

Impact of geographical variation on proximate composition of *Sesbania grandiflora* L. in Sri Lanka

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Abstract

Sesbania grandiflora L. is a widely consumed green leafy vegetable in Sri Lanka, valued for its nutritional and therapeutic benefits. The nutrient composition can vary depending on many factors, including the geographical location. This study investigated the variation in proximate composition of *S. grandiflora* L. leaves collected from 16 locations across diverse agro-climatic zones in Sri Lanka, focusing on moisture, ash, protein, fat, carbohydrate, and fibre content. Samples were collected, cultivated under organic farming practices, and analysed using standard AOAC methods, methods of analysis established by the AOAC International (formerly the Association of Official Analytical Chemists). One-way ANOVA followed by Tukey post hoc test revealed significant differences ($p < 0.05$) in nutrient composition among the locations. Moisture content ranged from 64.13% to 82.79%, with both extremes recorded within the low-country wet zone, indicating substantial micro-environmental influence. Ash content varied from 1.89% to 5.68%, reflecting differences in mineral availability across soils. The highest protein content was recorded in the low-country dry zone (16.38%). Carbohydrate and fibre content were notably high in the low-country wet zone, with values reaching 18.33% and 11.79%, respectively. The findings highlight the influence of geographical location on the nutritional quality of *S. grandiflora* L. This study provides valuable insights for optimising the cultivation of *S. grandiflora*, contributing to improved dietary planning and region-specific agricultural practices in Sri Lanka.

Keywords: Geographical variation, nutrients, proximate composition, *Sesbania grandiflora*.

Introduction

Green leafy vegetables (GLVs) are integral components of traditional diets in many countries, particularly in South and Southeast Asia. Known for their nutritional density and therapeutic properties, GLVs provide essential nutrients, dietary fibre, and a wide range of bioactive compounds (Nadeeshani et al., 2018). Among the various GLVs consumed in Sri Lanka, *S. grandiflora* L., commonly known as Kathurumurunga, holds significant nutritional importance. It is used in traditional cuisines and Ayurvedic medicine due to its high nutrient content, including proteins and fibre (Ananthi and Jayasri, 2021). The nutritional composition of GLVs is influenced not only by their genetic makeup but also by environmental factors like soil type, climate, cultivation method, and season, which can change depending on the geographical location. Several previous studies have evaluated the nutritional properties of GLVs under uniform conditions (Nadeeshani et al., 2018; Ananthi and Jayasri, 2021); however, there is a knowledge gap in the nutrient composition of *S. grandiflora* across different regions of the island. Understanding such variability is crucial for guiding better dietary planning and food security initiatives, allowing plant breeders to identify optimal growing regions for producing nutrient-rich crops.

This study was designed to explore the variation in proximate composition: moisture, ash, protein, fat, carbohydrate, and fibre of *S. grandiflora* L. leaves collected from 16 locations representing six agro-climatic zones in Sri Lanka. This research contributes valuable data on the geographical variation in nutritional quality of *S. grandiflora* L. and lays the groundwork for more detailed agro-ecological and biochemical studies. By integrating such data into agricultural planning, Sri Lanka can promote the targeted cultivation of nutrient-dense crops that support both public health and sustainable farming.

Materials and Methods

Three samples of *S. grandiflora* L. were collected from each 16 locations in Sri Lanka (Table 1) by following the random sampling method. The sample collected were home gardens grown, under organic farming practices. Chemical reagents, H₂SO₄, Na₂CO₃, and petroleum ether were obtained by Breckland Scientific™, UK. Zn granules, NaOH, K₂SO₄, HgO, and Na₂S₂O₃, were obtained from Merck, Germany.

Table 1: The sampling locations and geographical coordinates

Agro-climatic Zone	Sample location	Geographical coordinate	
		Latitude	Longitude
Low-country dry zone (LD)	Jaffna	9.738817	80.01751
	Anuradhapura	8.310921	80.38111
	Polonnaruwa	7.772025	81.211141
	Hambanthota	6.145451	81.144426
	Kalpitiya	8.039823	79.714747
Low-country intermediate zone (LI)	Kurunegala	7.435698	80.362343
Mid-country intermediate zone (MI)	Badulla	6.907357	81.215564
	Monaragala	6.855969	81.342407
Upcountry intermediate zone (UI)	Ella	6.861539	81.02505
	Welimada	6.869918	80.943397
	Kalutara	6.546935	80.045276

Low-country wet zone (LW)	Hikkaduwa	6.130542	80.10267
	Gampaha	7.071295	79.972292
	Rathnapura	6.710008	80.389119
	Kegalle	7.217894	80.2478
Mid-country wet zone (MW)	Kandy	7.30824	80.720608

The collected samples were taxonomically identified according to the online herbarium, the Atlas of Florida Plants from the Institute for Systematic Botany, the University of South Florida, USA (Accession number – 285380, <https://florida.plantatlas.usf.edu/specimen/plantdetails/1487>). The samples were cleaned well with distilled water to remove impurities. Then comestibles were air-dried at room temperature to remove surface water. They were kept in a refrigerator at 4 °C for chemical analysis.

