

## Species, nutritional value, and elemental content of *Stenochlaena* distributed in Central Kalimantan, Indonesia

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**Abstract.** Chotimah HENC, Muliansyah, Widyawati W, Pitrama, Suparto H. 2022. Species, nutritional value, and elemental content of *Stenochlaena* distributed in Central Kalimantan, Indonesia. *Biodiversitas* 23: 5367-5372. *Stenochlaena* J. Smith is belonging to the family of Blechnaceae, consisting of only seven species and widely distributed in tropical and subtropical regions. In Central Kalimantan Indonesia, *Stenochlaena* is also widely distributed and abundant in this province. The paper will deliver the diversity of species, and chemical composition value of *Stenochlaena* in Central Kalimantan. The method used was a survey conducted in the tree district of Central Kalimantan namely Barito Selatan, Kapuas, and Palangka Raya. The key to species determination used was a paper published by Chamber (2013). Chemical composition was measured by proximate analysis while elemental content was established by atomic absorption spectrophotometer. This is the first report on the proximate and element components of some *Stenochlaena* species, other than *Stenochlaena palustris*. The results showed that there were four species of *Stenochlaena* found in Central Kalimantan, namely *Stenochlaena palustris*, *Stenochlaena tenuifolia*, *Stenochlaena milnei* and *Stenochlaena cumingi*. *Stenochlaena palustris* had the greatest moisture and proteins while *S. cumingii* had the highest content of ash. The biggest content of lipids was owned by *S. milnei* meanwhile *S. tenuifolia* had the most content of fiber. *Stenochlaena palustris* also had the highest N, P, K, Mg meantime, the highest Ca and Fe were in *S. cumingii* and *S. milnei*, respectively.

**Keywords:** Biodiversity, *Blechnaceae*, Central Kalimantan, *Stenochlaena*

### INTRODUCTION

*Stenochlaena* J. Smith belongs to the Blechnaceae family (Wardani et al. 2012; Chambers 2013; Wang et al. 2013), consisting of six or seven species (Gasper 2016; Wang et al. 2013) and widely distributed in tropical and subtropical regions (Chambers 2013; Gasper 2016). Five species have been found in Africa, Asia, Australia, Pacific Islands, while one species has been reported in China (Wang et al. 2013). *Stenochlaena* is primarily a genus of the rainforest. The distribution pattern is related to the environment. *Stenochlaena* is primarily found on the edges of forests with a relatively high intensity of light and humid soil conditions (Chambers 2013). It is a climbing (Gabriel et al. 2013) and a creeping rhizome of earthly plants. The stout rhizome at the apex is scaly, brown to blackish. The shape of the rhizome is orbicular, ovate, and a tiny oval shape tapering at each end to a point. *Stenochlaena* has dimorphic fronds (Gabriel et al. 2013) which are old glabrous stalks. *Stenochlaena* also has a unique chromosome number in the family,  $x=74$  of *S. palustris* (Burm.f.) Bedd. (Gasper 2016). It has sterile and fertile pinnae (Gasper 2016; Wang et al. 2013). The sterile pinnae were distinguished by narrowly lanceolate, shortly stalked, articulated rachis, the margin sharply toothed, respectively. Its veins are usually opposite each other in pairs. Linear, smaller compared to sterile, and coated with spores are the

fertile pinnae. Spores are ellipsoid in shape with prominent tubercles (Wang et al. 2013). *Stenochlaena* has sori that lack an indusium (Gasper 2016). The close association between American *Salpichlaena volubilis* and American *S. thalassica* Grayun & R.C. Moran and Philippine *S. milnei* Underw was seen in molecular research (Gabriel et al. 2013). The characteristic spores of *S. milnei* are found as far north as south China, west of Wallace's Line, and westward to India (inexplicably, during the earliest Quaternary, this species suddenly became extinct. The spores of *S. milnei* Underwood and *S. cumingii* are similar to *Stenochlaenidites papuanus*. *S. milnei* (*Stenochlaenidites papuanus*) was originally described from the late Miocene to Pliocene of Papua (Fakhruddin et al. 2020). *S. areolaris* became extinct in Borneo (Gorsel 2018).

