RESEARCH ARTICLE

Comparative analysis of nutritional components in different parts of *Manglietia aromatica*

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***Manglietia aromatica*, a second-class nationally protected plant species in China, is primarily distributed in southeastern Yunnan and southwestern Guangxi provinces of China. While its aromatic properties have been utilized for essential oil extraction, its nutritional value and broader development potential remain largely unexplored. This study analyzed and evaluated the nutritional composition of different parts of *Manglietia aromatica* including petals, stamens, young leaves, and mature leaves, focusing on five basic nutrients, 17 amino acids, 11 mineral elements, and three secondary metabolites. The results showed that the mature leaves had significantly higher contents of ash, protein, and crude fiber than that of other parts. Furthermore, the mature leaves' total amino acids (TAA) and essential amino acids (EAA) met the criteria for ideal protein (EAA/TAA = 41.03%, EAA/NEAA = 69.59%). However, the stamens exhibited the greatest levels of polysaccharides and lipids and achieved the highest essential amino acid ratio coefficient (SRC = 62.21), reflecting improved amino acid nutritional quality. Regarding mineral elements, nitrogen (N) was determined to be the most abundant in the stamens, young leaves, and mature leaves, whereas potassium (K) predominated in the petals. For trace elements, manganese (Mn) was the most abundant in the leaves, while iron (Fe) was primarily found in the floral organs. Furthermore, all four parts were rich in saponins and phenolic compounds, whereas flavonoid levels remained comparatively low. Although the mature leaves exhibited the greatest overall nutritional value, the other parts also possessed unique compositional advantages, highlighting their potential for diversified development and application. This research provided a scientific basis for the targeted development and efficient utilization of different parts of *Manglietia aromatic*.**

Keywords: *Manglietia aromatica*; nutrient composition; amino acids; chemical compounds; mineral elements.

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Introduction

Manglietia aromatica (family Magnoliaceae) is a broadleaf evergreen tree. It is currently classified as a second-class nationally protected plant species in China, primarily distributed across southeastern Yunnan and southwestern Guangxi provinces. Within China, it predominantly grows at elevations of 800 – 1,500 meters, primarily in limestone mountain areas, subtropical monsoon

evergreen broadleaf forests, and northern tropical monsoon forest zones [1]. *Manglietia aromatica* is a heliophilous (sun-loving) species that can grow up to 35 meters in height. It flowers in the months of May and June, and fruits between September and October. The species is renowned for its large, fragrant flowers, and bright red aggregate fruits when mature, making it highly valued for ornamental purposes. Furthermore, the straight and upright trunk, combined with fine-grained, decay-resistant wood, renders *Manglietia aromatica* an excellent source of construction material. However, the natural populations of *Manglietia aromatica* have significantly declined due to low germination rates, limited natural regeneration, and severe threats from illegal logging.

Beyond its ornamental and timber value, *Manglietia aromatica* is of considerable scientific importance, especially in the classification and evolutionary studies of Magnoliaceae plants. It is regarded as a relatively primitive taxon within the *Manglietia* genus, offering insights into the evolutionary history of the family [2]. In addition to its ecological and economic values, *Manglietia aromatica* exhibits potential medicinal properties. The entire plant is strongly aromatic with crushed tissues emitting a distinctive fragrance. Various parts of *Manglietia aromatica* including branches, leaves, and flowers can be processed for essential oil extraction, serving as important raw materials in the fragrance industry [3]. To date, research on *Manglietia aromatica* has primarily focused on its photosynthetic characteristics [4], physiological and ecological responses [5], and genetic diversity [6]. Few studies have addressed the nutritional elements of *Manglietia aromatica*. Wei *et al*. explored variations in leaf mineral nutrient content during the flowering period of *Manglietia aromatica*. The results indicated that, at different sites, leaf phosphorus (P), nitrogen (N), and potassium (K) concentrations initially increased and then declined from the full flowering stage to the young fruit stage with the elemental abundance following the order of N > K > P [7]. However, comparative studies analyzing the nutritional composition of different parts of *Manglietia aromatica* have not yet been reported.

The purpose of this study was to elucidate the differences in nutritional value among various parts of *Manglietia aromatica*. The research selected petals, stamens, young leaves, and mature leaves of *Manglietia aromatica* as the study materials to determine and evaluate the contents of basic nutrients, amino acids, minerals, and secondary metabolites. The research would provide a reference for the development and application of *Manglietia aromatica*.

