



Comparative Analysis of Phenolic Compounds in the Aerial Parts of Wild and Cultivated *Caryopteris mongolica* Bunge from Mongolia

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Abstract. The total flavonoid content of the aerial part of *Caryopteris mongolica* was determined, the content of some flavonoids was determined, and the microstructural characteristics of the leaf were revealed. *C. mongolica* has been cultivated at the plantation biostation of the New Medical University in Kherlenbayan-Ulaan, Delgerkhaan soum, Khentii province since 2013. This study was conducted to compare the content of certain phenolic compounds in wild-grown and cultivated *C. mongolica*. The content of some flavonoids was determined using HPLC, and the total flavonoid content was determined by spectrophotometry. Moisture was determined by the Pharmacopoeia method, and the microstructure study was conducted using Novel light microscopy. Linear regression analysis was employed for the quantitative determination of rutin, luteolin, apigenin, and acacetin content. A one-way ANOVA was applied to compare the total flavonoid and moisture contents between wild-grown and cultivated samples. Analyses were performed using SPSS Statistics 26.0 software. Although there were no statistically significant differences in total flavonoid or moisture content between wild-grown and cultivated *C. mongolica* plants growing in Mongolia, the cultivated plants exhibited higher levels of some flavonoids. The average contents of rutin, luteolin, apigenin, and acacetin in the wild-grown *C. mongolica* sample were 0.00471 mg/g, 0.11999 mg/g, 0.11468 mg/g, and 0.06831 mg/g, respectively. In contrast, the corresponding values in the cultivated *C. mongolica* sample were 0.02371 mg/g, 0.09971 mg/g, 0.35149 mg/g, and 0.32529 mg/g. The total flavonoid content in the aerial parts of wild-grown and cultivated *C. mongolica* was measured at 0.328±0.049% and 0.310±0.027%, with no significant difference ($p=0.350$). The moisture content was also not significantly different between the wild-grown (6.78±0.03%) and cultivated (6.88±0.59%), respectively. A comparative anatomical study of the leaves of *C. mongolica* revealed that the leaves have an isolateral structure, multicellular hairs, and well-developed palisade tissues arranged in multiple layers.

Keywords: Lamiaceae, Phenolic compounds, HPLC, leaf, anatomical structure

1 Introduction

Caryopteris mongolica Bunge (Lamiaceae) grows in the deserts, hill slopes, steppes, and mountainous areas, and this aromatic shrub is widely distributed across Khangai, Khentii, Mongolian Altai, Mongolian Dauria, Middle Khalkh, East Mongolia, Valley of Lakes, East Gobi, Gobi-Altai, Transaltai Gobi, and Alashan Gobi phyto-geographical regions of Mongolia.^[1] "This plant is called 'goat's horn' or 'goat horn bush' by Mongolians, and 'dogar' in Tibetan. It has been used in both Mongolian traditional medicine and Tibetan medicine for various purposes. These include stopping bleeding, increasing uterine muscle contractions, treating chronic bronchitis, promoting urination, reducing inflammation, and enhancing physical fitness.^[2] The leaves and flowers of the plant are primarily used to treat worm diseases, anthrax, and to dry up wounds and a condition known as *chu-ser*."^[3] *C. mongolica* also grows in Inner Mongolia, China, and the aerial parts of *C. mongolica* have been traditionally used to alleviate rheumatoid arthritis, edema, and dyspepsia.^[3]