*Stenochlaena* is also widely distributed in Central Kalimantan and abundant in this region. Its species are distributed on the riverside, ex-burnt field, yard, and clear land. The community, however, knows only one species, namely *S. palustris* (Burm.f.) Bedd or its vernacular name is *kelakai* which can be consumed as vegetables (Chotimah et al. 2013). They know only two kinds of *kelakai*, namely white and red *kelakai*. For the Dayak people, consumption of *S. palustris* is believed to be able to increase the production of breast milk for pregnant and lactating mothers, increase hemoglobin levels and prevent premature aging, treat anemia and postpartum care (Zannah et al.

2015). Margono et al. (2016) have proved that the extract *S. palustris* has the potential impact on treating malaria. In Thailand, *S. palustris* is used as cough medicine (Neamsuvan et al. 2015). The bioactive compounds of *S. palustris* found were flavonoids, steroids, and alkaloids (Suhartono et al. 2010) which were not inferior to several medicinal plants in South Kalimantan such as gerunggang stems and pasak bumi roots (Suhartono et al. 2012). *Sauteed kelakai* is one of the favorite foods of the Dayak tribe. The part consumed was the young fronds (Chotimah et al. 2013). The others of food made from kelakai are juhu kelakai, kelakai luntuh (boiled), and kelakai chips. In Malaysia, *S. palustris* (Midin) young leaves are used as a dish by cooking them using shrimp paste (Chear et al. 2016). It has also been served as a green salad with vinegar (Ting et al. 2017).

Recently, wild edible plants have been recognized as a significant source of macro and trace elements acquisition (Jalali & Fakhri 2021) than commercial vegetables and may be used for the nutritional purposes (Chettri et al. 2018), including ferns. Fern decided to consider their use as food, bioactive, and proteins in order to display their health and wellness advantages (Amoroso et al. 2017). However, the decline that has been reported in other than *S. palustris* consumption has been attributed to factors including a lack of knowledge of the species' availability, the favorable nutritional composition, a fear of their poisoning, the more bitter taste, and their crude texture, respectively. Therefore, the study on the nutritional value and element content of these species of *Stenochlaena* lead to a better assessment of their importance. To the best of our knowledge, a study on the diversity of species belonging to *Stenochlaena* in Central Kalimantan has never been carried out anywhere. Hence, the objectives of the research were to investigate the species, the proximate composition, and element content with the goal to rescue these important food sources germplasm and provide the chemical value information contained in species other than edible *S. palustris*.

## MATERIALS AND METHODS

### Study area

Exploration for *Stenochlaena* was carried out purposively in three districts of Central Kalimantan namely Barito Selatan, Kapuas, and Palangka Raya based on the species abundance. We decided on three sub-districts in each district for sampling. Barito Selatan is located 183 km from Palangka Raya, the capital of Central Kalimantan. The study locations were Dusun Selatan, Dusun Utara, and Gunung Bintang Awei sub-districts. The sampling in Kapuas district was located in sub-district Basarang, Dadahup, and Kapuas Murung, respectively. Samples from Palangka Raya were taken from Bukit Batu, Jekan Raya, and Sebangau (Figure 1). The samples were taken at a rate of 10 plants in each location using the quadrant method. The variables observed were the number of species, and the chemical content (proximate value and elements content).

The key for identification and characterization of species used was an investigation resulted by (Chambers 2013).

### Plant materials

Four species selected from the field namely *S. palustris*, *S. milnei*, *S. cumingii* and *S. tenuifolia* were identified and analyzed then on their young leaves and young stalks parts. The samples were washed under running water and oven-dried at 65°C for a couple of days and ground to a fine powder. The powdered samples were used for further analyses.

### Proximate analysis

Evaluation of chemical composition involved the moisture, protein, ash content, fiber, and lipid content which was performed using proximate analysis according to AOAC methods (AOAC, 1980). Determination of moisture was done by weighing the powdered samples. Determination of ash content by placing a dried sample in a porcelain jar (1 g) in a furnace at 600°C for 4h until the ash turned white. Fat content was detected by hexane extraction for 6 h in a soxhlet apparatus as a total lipid. The protein content was determined using the Kjeldahl method of nitrogen analysis. The 0.25 g sample was weighed, then placed on a Kjeldahl flask 100 ml. Then, an approximate mixture of 0.25 g selenium and 3 mL of H<sub>2</sub>SO<sub>4</sub> were added. It was then destructed for 1h until transparent. The solution was poured cold into a 500 mL volumetric flask and added 500 mL aquadest and 20 mL NaOH 40%, were then rinsed with distilled water. An erlenmeyer consisting of 10 mL H<sub>3</sub>BO<sub>3</sub> 2% + 2 drops indicator solution (Brom Cresol Green-Methyl Red) was prepared to collect the distillation. The distilled was then titrated using HCl 0.1 N solution until the solution changed into light red. The calculation using the formula below:

$$\text{Nitrogen \%} = \frac{V \times N \times 14}{W \times 1000} \times 100\%$$

While, V is sample titration volume (ml), N is the normality of HCl and W is dry sample weight (mg). The protein content was obtained by multiplying with 6.25.