Materials and methods

Plant material collection and sample preparation

Samples of petals, stamens, young leaves, and mature leaves of *M. aromatica* were obtained from Leye County, Baise City, Guangxi Zhuang Autonomous Region, China in late April 2024. After collection, the petals and stamens were manually separated and thoroughly washed along with the young and mature leaves before drying to constant weight in a forced-air oven at 60°C. The samples were then ground using a QE-100 high-speed grinder (Zhejiang Yili Industry and Trade Co., Ltd., Hangzhou, Zhejiang, China) and sieved through 60-mesh filter to obtain uniform powders for the further analysis of the basic nutrients, amino acids, chemical constituents, and mineral elements in the petals, stamens, young leaves, and mature leaves following the National Standards for Food Nutrition Analysis of China (GB 5009 series).

Determination of basic nutrients

The ash contents were measured as described in the GB 5009.4-2016 protocol. A 2.00 g portion of the dried sample was accurately weighed followed by incineration at 550°C in a SX2-4-10 muffle furnace (Shanghai Yiheng Scientific Instrument Co., Ltd., Shanghai, China) to constant weight. After cooling down to 200°C, the samples were put in a desiccator for 30 min before being

re-weighed. Ignition was repeated until the difference between consecutive weighing was less than 0.5 mg. Polysaccharide content was determined according to SN/T 4260-2015. A 1.00 g sample was incubated with 50 mL deionized water in a water bath at 80°C while stirring for 2 hours. After centrifugation using a CR22G III high-speed refrigerated centrifuge (Hitachi, Tokyo, Japan), 1.0 mL of the resulting supernatant was mixed with 1.0 mL of 5% phenol and 5.0 mL of concentrated sulfuric acid. After incubating the samples at room temperature for 20 minutes, absorbances at 490 nm were obtained using a TU-1810 UV-visible spectrophotometer (Beijing Puxi General Instrument Co., Ltd., Beijing, China) with glucose as the blank. Protein contents were assessed using the Kjeldahl method following the guidelines outlined in GB 5009.5-2016. Briefly, a 0.50 g sample was digested with 10 mL of 98% concentrated sulfuric acid and 0.5 g of catalyst mixture ($CuSO_4$:K_2SO_4 = 1:9) at 420°C until the solution became clear. Upon cooling, the digest was analyzed using a K9840 fully automated Kjeldahl nitrogen analyzer (Jinan Hanon Instruments Co., Ltd., Jinan, Shandong, China). The sample was then distilled with the addition of 10 mL of 40% NaOH, and the released ammonia was absorbed into 2% boric acid followed by titration with 0.1 mol/L HCl. A conversion factor of 6.25 was used for calculating protein contents according to the nitrogen value. Crude fiber was determined according to GB/T 5009.10-2003. Samples were boiled sequentially with 1.25% H_2SO_4 and 1.25% NaOH. After that, the residues were dried, weighed, and adjusted for ash content. The fat contents were determined using Soxhlet extraction method following GB 5009.6-2016. 5.00 g sample enclosed in a filter paper cartridge was extracted with 80 mL petroleum ether at 85°C in a SXT-06 Soxhlet extractor (Shanghai Xinrui Instrument and Meter Co., Ltd., Shanghai, China) for 6 hours with approximately six cycles per hour. Following concentration of the extract in a RE-52AA rotary evaporator (Shanghai Yarong Biochemical Instrument Factory, Shanghai, China), the remaining fat was dried at 105°C and weighed.

Determination of amino acids

The amino acid composition was determined according to GB 5009.124-2016. Briefly, 0.20 g of each sample was hydrolyzed in 6 mol/L HCl at 110°C under vacuum for 24 hours. After cooling down, the hydrolysates were neutralized to pH 2.2 using 6 mol/L sodium hydroxide, filtered through a 0.22 μm microporous membrane, and stored at −20°C. A 20 μL aliquot was injected into the L-8900 amino acid analyzer (Hitachi, Tokyo, Japan) with the chromatographic conditions as 57°C column temperature and a buffer flow rate of 0.4 mL/min. After ninhydrin derivatization, 17 amino acids were quantified at 570 nm with absorbance at 440 nm specifically for proline. The result was expressed as g/100 g dry weight.