C. mongolica is rich in biologically active substances, and researchers have conducted several studies on the roots and aerial parts of the plant. This plant contains essential oils, mono- and sesquiterpenoids, as well as steroids.^[4] The essential oil of the leaves and flower of *C. mongolica* collected from Gobi desert region was predominantly composed of monoterpene hydrocarbons (71.27%), followed by oxygenated monoterpenes (17.49%), sesquiterpene hydrocarbons (8.56%), and oxygenated sesquiterpenes (2.85%), and α -thuein (18.72%), (E)-beta-ocimene (11.00%), limonene (8.79%), β -pinene (8.04%), terpine-4-ol (7.22%), α -pinene (6.30%), and sabinene (5.63%) were reported as the primary components.^[4,5] Ya-Zhou Shao (2021) isolated the essential oil from the flowers, fruits, leaves, stems, and aerial parts of *C. mongolica* and found that it contained β -pinene (24.77%), 4-terpineol (15.80%), β -cis-osimene (9.31%), α -pinene (8.20%), and 2-isopropyltoluene (7.37%).^[6] In our previous study, we reported that the essential oil from the aerial parts contains 65 compounds, with limonene (22.49%), trans-ferruginol (8.48%), and phytol (8.41%) as the primary components.^[7] Duma M (2021). isolated seven pyridine alkaloids, acetin, and L-proline anhydride from the aerial parts of *C. mongolica* for the first time.^[8] The researchers also identified compounds such as apigenin, luteolin, and caffeic acid in preliminary studies.^[9] Liu Meiling (2012) suggested that flavonoids play a key role in regulating plant stress tolerance in *C. mongolica*.^[10] *C. mongolica* shows promising potential for managing rheumatoid arthritis and digestive disorders, attributed to its rich content of bioactive compounds such as polyphenols and flavonoids.^[3]

To protect subendemic plant resources and utilize them for medicinal purposes, it is necessary to cultivate them in accordance with the Law on Genetic Resources of Mongolia. *C. mongolica* has been cultivated at the plantation biostation of the New Medical University in Kherlenbayan-Ulaan, Delgerkhaan soum, Khentii aimag, since 2013. This study was conducted to compare the content of some phenolic compounds in wild-grown and cultivated *C. mongolica*.

2 Material and methods

Plant material: The aerial parts of *C. mongolica* were collected from the sunny, rocky soil of Bayanzurkh Mountain, near the Narin River, Songinokhairkhan District, Ulaanbaatar City, on 25 July 2023. The taxonomic identification of the plant was carried out by Professor Dr. E. Ganbold and Dr. B. Mandakh of the Institute of the Botanical Garden, Mongolian Academy of Sciences. A voucher specimen (No. UBA000402) has been deposited in the herbarium of the Institute.

The aerial parts of cultivated *C. mongolica* were harvested during the flowering period of plants grown for three years at the Plant Biostation of the New Medical University, located in Kherlenbayan-Ulaan bag, Delgerkhaan soum, Khentii province.

Standards and chemicals: Apigenin (M29GB150104, purity \geq 98%, Shanghai Yuanye Biotechnology Co., Ltd.), rutin (A05GB144263, purity \geq 98%, Shanghai Yuanye Biotechnology Co., Ltd.), acacetin (HY-N0451/CS-5336, Med Chem Express), and luteolin (DSTDM003201, purity \geq 98%, Chengdu Desiter Biotechnology Co., Ltd.) were used as standard substances. The solvents used for the HPLC study were of HPLC grade, and all other reagents and solvents were of analytical grade.

Determination of some flavonoid content

Preparation of Test sample solutions for HPLC: From the aerial parts of wild-grown and cultivated *C. mongolica*, 30 g each of air-dried and powdered samples were weighed and extracted with methanol (CH₃OH) at room temperature, three times in total, separately. Methanol was evaporated under reduced pressure to yield 6.82 g of thick extract from the wild-grown plant sample and 8.74 g from the cultivated plant sample. 1 g of each extract was placed in tubes, and 5 mL of methanol was added to dissolve, followed by ultrasonic treatment. The resulting solutions were transferred to 10 mL volumetric flasks. The tubes were rinsed several times with small amounts of methanol, and the rinsing solutions were also transferred into the corresponding volumetric flasks. Methanol was added to each flask to the nominated volume of 10 mL. Each solution was then transferred to a 50 mL centrifuge tube and centrifuged at 5000 r/min for 10 minutes. The supernatants were filtered through 0.22 μ m membrane filters and injected into the instrument for HPLC analysis.

Preparation of Reference standard solutions for HPLC: Solutions of methanol containing rutin at a concentration of 1003 μ g/mL, luteolin at 1000 μ g/mL, apigenin at 200.8 μ g/mL, and acacetin at 202 μ g/mL were prepared.