Determination of proximate composition

The proximate composition was presented on a fresh weight basis. The moisture content of the samples was determined using the loss on drying by AOAC methods (2002). The ash content and protein content were determined using the dry ashing method and the Kjeldahl method by AOAC method (2002). The crude fat content was determined using the Soxhlet extraction by AOAC method (2002). By subtracting the sum of the percentage of protein, moisture, fat, and ash from 100, the carbohydrate content was determined (Arasaretnam et al., 2018). The determination of crude fibre content was carried out using the method, acid and base digestion (Lesten and Kingsley, 2020).

Statistical analysis

All experiments were performed in triplicate, and results are presented as mean ± standard deviation (SD). Statistical analyses were conducted using one-way analysis of variance (ANOVA) in IBM SPSS Statistics. Tukey's post hoc test was applied to identify significant differences among locations, with statistical significance accepted at $p < 0.05$.

Results

Table 2 summarizes the proximate composition of *S. grandiflora* L. collected from different geographical regions. One-way ANOVA followed by Tukey's test revealed statistically significant differences ($p < 0.05$) in the nutritional profiles of samples across the various agro-climatic zones. Moisture levels in *S. grandiflora* L. range from 64.13% in Hikkaduwa (LW zone) to 82.79% in Rathnapura (LW zone). Ash content varies from 1.89% in Polonnaruwa (LD zone) to 5.68% in Kandy (MW zone). The highest protein concentration was observed in Hambanthota (LD zone) at 16.38%, followed closely by Anuradhapura (LD zone) at 16.27% and Polonnaruwa (LD zone) at 15.34%. Fat content peaked in Kalutara (LW zone) at 1.48%, with notably elevated values also detected in Jaffna (LW zone) at 1.15% and Ella (UI zone) at 1.10%. Carbohydrate levels are notably high in Hikkaduwa (LW zone) at 18.33%, followed by Kalutara (LW zone) at 16.59% and Monaragala (MI zone) at 13.95%. Fibre content is highest in Kalutara (LW zone) at 11.79%, followed by Rathnapura (LW zone) at 11.55% and Polonnaruwa (LD zone) at 11.19%. The lowest fibre content was recorded from Rathnapura (LW zone) at 5.02%.