Determination of chemical constituents

Total saponin content was assessed according to the "Technical Guidelines for the Examination and Evaluation of Chemical and Hygienic Indicators of Health Foods" (2020 Edition). Briefly, 1.00 g sample was ultrasonically extracted with 80% ethanol for 30 minutes. After centrifugation, 1.0 mL supernatant was added to 0.5 mL of vanillin-glacial acetic acid (5%) followed by adding 0.8 mL perchloric acid. Following ultrasonic extraction, the mixture was incubated in a 60°C water bath for 15 minutes to enhance saponin release. After rapid cooling in an ice bath, absorbances at 546 nm were obtained using TU-1810 UV-visible spectrophotometer. Quantification was performed using a standard curve prepared with ginsenoside Re. Total flavonoids were determined following SN/T 4592-2016. 0.50 g of sample was extracted with 50 mL 70% methanol by ultrasonic treatment for 1 hour. After centrifugation, 0.5 mL of the supernatant was added to 0.3 mL of 5% $NaNO_2$. After 6 min, 0.3 mL of 10% $Al(NO_3)_3$ was added and incubated for another 6 min before adding 4.0 mL of 4% NaOH. Absorbances at 510 nm were recorded. Quantification was based on a standard curve prepared with rutin. Total phenolic content was determined according to GB/T 8313-2018 using high-performance liquid chromatography (HPLC) with a ZORBAX SB-C18 column (4.6 × 250 mm, 5 μm), eluting with a

gradient of 0.1% phosphoric acid and acetonitrile, and detecting at 278 nm. An accurately weighed 0.20 g sample was extracted with 70% methanol and ultrasonication. After filtration of the extract, a 10 µL aliquot (0.22 µm) was analyzed chromatographically. The quantification was performed using an external standard method with tea polyphenols as the reference.

Determination of mineral elements

Approximately 1.00 g of powdered sample in a digestion tube was mixed with 5.0 mL of nitric acid (HNO_3) and 2.0 mL of hydrogen peroxide (H_2O_2) for digestion using a Speedwave XPERT microwave digestion system (Berghof, Germany). The digestion was performed by increasing the temperature to 100°C over 15 min and maintaining for 5 min followed by increasing the temperature to 180°C over 10 min and maintaining for 5 min. The temperature eventually increased to 200°C over 5 min and maintained for 10 min. After digestion, the solutions were cooled down to 25°C, transferred to a quartz acid-evaporation tube, and concentrated using an EH-45A acid-digestion system (Jinan Hanon Instruments Co., Ltd., Jinan, Shandong, China) at 120°C until approximately 1 mL of solution remained. The concentrated samples were then diluted to 50 mL with 2% HNO_3 followed by filtration using 0.45 µm membrane. P, Ca, K, Mg, Fe, Al, Cu, Zn, and Mn were determined using a ZEEEnit 700 atomic absorption spectrometer (Analytik Jena AG, Germany), while Se was measured using an X7 series inductively coupled plasma mass spectrometer (ICP-MS) (Thermo Fisher Scientific, Waltham, MA, USA). Each measurement was carried out in triplicate, and mean values were reported.

Amino acid nutritional evaluation

The essential amino acid (EAA) nutritional assessment was performed using the amino acid ratio coefficient method according to the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) guidelines [8]. The ratio of amino acid (RAA) was calculated as below.

$$\mathrm{RAA}=\frac{\text{Content of a specific EAA in the sample}}{\text{Content of the corresponding EAA in the WHO/FAO pattern}}$$

Amino acid score (AAS) = RAA × 100

The ratio coefficient (RC) was determined as follows.

$$\mathrm{RC}=\frac{\text{The RAA of an EAA in the sample}}{\text{Average RAA for all EAAs}}$$

Score of ratio coefficient (SRC) = (1 - CV) × 100

The coefficient of variation of RC (CV) was then calculated as below.

$$\mathrm{CV}=\frac{\text{The standard deviation of RC}}{\text{The mean value of RC}}$$

According to the AA ratio coefficient method, a value closer to 1 for RC and a value closer to 100 for the SRC indicated that the amino acid composition of the protein aligned more closely with the WHO/FAO reference, which signified a more balanced essential amino acid profile, higher nutritional value, and better capacity to meet human nutritional needs. An RC value greater than 1 indicated an excess of the essential amino acid, while a value below 1 signaled a deficiency. The essential amino acid with the lowest RC value represented the first limiting amino acid (FlAA) of the protein [9].

Statistical analysis

Microsoft Excel 2021 and SPSS 22 (IBM, Armonk, NY, USA) were utilized for statistical analysis. ANOVA and Duncan's tests were applied in this study with *P* value less than 0.05 as statistically significant difference and P value less than 0.01 as very significant difference.