Assay Method: The contents of rutin, luteolin, apigenin, and acacetin were determined using Ultimate High-Performance Liquid Chromatography (HPLC) (190–800 nm, Thermo Fisher Scientific (China) Co., Ltd.) by the Chinese Pharmacopoeia (2020 Edition, General Chapter 0512).

Chromatographic Procedures: Hypersil GOLD C18 (250 \times 4.6 mm, 5 μ m, Thermo Fisher) was used as the stationary phase. 0.2% phosphoric acid solution (A)-methanol (B) was used as the mobile phase with gradient system: 0-60 min, 80% A - 20% B; 60-90 min, 55% A - 45% B; 90-91 min, 25% A - 75% B; 91-97 min, 80% A - 20% B. The total runtime: 97 min; flow rate: 1.0 mL/min; column temperature: 35 $^{\circ}$ C; injection volume: 20 μ L; UV detection wavelength: 350 nm; Theoretical plate number: shall not be lower than 10,000. All prepared samples and standard solutions were filtered through a 0.45 μ m filter membrane before being injected into the Ultimate 3000 HPLC instrument (190–800 nm, Thermo Fisher Scientific (China) Co., Ltd.).

Determination of Total flavonoid content

Assay Method: The contents of total flavonoids were determined using Spectrophotometric analysis by the Russian Pharmacopoeia (13th Edition, General Chapter 0512)

Preparation of Test sample solution and Procedure: The aerial parts of wild-grown and cultivated *C. mongolica* Bunge were dried, pulverized, and sieved through a 2 mm mesh screen. One gram of each prepared sample was accurately weighed to an accuracy of 0.001 g and placed in a 100 mL round-bottom flask. 50 mL of 70% ethanol was added, and the mixture was extracted in a water bath at 90°C for 1 hour under a reflux condenser. After cooling, the extract was filtered through filter paper into a 100 mL volumetric flask. The plant residue was extracted twice with 10 mL of 70% ethanol for 20 minutes, then cooled and filtered into the same volumetric flask containing the initial extract. The filter paper was rinsed twice with 70% ethanol. After cooling, the volume was adjusted to the nominal volume with 70% ethanol to obtain Solution A. From Solution A, 1.0 mL was transferred into a 50 mL volumetric flask, and 10 mL of distilled water, 2 mL of 2% AlCl₃ solution (prepared in ethanol), and one drop of 30% acetic acid (CH₃COOH) solution were added. The volume was then adjusted to 50 mL with 70% ethanol to obtain Solution B. After 40 minutes, the absorbance of Solution B was measured at 339 nm using a spectrophotometer. A 70% ethanol solution was used as the blank solution.

Preparation of Apigenin standard solution: 10 mg of standard apigenin was precisely weighed to an accuracy of 0.001 g and placed in a 25 mL volumetric flask. 10 mL of 96% ethanol was added and gently swirled until the solution was fully dissolved. 96% ethanol was added until the nominated volume, and 1 mL of solution was transferred to a 25 mL volumetric flask. 3 mL of distilled water, 2 mL of 2% AlCl₃ solution prepared in ethanol, and one drop of 30% acetic acid were added. 70% ethanol was added until the nominated volume. After 40 minutes, the absorbance of the solution was measured at 339 nm using a spectrophotometer. A 70% ethanol solution was used as the blank solution.

Microstructure study: Certain parts of leaves and petioles were excised from fresh plant specimens and preserved in 70% ethanol. The samples were prepared by making transverse sections, which were then embedded in a glycerin–water solution (1:1) and temporarily fixed with a flat glass plate. The prepared sections were observed under 10× – 40× magnification using a NOVEL light microscope (Model: XSZ-107BN).