Discussion

The nutrient composition of *S. grandiflora* L. leaves varied markedly across Sri Lanka's agro-climatic zones (Table 2), revealing valuable insights into nutrient variation. The present findings show the highest moisture content (76.99%), which is comparable to the values reported by Nadeeshani et al. (2018). The highest moisture content in Rathnapura may be attributed to the region's environmental factors, such as higher rainfall and humidity, which promote water retention in plant tissues (Dahanayaka et al., 2025). The lowest moisture content was also reported from an area in the LW zone (Hikkaduwa), showing a drastic change in moisture content within the same agro-climatic zone. Both extremes occur in the Low-country Wet zone, suggesting that, even within a single zone, micro-environmental factors (e.g., local rainfall patterns, soil water-holding capacity) drive large moisture fluctuations. Although situated in a wet zone, the lower moisture content in Hikkaduwa, which is a coastal area, may reflect sandy, well-drained soils (Mapa et al., 2010). The ash content range (1.89% - 5.68%) of the present study approximates to the results reported by Ananthi and Jayasri et al. (2021) (2.24%) and Nadeeshani et al. (2018) (2.26%). According to the results, the higher ash content in Kandy could result from the fertile soils and optimal growing conditions in the region (Szpunar-Krok and Wondolowska-Grabowska, 2025). Variations in ash content between locations may be attributed to differences in the availability of minerals and the presence of heavy metals in the soils where the plants were cultivated, as the ash content reflects the mineral composition in the soil (Dahanayaka et al., 2025; Zhang et al., 2024). The protein content results approximate the results reported by Nadeeshani et al. (2018) (7.17%). However, LD locations showed the highest protein contents, including Hambantota and Anuradhapura (16.38% and 16.27% respectively), with Polonnaruwa and Kalpitiya also above 15%. Drier zones may induce mild water stress, which sometimes triggers the accumulation of osmoprotective and structural proteins (Singh et al., 2015). Upcountry sites (Ella, UI: 9.33%) and Low-country Wet zone (Kalutara: 9.27%) had the lowest protein, perhaps reflecting cooler growing temperatures or shade-dominated cultivation reducing nitrogen assimilation. The fat content results reported by the present study aligned with the previous study of Nadeeshani et al. (2018) (1.81%). Leaf fat content was uniformly low (< 1.5%) but with significant fluctuations between locations. However, the results show that *S. grandiflora* L. cannot be considered a rich source of fat for dietary consumption. The carbohydrate content showed a huge variation of 1.48% to 18.33% between the locations. The results reported by Nadeeshani et al. (2018) showed an average carbohydrate content (9.81%), which is similar to the results reported by several location in this study (Kegalle and Kandy). Kalutara (16.59 %), Hikkaduwa (18.33 %), and Monaragala (13.95 %) stand out for elevated carbohydrate levels. However, the huge variation of carbohydrate content between locations can be explained by the report of accumulation of carbohydrate due to the environmental factors and seasonal changes (Dhuli et al., 2014). The results of crude fibre content approximate the results reported by Ananthi and Jayasri (2021) (15.77%). Locations such as Kalutara (11.79 %), Rathnapura (11.55 %), Polonnaruwa (11.19 %), Hambantota (7.64 %), and Hikkaduwa (8.84 %) showed the highest fibre content, suggesting higher intake of dietary fibre. Overall, these findings suggest that plant nutrient composition can vary depending on the geographical location and environmental factors where they are grown. The influence of environmental factors on dietary significance, can be identified by the insights of this study. By recognising environment interactions, breeders could select *S. grandiflora* varieties that maximise desired traits (protein and fibre) under specific agro-ecological conditions. Furthermore, this study exhibits the role of local climate and soil in determining the plant nutritional profile, providing insights for site-tailored cultivation strategies to meet targeted nutritional goals.

Table 2: The nutrient content of *S. grandiflora* L. from different geographical locations in Sri Lanka
 Values are presented as mean \pm SD. Means followed by the same letters in a column are not significantly different at $P < 0.05$ level.