Results

Table 1. Composition contents of essential nutrients in petals, stamens, young leaves, and mature leaves of *Manglietia aromatica*.

Essential nutrient (g/100 g)	Petal	Stamens	Young leaves	Mature leaves
Ash	1.10 ± 0.20^{B}	1.20 ± 0.20^{B}	1.03 ± 0.25^{B}	3.20 ± 0.30^{A}
Polysaccharide	0.35 ± 0.02^{C}	0.61 ± 0.04^{A}	0.23 ± 0.02^{D}	0.55 ± 0.04^{B}
Protein	2.25 ± 0.08^{C}	3.19 ± 0.08^{B}	3.31 ± 0.06^{B}	4.25 ± 0.03^{A}
Crude fiber	4.90 ± 0.30^{C}	5.40 ± 0.20^{C}	7.00 ± 0.30^{B}	15.50 ± 0.40^{A}
Fat	0.70 ± 0.10^{A}	0.90 ± 0.30^{A}	0.40 ± 0.10^{B}	0.70 ± 0.20^{A}

Notes: Data were shown as mean ± SD (n = 3). Different uppercase letters indicated very significant differences ($P < 0.01$).

Comparison of basic nutrient contents in different parts of *Manglietia aromatica*

The results showed that the levels of ash, polysaccharides, protein, crude fiber, and lipids among the four parts of *Manglietia aromatica* demonstrated very significant differences ($P < 0.01$) (Table 1). For ash content, the mature leaves had the highest value of 3.20 ± 0.30 g/100 g, which was significantly different from the other three parts, while values in the petals, stamens, and young leaves were comparable. The ash contents ranked in the order of mature leaves > stamens > petals > young leaves. Polysaccharide content varied significantly among all examined parts with stamens exhibiting the highest concentration of 0.61 ± 0.04 g/100 g and in the order of stamens > mature leaves > petals > young leaves. The mature leaves exhibited the highest protein content value of 4.25 ± 0.03 g/100 g, while the petals showed the lowest protein content of 2.25 ± 0.08 g/100 g. Marked differences in protein content were found between the mature and young leaves compared to the other parts, whereas no significant difference was noted between the stamens and young leaves. The protein contents followed the order of mature leaves > young leaves > stamens > petals. For crude fiber, the mature leaves contained a markedly higher amount of 15.50 ± 0.40 g/100 g than the other parts. Significant differences were detected between mature leaves, young leaves, and the floral parts including petals and stamens, while the petal and stamen contents did not differ significantly. The crude fiber content ranked as mature leaves > young leaves > stamens > petals. In terms of lipid content, the highest levels were found in the stamens as 0.90 ± 0.30 g/100 g, while the lowest one were recorded in the young leaves as 0.40 ± 0.10 g/100 g. Marked differences were observed between young leaves and the other parts, but not among petals, stamens, and mature leaves. Lipid content followed the descending order of stamens > mature leaves = petals > young leaves. Overall, crude fiber and protein were the predominant basic nutrients across the various parts of *Manglietia aromatica* although their contents varied significantly among different plant organs.

Analysis of amino acid content

The amino acid (AA) compositions and contents of the petals, stamens, young leaves, and mature leaves demonstrated that 16 AAs with 7 EAAs were detected in the stamens and young leaves, whereas 15 AAs including 6 EAAs were detected in the petals and mature leaves (Table 2). Among the detected AAs, aspartic acid had the highest content ranging from 0.23 ± 0.04 to 0.36 ± 0.06 g/100 g followed by glutamic acid from 0.22 ± 0.02 to 0.32 ± 0.01 g/100 g. Methionine had the lowest content at 0.01 g/100 g in the stamens and young leaves only. Methionine and histidine levels did not differ significantly among all the parts, whereas threonine, valine, leucine, isoleucine, tyrosine, and arginine contents varied significantly ($P < 0.05$). The contents of other AAs showed very significant differences among the four parts of plant ($P < 0.01$). The total amino acid contents (TAA) ranged from 1.77 ± 0.06 to 2.90 ± 0.07 g/100 g, while the total EAA contents were from 0.70 ± 0.05 to 1.19 ± 0.06 g/100 g, and the total non-essential amino acids (NEAA) contents were from 1.07 ± 0.11 to 1.71 ± 0.02 g/100 g,

Table 2. Composition and contents of amino acids in petals, stamens, young leaves, and mature leaves of *Manglietia aromatica*.