Crude fiber determination was carried out by dissolving 1 g of sample with 100 ml H<sub>2</sub>SO<sub>4</sub> 1.25 %, heating to boiling, then digestion for 30 minutes, then filtering with filter paper and using a Buchner funnel. The filter residue was rinsed 3 times with 20-30 ml of boiling water and 25 ml of water. With 1.25 % NaOH for 30 minutes, the residue was again digested, then filtered as above and rinsed successively with 25 ml H<sub>2</sub>SO<sub>4</sub> 1.25 % boiling, 25 ml of water three times, and 25 ml of residual alcohol and filter paper were transferred to a porcelain dish and dried for 2 hours in a 130°C oven (A) and the residue was weighed along with the porcelain dish after cold, then put in a 600°C oven (B) The crude fiber content was calculated as follows:

$$\text{Crude fiber content} = \frac{A - B}{\text{Sample weight}} \times 100\%$$

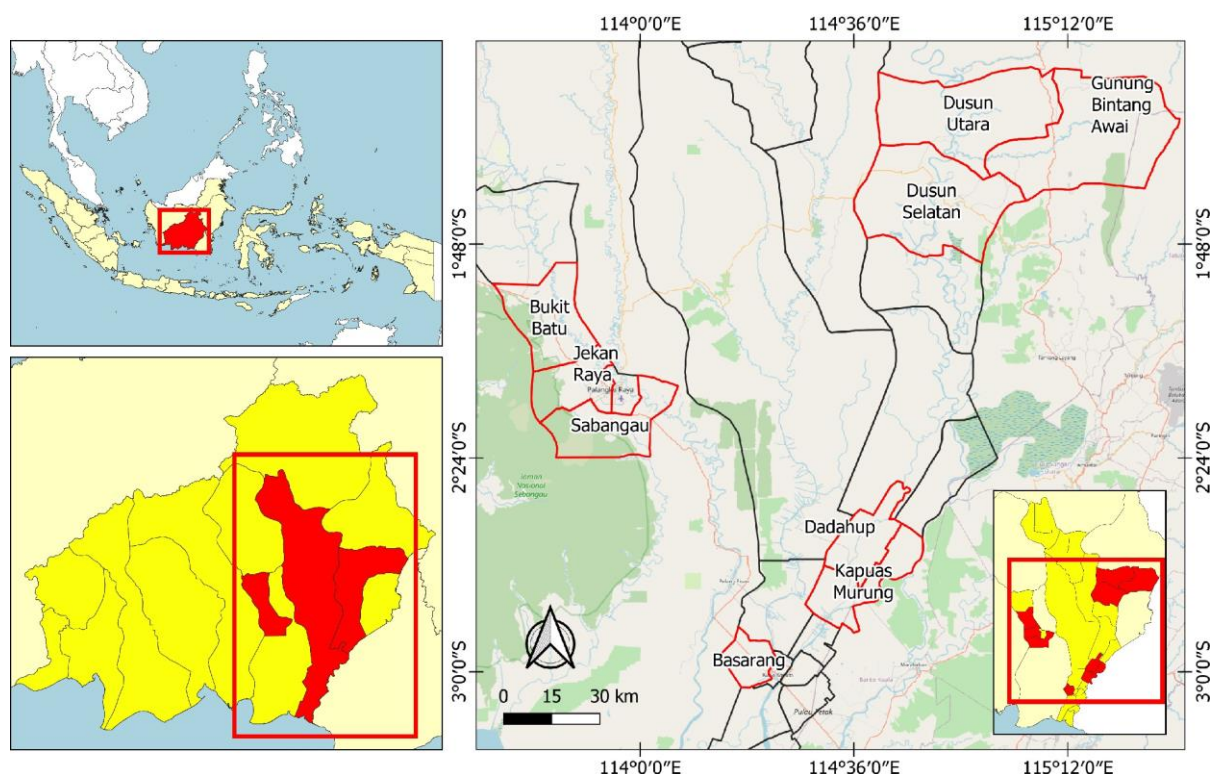


Figure 1. Map of sampling locations

### Evaluation of elements content

The content of elements (P, K, Ca, Mg, and Fe) was estimated by wet ashing of 1 g sample and dissolved in an acid mix of HCl : HNO<sub>3</sub> (2:1) and analyzed using the atomic absorption spectrophotometer (AAS) with 766.5 nm, 589 nm, 422.7 nm, 285.2 nm, 248.3 nm, 279.5 nm, 196 nm, and 213.9 nm wavelength for K, Na, Ca, Mg, Fe, Mn, Se, and Zn, respectively. The P mineral was measured using a spectrophotometer with a wavelength of 650 nm. The analysis of proximate and elements content was performed in the Laboratory of Natural Resources and Biotechnology Research Centre, Bogor Agricultural University. Data on species availability were delivered descriptively while the proximate composition and elements content was presented in the triplicate average value of composite samples.

## RESULTS AND DISCUSSION

### Species availability

Exploration conducted in the three districts of Central Kalimantan found four species belonging to the *Stenochlaena* genus, namely *S. palustris*, *S. milnei*, *S. cumingii*, and *S. tenuifolia*. Based on the abundance, the order of population was as follows *S. palustris* > *S. tenuifolia* > *S. cumingii* > *S. milnei*. *S. palustris* was the greatest availability among other species and was found in nearly every sampling location. *S. cumingii* was obtained in Palangka Raya in large quantities growing on the river banks. According to the local community, one of the characteristics that distinguish the species from the others is hairy stems and brownish-yellow spores. In

the highland, such as Gunung Bintang Awei, *S. tenuifolia* was not found. The species was characterized by slightly square stalks while the others were visualized by round stalks. It was difficult to determine the difference between *S. milnei* and *S. palustris* due to they grew in a group. We used the rachis and fertile pinnae feature to distinguish it. Chambers (2013) confirmed that *S. milnei* might be of hybrid origin between *S. palustris* and *S. cumingii*, so that is sometimes confused with *S. palustris*. *S. milnei* is a robust fern with complex rachis. At maturity, the fertile pinnae of *S. milnei* are more robust than those of *S. palustris*. The growing habitats observed were swamps, empty land, peatland, riverbanks, and shrubs. The dominating soil type was peat in Palangka Raya, peat, alluvial, and regosol in Barito Selatan, and in Kapuas of peat and acid sulfate soils. The vegetation around included *Acacia*, *Imperata cylindrica*, fern, *Caladium*, *Bauhinia variegata*, *Samanea saman*, *Terminalia catappa*, *Gigantochloa apus*, *Oryza sativa*, *Cocos nucifera*, *Hevea brasiliensis*, *Psidium guajava*, and *Pennisetum purpureum*.

Chambers (2013) pointed out that most *Stenochlaena* species were present in the Malesian region. The most widely distributed, best known, and abundant was *S. palustris*, whereas *S. milnei* was limited available and appear to be confined to New Guinea, the Philippines, and Solomon Islands. There were very few collections of *S. cumingii* from New Guinea, the Philippines, and Indonesia. *Stenochlaena palustris* was very adaptable in coastal environments, forest edges, tropical and subtropical lowlands, rubber and oil palm plantations areas, and abandoned gardens. *Stenochlaena milnei*, a very robust fern compared to others

was also observed in Indonesia (Maluku) occurring in the closed forest in humid habitats. The favorable habitats of *S. tenuifolia* were mainly in inland coastal forests. *Stenochlaena milnei* and *S. palustris* were identified in South Sumatera growing on oil palm plants which grew in a more open place and got plenty of sun, and high humidity of 52.5% (Harmida et al. 2018). Sari & Sofiyanti (2019) made an inventory of ferns in Riau province. They found 3 species belonging to the Blechnaceae, namely *Blechnum finlaysonianum* Wall, *Blechnum orientale* L dan *S. palustris* (Burm. F) Bedd. The findings of (Ridianingsih et al. 2017) showed that Pteridophyta was abundantly found in humid places, shaded areas, open fields, around the coast, mountain slopes, valleys, forests, and plantations. In addition, Ridianingsih et al. (2017) also measured the presence of abiotic and biotic factors that affect Pteropsida growth. They found that soil pH was around 6.6, soil humidity was 17.42%, air humidity was 65, the air temperature was 30°C, light intensity was  $\geq 500$ , and wind speed of 19.2Knots. Teak, not too dense, forest betel, and *Piper retrofractum* Vahl have dominated the vegetation around the species belonging to Pteropsida. *Stenochlaena palustris* dominated on marsh swamps or treeless shallow water bodies dominated by a lush growth of herbaceous plants (Rajpar & Zakaria 2013). The lowlands are also a favorable condition for *S. palustris* (Sémah & Sémah 2012). In a degraded tropical peatland, the ground cover dominated by *S. palustris* was abundant ( $42.1 \pm 30.2\%$ ) (Blackham et al. 2014).