Agro-climatic Zone	Location	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Fibre (%)
Low-country dry zone (LD)	Jaffna	75.53 \pm 0.22 ^{defg}	2.84 \pm 0.41 ^{bc}	14.51 \pm 0.45 ^{def}	1.15 \pm 0.22 ^{ab}	5.98 \pm 0.78 ^{abc}	9.70 \pm 1.10 ^{defg}
	Anuradhapura	71.41 \pm 1.31 ^{bcd}	4.06 \pm 0.23 ^d	16.27 \pm 0.59 ^g	0.99 \pm 0.07 ^c	7.27 \pm 0.56 ^{bc}	4.32 \pm 0.55 ^a
	Polonnaruwa	77.67 \pm 0.67 ^{fg}	1.89 \pm 0.13 ^a	15.34 \pm 0.35 ^{efg}	1.02 \pm 0.10 ^{ab}	4.08 \pm 0.47 ^{bc}	11.19 \pm 0.60 ^g
	Hambanthota	76.45 \pm 0.42 ^{efg}	3.61 \pm 0.04 ^{cd}	16.38 \pm 0.56 ^g	1.02 \pm 0.02 ^c	2.54 \pm 0.82 ^{ab}	7.64 \pm 0.56 ^{cd}
Low-country Intermediate zone (LI)	Kalpitiya	72.79 \pm 1.24 ^{bcd}	3.34 \pm 0.19 ^{cd}	15.65 \pm 1.07 ^{fg}	1.07 \pm 0.12 ^c	7.14 \pm 0.35 ^{bc}	8.91 \pm 0.09 ^{cdef}
	Kurunegala	76.29 \pm 0.67 ^{defg}	3.28 \pm 0.31 ^{cd}	12.52 \pm 0.15 ^{bc}	0.96 \pm 0.03 ^{bc}	6.94 \pm 0.64 ^{bc}	6.86 \pm 0.84 ^{bc}
Mid-country intermediate zone (MI)	Badulla	79.97 \pm 0.81 ^{gh}	3.22 \pm 0.51 ^c	11.66 \pm 0.85 ^b	0.82 \pm 0.09 ^{ab}	4.32 \pm 0.55 ^{ab}	8.09 \pm 0.75 ^{cde}
	Monaragala	71.64 \pm 4.31 ^{bcd}	2.15 \pm 0.18 ^a	11.33 \pm 0.31 ^b	0.93 \pm 0.16 ^{bc}	13.95 \pm 4.11 ^{de}	7.71 \pm 0.61 ^{cd}
Upcountry intermediate zone (UI)	Ella	79.37 \pm 0.35 ^{gh}	5.23 \pm 0.35 ^e	9.33 \pm 0.09 ^a	1.10 \pm 0.07 ^c	4.97 \pm 0.46 ^{ab}	10.50 \pm 0.34 ^{fg}
	Welimada	79.35 \pm 0.55 ^{gh}	2.84 \pm 0.19 ^{bc}	12.91 \pm 0.33 ^{bcd}	0.95 \pm 0.08 ^{bc}	3.94 \pm 0.48 ^{ab}	7.21 \pm 0.36 ^{bc}
	Kalutara	69.77 \pm 2.42 ^b	2.88 \pm 0.19 ^{bc}	9.27 \pm 0.51 ^a	1.48 \pm 0.17 ^d	16.59 \pm 3.04 ^e	11.79 \pm 1.82 ^g
Low-country wet zone (LW)	Hikkaduwa	64.13 \pm 2.37 ^a	3.40 \pm 0.20 ^c	13.90 \pm 0.09 ^{cde}	0.56 \pm 0.08 ^a	18.33 \pm 2.34 ^e	8.84 \pm 0.56 ^{cdef}
	Gampaha	70.64 \pm 2.43 ^{bc}	1.99 \pm 0.01 ^a	12.97 \pm 0.52 ^{bcd}	0.65 \pm 0.19 ^{ab}	13.75 \pm 2.26 ^{de}	8.55 \pm 0.81 ^{cdef}
	Rathnapura	82.79 \pm 0.63 ^h	3.18 \pm 0.17 ^c	11.55 \pm 0.56 ^b	1.00 \pm 0.03 ^c	1.48 \pm 0.11 ^a	5.02 \pm 0.06 ^{ab}
Mid-country wet zone (MW)	Kegalle	73.35 \pm 0.71 ^{cdef}	3.42 \pm 0.34 ^{cd}	11.95 \pm 1.02 ^b	0.95 \pm 0.01 ^{bc}	10.33 \pm 0.98 ^{cd}	9.97 \pm 0.06 ^{efg}
	Kandy	73.81 \pm 0.24 ^{cdef}	5.68 \pm 0.51 ^e	12.37 \pm 0.43 ^{bc}	0.99 \pm 0.23 ^c	7.15 \pm 0.70 ^{bc}	7.28 \pm 0.55 ^c

However, the present study holds several limitations that need to be acknowledged. The number of sample sites per location was limited to one due to the inaccessibility of *S. grandiflora* cultivated according to organic agricultural practices. A broader sampling strategy, including multiple sites per location, would have enhanced statistical reliability and better captured micro-environmental variations, such as differences in soil composition. The plants were collected at commonly consumed maturity stages where their exact ages were not controlled, introducing potential variability. The sampling was confined to a single season; therefore, potential seasonal fluctuations in nutrient and phytochemical content were not accounted for. Moreover, this study did not examine detailed environmental factors, including soil pH, mineral content, or microclimatic conditions, which may have a considerable impact on the biochemical composition of plants. To overcome these limitations, future investigations should broaden both the geographical coverage and environmental scope by sampling multiple sites within each location and incorporating diverse agro-ecological zones across Sri Lanka. Integrating environmental variables such as soil properties, pH, nutrient status, and local climatic conditions would provide deeper insights into the environmental influences on the nutritional composition of *S. grandiflora*.

Conclusion

This study reveals that the proximate composition of *Sesbania grandiflora* L. leaves varies significantly across different geographical regions of Sri Lanka, emphasising the influence of environmental conditions on the plant's nutritional quality. All the proximate components showed statistically significant differences among the 16 sampling locations. Notably, the LD zone exhibited higher protein concentrations, while carbohydrate and fibre levels peaked in the LW zone, reflecting the potential impact of water availability, soil fertility, and microclimatic variations on plant physiology. The findings underscore the importance of considering geographical origin when evaluating the nutritional potential of GLVs like *S. grandiflora*.

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