Moisture determination: The moisture content of the aerial parts of *C. mongolica* Bunge was determined according to the GPhM.1.5.3.0007.15 Determination of humidity of medicinal plant raw materials, Russian Pharmacopoeia 13th edition. 1.0 g of sample was weighed to an accuracy of 0.001 and dried in an oven at a temperature of 100-105°C. The dried sample was cooled in a desiccator for 30 minutes and reweighed. The procedure was continued until a constant weight was achieved. The difference between the initial and final weight is used to calculate moisture content (% w/w).

Statistical analyses: Linear regression analysis was used for the quantitative determination of the content of rutin, luteolin, apigenin, and acacetin, and the data are reported as the mean ± relative standard deviation. The contents of total flavonoids and moisture in the aerial parts of wild-grown and cultivated plants were defined, and the results were expressed as mean ± standard deviation. A one-way ANOVA was applied

to compare the contents of total flavonoid and moisture of wild-grown and cultivated samples. Analyses were performed using SPSS Statistics 26.0 software.

3 Results

3.1 Comparative study of flavonoid compounds in aerial parts of wild-grown and cultivated *C. mongolica* Bunge

System Suitability

The HPLC analyses of standard rutin, luteolin, apigenin, and acacetin were recorded, and the retention times were determined (**Figure 1**).

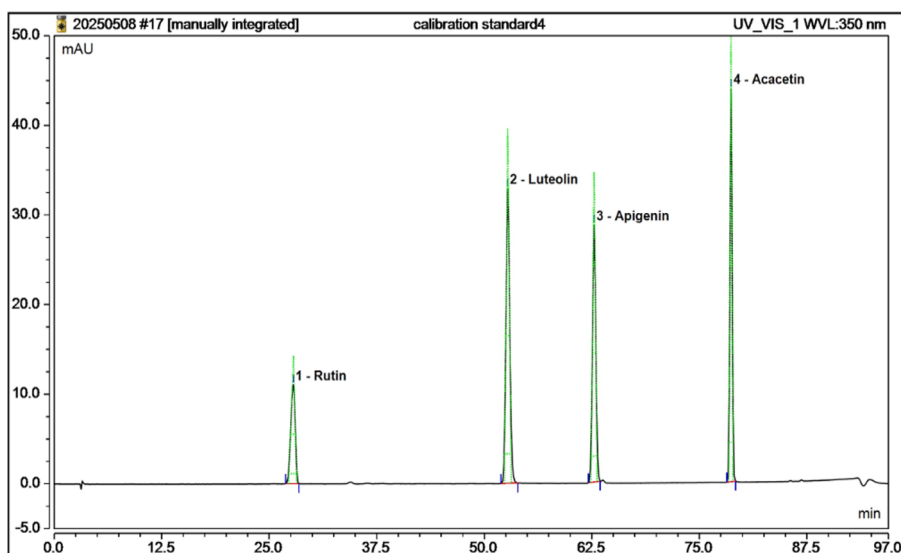


Figure 1. Chromatogram of Reference Standards

The analysis demonstrated that all system suitability parameters, including retention time, theoretical plate number, resolution, and tailing factor for the four flavonoid reference standards, met the predefined acceptance criteria. These evaluations were conducted under specified chromatographic conditions indicated in the method section, confirming that the system operated within acceptable limits and ensuring the reliability and reproducibility of the method. System suitability data are shown in **Table 1**.

Table 1. System Suitability Data

Component	Ret.Time/mn	Resolutin	Tailing Factor	Theoretical Plate Number
Rutin	27.853	26.37	0.93	17388
Luteolin	53.351	10.49	1.08	38050
Apigenin	63.401	23.99	1.04	93811

Acacetin	78.935	n.a.	1.00	450359
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Specificity Test

The test sample solutions of cultivated and natural *C. mongolica*, solvent methanol, and the reference standard solution were injected sequentially for detection. Figure 2. HPLC comparison chart showing chromatographic profiles of compounds used in the specificity test.