Amino acid (g/100 g)	Petal	Stamens	Young leaves	Mature leaves
Asp	0.23 ± 0.04^{B}	0.36 ± 0.06^{A}	0.35 ± 0.01^{A}	0.33 ± 0.02^{A}
Thr*	0.08 ± 0.01^{b}	0.11 ± 0.01^{ab}	0.12 ± 0.03^{ab}	0.16 ± 0.04^{a}
Ser	0.11 ± 0.01^{B}	0.14 ± 0.02^{B}	0.14 ± 0.01^{B}	0.18 ± 0.02^{A}
Glu	0.22 ± 0.02^{C}	0.28 ± 0.01^{B}	0.28 ± 0.03^{B}	0.32 ± 0.01^{A}
Pro	0.09 ± 0.01^{B}	0.12 ± 0.01^{B}	0.18 ± 0.04^{A}	0.19 ± 0.02^{A}
Gly	0.09 ± 0.01^{C}	0.13 ± 0.02^{B}	0.14 ± 0.01^{B}	0.19 ± 0.03^{A}
Ala	0.12 ± 0.02^{B}	0.20 ± 0.03^{A}	0.16 ± 0.02^{A}	0.20 ± 0.01^{A}
Cys	-	-	-	-
Val*	0.12 ± 0.01^{b}	0.16 ± 0.03^{ab}	0.16 ± 0.03^{ab}	0.19 ± 0.01^{a}
Met*	-	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	-
Ile*	0.09 ± 0.01^{b}	0.12 ± 0.01^{a}	0.12 ± 0.02^{a}	0.14 ± 0.01^{a}
Leu*	0.16 ± 0.03^{c}	0.2 ± 0.01^{bc}	0.23 ± 0.04^{ab}	0.28 ± 0.04^{a}
Tyr	0.07 ± 0.01^{b}	0.08 ± 0.01^{b}	0.10 ± 0.01^{a}	0.10 ± 0.01^{a}
Phe*	0.09 ± 0.01^{C}	0.13 ± 0.02^{BC}	0.16 ± 0.01^{AB}	0.18 ± 0.04^{A}
Lys*	0.16 ± 0.02^{C}	0.19 ± 0.01^{B}	0.20 ± 0.02^{B}	0.24 ± 0.01^{A}
His	0.04 ± 0.01^{a}	0.05 ± 0.01^{a}	0.06 ± 0.01^{a}	0.06 ± 0.01^{a}
Arg	0.10 ± 0.02^{b}	0.12 ± 0.01^{ab}	0.14 ± 0.02^{a}	0.14 ± 0.01^{a}
TAA	1.77 ± 0.06^{D}	2.40 ± 0.07^{C}	2.55 ± 0.01^{B}	2.90 ± 0.07^{A}
EAA	0.70 ± 0.05^{C}	0.92 ± 0.07^{B}	1.00 ± 0.09^{B}	1.19 ± 0.05^{A}
NEAA	1.07 ± 0.11^{C}	1.48 ± 0.00^{B}	1.55 ± 0.10^{B}	1.71 ± 0.02^{A}
EAA/TAA (%)	39.55	38.33	39.22	41.03
EAA/NEAA (%)	65.42	62.16	64.52	69.59

Notes: * indicated essential amino acids. Data were shown as mean ± SD (n = 3). Distinct lowercase letters within the same row denoted statistically significant differences ($P < 0.05$). Different uppercase letters indicated very significant differences ($P < 0.01$).

which were all the highest in the mature leaves. Statistically significant differences in TAA, EAA, and NEAA were observed across the four plant parts. The EAA/TAA ratios ranged from 38.33% to 41.03%, while the EAA/NEAA ratios ranged from 62.16% to 69.59% with the highest values observed in the mature leaves. Based on the WHO/FAO (1973) criteria, proteins are classified as ideal when the ratio of EAA/TAA exceeds 40% and the ratio of EAA/NEAA surpasses 60% [10]. Therefore, the protein profile of the mature leaves fulfilled the conditions for an ideal protein, while the other plant parts exhibited values approaching the ideal benchmark.

Nutritional evaluation of essential amino acids

Based on the WHO/FAO recommended AA pattern, the RAA, RC, and SRC values of EAAs in the petals, stamens, young leaves, and mature leaves of *Manglietia aromatica* were calculated (Table 3). The findings indicated that the RC values for methionine + cysteine (Met + Cys) were the lowest and significantly below 1 in all four parts, indicating that Met + Cys constituted the FLAA. In the petals, the RC of threonine was less than 1, suggesting relative deficiency. The RC values for the remaining EAAs were greater than 1, indicating relative abundance. Among the four parts, the stamens exhibited the highest SRC value at 62.21, indicating that their EAAs composition most closely aligned with the ideal reference pattern, reflecting improved nutritional quality relative to the other tissues.