*Stenochlaena milnei* also was presented in the Philippines (Magtoto & Austria 2017), in Northern Mindanao with an average annual rainfall of 2,195 mm, and the elevation ranges from 303 m to 600 m asl. Flat lowland areas, gentle slopes, rocky crevices, exposed dry ridges and moist shaded gullies were favorable to its topography. A stoloniferous, evergreen climbing fern normally associated with marshy environments *S. tenuifolia* is found in South Africa and Florida (Sessa et al. 2018). *S. tenuifolia* has become abundant along the coastal plain in Zululand in pine plantations. It is also present in Transkei, Natal, and Mozambique and is generally found only on the coastal strip. The three terrestrial species were determined by (Pradipta et al. 2020) namely *S. palustris*, *S. milnei*, and *Blechnum occidentale* which live at very low temperatures. The color of the leaves is the uniqueness of this type of fern. The leaves are coated with brown sorus at the time of bud, while the open leaves are red in the young ones and turn green over time. *S. tenuifolia* is the specific fern in the wetlands, which appears to play a similarly pivotal role in helping forest growth during fire suppression times (Luvuno et al. 2013). *S. milnei* is also a scarce species found in Tien Hung, Vietnam (Chung et al. 2021).

*S. palustris* is widespread in the lowlands overgrown by mangrove forests which have humid soil or aquatic habitats with relatively high conditions of light (Chambers 2013; Mildawati et al. 2020). There are two species of *Stenochlaena* cultivated in the US, namely *S. palustris* and *S. tenuifolia*. The growth of *S. tenuifolia* was rather

difficult and quite slow. However, it grows rapidly once developed, providing good shade and heavy soil. This fern's rapid growth is during the rainy season. It also requires lots of water and does not like cold weather (Morton 2015). Little et al. (2018) conducted the five treatments to determine the competitive effect of under-canopy vegetation on pine tree growth, resulting that *S. tenuifolia* was occurred in the weedy plots (no further control of vegetation, except for the slashing of perennial vegetation to facilitate access prior to the two thinning events). In Northern KwaZulu Natal, *S. tenuifolia* can form a dense understory (Taylor 2016). Ramírez-Trejo et al. (2013) also observed the occurrence of *S. tenuifolia* in Mexico which had warm and humid weather, covering limestone bedrock soils and semi-deciduous seasonal forests.

### Proximate composition

Other than *S. palustris*, this is the first report on the proximate composition of *Stenochlaena* of Central Kalimantan. Table 1 shows the diversity of proximate value of some species belonging to *Stenochlaena*. *S. palustris* had the highest of proteins (17.44%), meanwhile, the greatest ash content was owned by *S. cumingii* (15.51%) followed by *S. milnei* (14.76%), *S. palustris* (13.58%), and *S. tenuifolia* (11.91%) based on the dry weight. Compared to others, *S. milnei* was found to have superior amounts (2.49%) of fat content whereas *S. palustris* had the smallest amount (18.67%) of fiber content to the rest of the species. A comparison with six Himalayan wild edible ferns revealed that the fat content was in the range of 0.18-0.40%, ash 0.98-1.57%, protein 3.56-12.10%, and fiber 2.35-5.05%, respectively (Chettri et al. 2018).

According to Negara et al. (2017) leaves of *S. palustris* had higher moisture, ash, protein, and fat content than the frond, meanwhile, the fiber was higher in the frond. Amoroso et al. (2017) claimed that *S. palustris* had 0.07 mg/mL proteins with molecular weights ranging from 12-250kDa. In the present study, the *Stenochlaena* was also a good source of protein (11.25% - 17.44%) and fiber (18.67% - 25.81%), hence can be used to provide the dietary nutritional needs of poor communities. The green leafy vegetables that are commonly consumed and collected from the wild are a considerable good source of dietary fiber, which was found high in the leaves of *Sonchus asper* ( $12.86 \pm 1.39$  g/100 g) in North-East India (Chyne et al. 2019).

