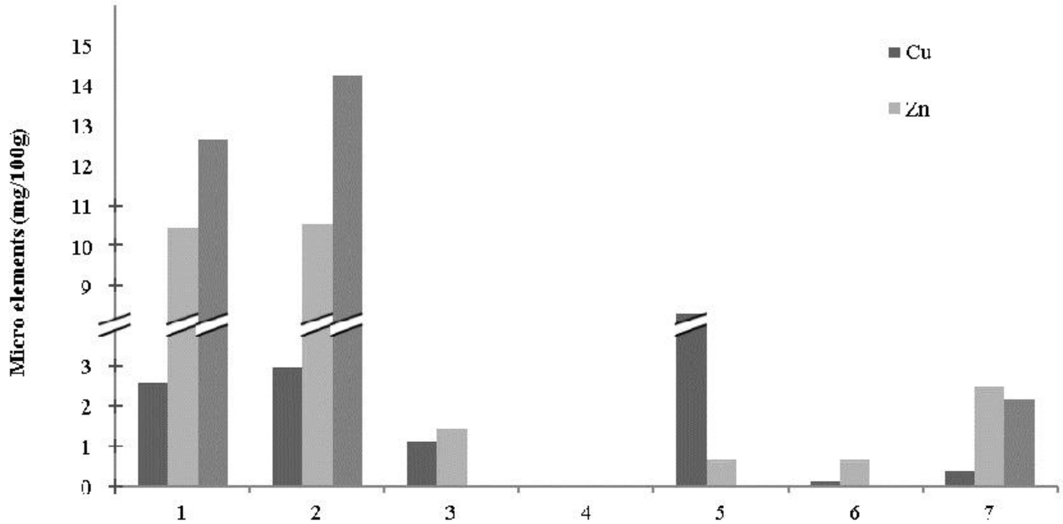

Figure 3. Comparison of micro mineral in *Neptunia oleracea* Loureiro edible parts with others aquatic vegetables. 1 (*Neptunia oleracea* present study, April), 2 (*N. oleracea* present study, October), 3 (*N. oleracea*, Paisooksantivatana, (1994)), 4 (*N. oleracea*, Abulude (2005)), 5 (*Limnocharis flava*, Saupi et al. (2009)), 6 (*Ipomoea aquatica*, Samy et al. (2005); Rukayah (2002)) and 7 (*I. aquatica*, Umar et al. (2007)).

Copper (Cu) is another trace element, essential in human body where it exists as an integral part of copper proteins ceruplasmin, the enzyme that catalyzes the oxidation of iron ion (Fleck, 1981; Insel et al., 2002). In this study, Cu concentration in this leafy vegetable legume was three times higher than concentration as reported by Abulude (2005) and two times higher of RDA (Institute of Medicine, 2001). With respect to Cu, only 0.10 mg/100g was found in cultivated *I. aquatica* from Malaysia and 0.36 mg/100g in Nigerian *I. aquatica.* Other studies reported that Cu in *L. flava* (8.31 mg/100g) was far greater than *N. oleracea* (Saupi et al., 2009). Despite being functional as K, zinc (Zn) element was needed during pregnancy particularly in the development of fetus central nervous system (Fleck, 1981). The value of Zn concentration found in this study was 10.53±1.36 mg/100g. This value was higher than reported in other studies (Abulude, 2005; Samy et al., 2005; Saupi et al., 2009). Although the content was high, Fleck (1981) also documented that it met the range that recommended from 10-15 mg per day and notably legumes one of the best sources of Zn. Manganese (Mn) are also important as an essential component for bone structure, reproductive and normal function in nervous system (Fleck, 1981). Mn concentration was found 14.23 mg/100g. In comparison to the other study done by Odhav et al. (2007) on traditional leafy vegetables in KwaZulu-Natal, South Africa, it was comparable with the value of 3-82 mg/100g.

Conclusion

The edible shoots consisted of leaves, spongy stems and young seedpods of *N. oleracea* have high moisture, crude protein, crude fiber, ash content and calorie and low in crude fat compared with other Malaysians leafy vegetables. The high potassium content in this plant is beneficial and acts as protective role against hypertension, stroke, kidney stones and osteoporosis. Consumption of *N. oleracea* (eg., 100 g dry weight or 180-190 g wet weight equivalent) could also provide an adequate daily intake of other minerals particularly Na, Ca, P and Zn.

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Author contributions

N. S. designed the study, did the analysis and wrote the article, M. H., J. S. and A. A. checked, wrote and corrected the article.

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