Comparison of mineral element contents in different parts of *Manglietia aromatica*

The contents of 11 mineral elements in the petals, stamens, young leaves, and mature leaves of *Manglietia aromatica* were determined, which included 5 macroelement and 6 trace elements.

(1) Analysis of macronutrient elements

The primary elements found in all four parts of *Manglietia aromatica* were N, P, K, Ca, and Mg.

Table 3. Ratio coefficient and the score of essential amino acids in petals, stamens, young leaves, and mature leaves of *Manglietia aromatica*.

Amino acid	WHO / FAO recommended value	Petal			Stamens			Young leaves			Mature leaves		
		RAA	RC	SRC	RAA	RC	SRC	RAA	RC	SRC	RAA	RC	SRC
Thr	40	0.02	0.96		0.03	1.01		0.03	1.01		0.04	1.15	
Val	50	0.02	1.16		0.03	1.18		0.03	1.08		0.04	1.09	
Met + Cys	35	0.00	0.00	57.10	0.00	0.11	62.21	0.00	0.10	60.35	0.00	0.00	57.96
Ile	40	0.02	1.09		0.03	1.10		0.03	1.01		0.04	1.01	
Leu	70	0.02	1.10		0.03	1.05		0.03	1.11		0.04	1.15	
Phe + Tyr	60	0.03	1.29		0.04	1.29		0.04	1.46		0.05	1.34	
Lys	55	0.03	1.40		0.03	1.27		0.04	1.23		0.04	1.26	

Note: unit: mg/g.

Table 4. Composition and contents of mineral elements in petals, stamens, young leaves, and mature leaves of *Manglietia aromatica*.

Mineral elements (mg/kg)		Petal	Stamens	Young leaves	Mature leaves
Macroelement	N	$3,600 \pm 400^{C}$	$5,100 \pm 300^{B}$	$5,300 \pm 400^{B}$	$6,800 \pm 300^{A}$
	P	264 ± 8^{C}	448 ± 9^{A}	409 ± 7^{B}	277 ± 2^{C}
	K	$5,230 \pm 80^{B}$	$4,430 \pm 60^{C}$	$4,090 \pm 80^{D}$	$6,280 \pm 110^{A}$
	Ca	204 ± 3^{D}	451 ± 4^{C}	648 ± 8^{B}	$5,780 \pm 12^{A}$
	Mg	422 ± 4^{C}	581 ± 6^{B}	432 ± 3^{C}	852 ± 9^{A}
Microelement	Cu	3.68 ± 0.02^{B}	4.76 ± 0.03^{A}	3.30 ± 0.06^{C}	3.06 ± 0.05^{D}
	Mn	3.81 ± 0.04^{C}	5.47 ± 0.06^{C}	23.9 ± 0.78^{B}	219 ± 4.17^{A}
	Fe	9.25 ± 0.28^{C}	11.1 ± 0.32^{C}	14.1 ± 0.25^{B}	44.8 ± 2.13^{A}
	Zn	4.89 ± 0.26^{D}	6.77 ± 0.15^{B}	5.86 ± 0.13^{C}	7.56 ± 0.39^{A}
	Al	3.50 ± 0.36^{B}	2.59 ± 0.07^{B}	5.81 ± 0.34^{B}	69.1 ± 3.47^{A}
	Se	-	-	-	0.012 ± 0.001

Notes: Data were shown as mean ± SD (n = 3). Different uppercase letters indicated very significant differences ($P < 0.01$).

In the stamens, young leaves, and mature leaves, N was the most abundant element with contents of 5,100 ± 300 mg/kg, 5,300 ± 400 mg/kg, and 6,800 ± 300 mg/kg, respectively, while P had the lowest concentrations in these parts as 448 ± 9 mg/kg, 409 ± 7 mg/kg, and 277 ± 2 mg/kg, respectively. However, in the petals, K was the predominant element at 5,230 ± 80 mg/kg, and Ca was the least abundant at 204 ± 3 mg/kg. Significant differences were observed in N contents among parts with no significant difference between stamens and young leaves. However, the petals and mature leaves demonstrated significant differences from the other parts in terms of N contents. Regarding P contents, there was no significant difference between petals and mature leaves, but stamens and young leaves were significantly different from other parts. Significant differences were observed among all parts of *Manglietia aromatica*. Regarding Mg contents, no significant difference was found between the petals and young leaves, but both stamens and mature leaves differed significantly from the other parts (Table 4).