**Table 1.** The proximate value of *Stenochlaena*

Species	Ash (%)	Fat (%)	Protein (%)	Fiber (%)
<i>S. tenuifolia</i>	11.91	1.09	14.57	25.81
<i>S. milnei</i>	14.76	2.49	16.14	20.38
<i>S. palustris</i>	13.58	1.47	17.44	18.67
<i>S. cumingii</i>	15.51	1.81	11.25	25.20

**Table 2.** The content of elements of *Stenochlaena*

Species	Ca (%)	P (%)	K (%)	Mg (%)	Fe (%)	N (%)
<i>S.tenuifolia</i>	0.06	0.34	1.67	0.26	0.02	2.33
<i>S. milnei</i>	0.10	0.30	1.75	0.17	0.03	2.58
<i>S. palustris</i>	0.06	0.46	1.84	0.01	0.01	2.79
<i>S.cumingii</i>	0.21	0.22	1.80	0.02	0.02	1.80

Thursina (2010) reported that soil types have no impact on the water content of *S. palustris* whereas the highest ash was measured on peat soil (9.26%) followed by acid sulfate soil (9.12%), quartz sand soil (8.35%) and mineral soil (8.12%), respectively. The young frond of *S. tenuifolia* was edible and consumed as a vegetable in Madagascar (Maroyi 2014).

### Elemental content

Tables 2 shows that *S. palustris* had the highest N, P, K, Mg compared to others, while the highest Ca and Fe content were in *S. cumingii* and *S. milnei*. The calcium content in the present experiment revealed that it ranged between 0.06% in *S. palustris* and *S. tenuifolia* - 0.21% in *S. cumingii*. The edible fern *D. esculentum* in Himalaya consisted of 0.66 mg/100g calcium (Chettri et al. 2018) lower than all species analyzed. Singh & Fibres (2015) proposed two reasons to be attributed to the Ca uptake in the analyzed ferns, the heavy rainfall and acidic soil. The study site was located in mostly peat soil areas with low pH. Phosphorus content ranged from 0.22% (*S. cumingii*) - 0.46% (*S. palustris*). The highest phosphorus and potassium in *S. palustris* is in line with the proposal of Ndanusa et al. (2020) which revealed that *S. palustris* represents a good source of potassium and phosphorus minerals. K content was estimated to be highest in *S. palustris* (1.84%) followed by *S. cumingii* (1.80%) and *S. milnei* and lowest in *S. tenuifolia* (1.67%). The species namely *S. tenuifolia* had the highest amount (0.26%) of Mg whereas *S. palustris* was estimated to have the smallest amount (0.01%). Among the fifth *Stenochlaena* *S. cumingii* had the lowest value for N (1.80%). The smallest amount of iron content of *Stenochlaena* analyzed was found in *S. palustris* (0.01%). In addition, Negara et al. (2017) distinguished between *S. palustris* young leaves and trunks, resulting in the highest Ca (182.07 mg/100 g) and Fe (291.32 mg/100 g) on leaves. The *S. palustris* underground parts accumulated higher Fe concentration than their leaf parts. The concentration of Fe was at a rate of 1.0-2.1 µg/g dry weight of leaves (Rahmawati et al. 2017), 0.39 mg/L on young leaves and, 0.48 mg/L on old leaves (Jenny & Indrawati 2019). A previous study of *D. esculentum* fern by (Chettri et al. 2018) reported that the iron content was high range (14.38 mg/100g).

The macro element in the studied following order was found K > Ca > Mg, confirming the previous order found by (Renna et al. 2015). Kongkachuichai et al. (2015) recorded that indigenous vegetables provide small to moderate amounts of macronutrients and minerals. It had the content of calcium (252.49 mg/100g), potassium (689.12 mg/100g), and phosphorus (98.05 mg/100g) levels,

but the iron content was only 0.80 mg/100g. Red amaranth (*Amaranthus caudatus*) was a good source of iron (3.35 mg/100g) and magnesium (180.81 mg/100g).

In conclusion, the results showed that there were four species of *Stenochlaena* found in Central Kalimantan, namely *S. palustris*, *S. tenuifolia*, *S. milnei* and *S. cumingii*. The order of population abundance was as follows *S. palustris* > *S. tenuifolia* > *S. cumingii* > *S. milnei*. Biochemical investigation of the species revealed that their proximate and element values are similar to those of *S. palustris*. The poisonous compounds should carefully be examined to ensure safety as well as the heavy metal content.

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