(2) Analysis of trace elements

Six trace elements were detected in the mature leaves, while only five were detected in the petals, stamens, and young leaves and Se was only detected in mature leaves. Manganese (Mn) was the most abundant trace element in the mature leaves and young leaves, whereas iron (Fe) was predominant in the petals and stamens. Significant differences were observed in the contents of copper (Cu) and zinc (Zn) among all parts. Mn and Fe levels did not differ significantly between petals and stamens, while young leaves and mature leaves were significantly different from the other parts. Regarding aluminum (Al),

Table 5. Composition and contents of chemical composition in petals, stamens, young leaves, and mature leaves of *Manglietia aromatica*.

Active substance (g/100 g)	Petal	Stamens	Young leaves	Mature leaves
Total saponins	0.34 ± 0.03^{C}	1.34 ± 0.05^{A}	0.41 ± 0.02^{C}	0.71 ± 0.06^{B}
Total flavonoids	< 0.05	< 0.05	0.08 ± 0.01^{a}	0.07 ± 0.01^{a}
Total phenolics	1.90 ± 0.30^{A}	1.50 ± 0.20^{B}	0.70 ± 0.10^{C}	0.60 ± 0.20^{C}

Notes: Data were shown as mean ± SD (n = 3). Distinct lowercase letters within the same row denoted statistically significant differences ($P < 0.05$). Different uppercase letters indicated very significant differences ($P < 0.01$).

the mature leaves showed a significant difference compared to the other three parts (Table 4).

Comparison of chemical component contents in different parts of *Manglietia aromatica*

All four parts of *Manglietia aromatica* exhibited substantial amounts of saponins ranging from 0.34 to 1.34 g/100 g and phenolic compounds ranging from 0.60 to 1.90 g/100 g. However, the flavonoid contents were relatively low across all parts (Table 5). In terms of total saponins, the stamens exhibited the highest content, whereas the petals were the lowest one. No significant difference was observed between petals and young leaves, whereas stamens and mature leaves differed significantly from the other parts. Regarding total flavonoids, all parts of *Manglietia aromatica* exhibited very low concentrations with comparable levels. In terms of total phenolic content, the petals showed the highest concentration, while the mature leaves demonstrated the lowest concentrations. No marked variation was found between young leaves and mature leaves, while the petals and stamens showed significant differences when compared to the other parts.

Discussion

The nutrient contents of plants vary across different growth stages and plant parts [7]. Li *et al*. found that the nutritional components differed significantly among the buds, leaves, young stems, and seeds of *Lonicera japonica* with buds and leaves being enriched with nutrients compared to stems and seeds [11]. Similarly, Xu *et al*. reported that different parts of *Sorbus pohuashanensis* including young branches, young leaves, mature leaves, fresh fruits, and dried fruits contained abundant nutritional and medicinal substances with each part offering unique benefits [12]. Ash content reflects the level of inorganic mineral elements in plants. The higher ash content in the mature leaves suggests a richer accumulation of inorganic nutrients [13]. Proteins are crucial biological macromolecules involved in tissue construction, growth, metabolism, repair and serve as essential components of animal feed [14]. The longer exposure of mature leaves to sunlight likely increases photosynthesis, leading to higher protein synthesis and, consequently, higher protein content in these leaves [15]. As plants grow, the cell walls of mature leaves thicken, leading to increased crude fiber content, a major component of plant cell walls. Mature leaves, due to their prolonged exposure to sunlight, likely experience increased photosynthesis, leading to increased protein synthesis and a higher protein content than other parts of plants [16]. Therefore, the mature leaves of *Manglietia aromatica* could represent a source of high-quality fiber for animal feed, particularly for ruminants.

In terms of AAs, glutamic acid and aspartic acid were the most abundant of all four parts of *Manglietia aromatica*. These excitatory AAs act as neurotransmitters in brain tissues [17] and are also associated with the mobilization and transport of heavy metals like copper, lead, and zinc [18]. Aspartic acid has important clinical applications including the treatment of hepatitis, cirrhosis, hepatic coma, and cardiovascular diseases such as arrhythmias, angina, tachycardia, and heart failure [19]. Glutamic acid,

as the primary amino donor in mammalian nitrogen metabolism, is important in animal growth. However, excessive glutamic acid can cause excitotoxicity, leading to neurological disorders [20]. Therefore, the content of these AAs should be carefully controlled during the edible and medicinal development of *Manglietia aromatica*. The FLAA in all four parts of *Manglietia aromatica* was methionine plus cysteine (Met + Cys). Methionine deficiency is common in plants due to its biosynthesis pathway limitations, while cysteine content may be reduced because it is synthesized from methionine and is prone to oxidative degradation during analysis [21]. Both methionine and cysteine are sulfur-containing AAs essential for various physiological functions in humans [22]. Thus, supplementation with sulfur-containing amino acids may be necessary when utilizing *Manglietia aromatica*.

The mineral composition in all parts of *Manglietia aromatica* was abundant, particularly for N and K with the highest concentrations found in the mature leaves. N, being a critical element for protein and enzyme synthesis, directly impacts plant structure and organ differentiation [23]. The strong positive correlation between nitrogen and protein content across the different parts further reinforces this relationship. K acts as the principal intracellular cation and is crucial for maintaining cellular membrane potential *via* Na^+/K^+-ATPase regulation. K plays a crucial role in nerve impulse conduction and muscle contraction. Its antagonistic effect against sodium makes high potassium diets an effective non-pharmacological strategy for blood pressure management [24]. Ca content was markedly greater in the mature leaves relative to other parts of plant. As the most plentiful mineral in the body, Ca is vital for maintaining bone health, regulating metabolic processes, and preventing various diseases including osteoporosis, cancer, metabolic syndromes, autoimmune diseases, cardiovascular diseases, and hypertension [25]. As the human body cannot synthesize calcium, it is essential to obtain Ca through dietary sources. Therefore, mature leaves of *Manglietia aromatica* hold the potential for development into products aimed at supporting bone health and cardiovascular well-being. The elements Mn and Fe were found to be relatively abundant, particularly in the mature leaves. Mn is vital for antioxidant defense, immune enhancement, protein and nucleic acid synthesis, and bone development, as well as regulating neurotransmission and endocrine functions [26]. Iron is crucial for oxygen transport, nutrient delivery, and immune function, playing a critical role in the formation of hemoglobin, myoglobin, cytochromes, and various enzymes [27]. Iron deficiency can impair cognitive and immune functions [28], and since plants are a major dietary source of iron for humans and animals [29], the mature leaves of *Manglietia aromatica* have the potential to be developed into iron-rich products. However, the Al content in mature leaves was determined to be highly significant. Al is not an essential element for humans and excessive intake can impair the nervous system, immune system, reproductive system, liver, and bones [30]. Thus, strict control of Al levels is necessary during the utilization of *Manglietia aromatica* leaves.

Among chemical constituents, the stamens showed the highest total saponin content, while the petals had the highest total phenolic content. Saponins known for their anti-inflammatory, antioxidant, anti-tumor, hepatoprotective, and hypolipidemic effects are active components widely utilized in traditional Chinese medicine. Their bioactivity makes them valuable for applications in both the pharmaceutical as well as food industries [31]. Phenolic compounds, the secondary metabolites in plants, possess potent antioxidant and anti-cancer properties. They also play a significant role in preventing conditions such as diabetes and obesity, making them valuable for promoting overall health [32]. Thus, the petals and stamens of *Manglietia aromatica* showed great potential for applications in pharmaceuticals, functional foods, and cosmetics.

The results of this study demonstrated that all four parts of *Manglietia aromatica* possessed distinct nutritional values and development potentials. The mature leaves exhibited the highest concentrations of key nutrients and met the standards for an ideal protein source, highlighting their potential application in animal feed, health foods, and medicinal products. The stamens demonstrated the highest total saponin content and the highest amino acid nutritional evaluation scores, suggesting valuable applications in the pharmaceutical and cosmetic industries. The petals showed the greatest total phenolic content, suggesting strong potential for antioxidant-related developments. Young leaves, exhibiting amino acid profiles closely approaching those of mature leaves, presented a promising complementary option for joint development with mature leaves as functional feed additives. The present findings provided a comprehensive comparative analysis of the nutritional components of *Manglietia aromatica* at a single growth stage. Future research should focus on the temporal variations in these bioactive and nutritional components during different growth stages, enabling the identification of optimal harvesting times for each part of the plant and facilitating the species' industrial application. Overall, the systematic evaluation of *Manglietia aromatica*'s nutritional values not only revealed the unique functions of different parts of the plant but also expanded its economic value beyond ecological benefits, providing new opportunities for the sustainable exploitation and industrial application of wild plant resources.

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