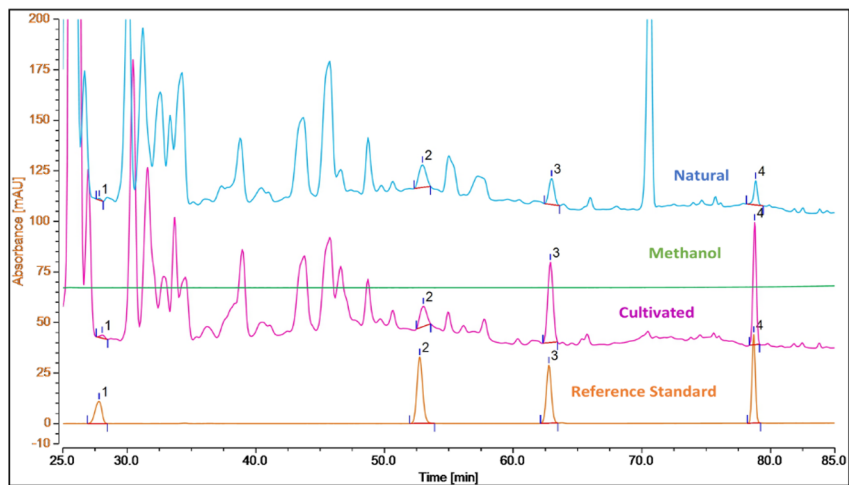


Figure 2. HPLC Comparison Chart of Specificity Test

The experimental results showed that methanol, used as the solvent, did not produce any interfering peaks or signals in the chromatographic analysis of the test samples. This indicates that the method possesses adequate specificity, meaning it can accurately measure the target compounds without interference from the solvent or other components.

Precision Test

The mixed standard solution of reference substances was injected continuously six times under the specified chromatographic conditions, and the peak areas were recorded. The results demonstrated that after six consecutive injections, the relative standard deviations (RSDs) of the peak areas corresponding to rutin, luteolin, apigenin, and acacetin in each chromatogram were as follows: 0.51%, 1.42%, 1.15%, and 1.37%. This indicated that the injection precision of the instrument for these components was satisfactory (**Table 2**).

Number	Rutin (mAU*min)	Luteolin (mAU*min)	Apigenin (mAU*min)	Acacetin (mAU*min)
1	0.637	1.591	14.756	14.423

2	0.635	1.632	14.804	14.676
3	0.637	1.641	14.977	14.551
4	0.634	1.589	14.524	14.207
5	0.630	1.591	14.547	14.176
6	0.640	1.613	14.726	14.505
Average	0.635	1.610	14.722	14.423
RSD/%	0.51	1.42	1.15	1.37

Table 2. Peak areas corresponding to the reference standard

Investigation of Linearity

The standard working curves for each reference standard were obtained by regression (Figures 3–6).

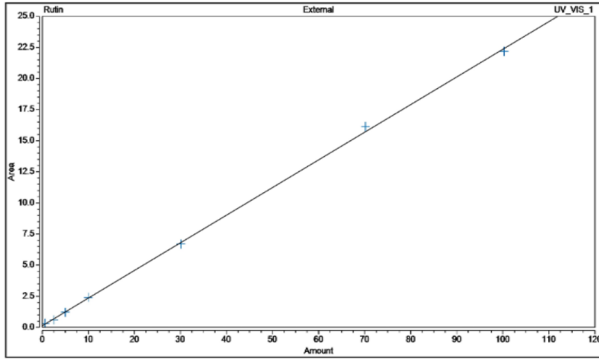


Figure 3. Standard working curve of Rutin

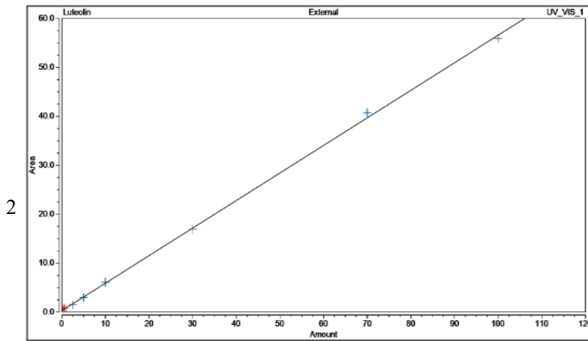


Figure 4. Standard working curve of Luteolin

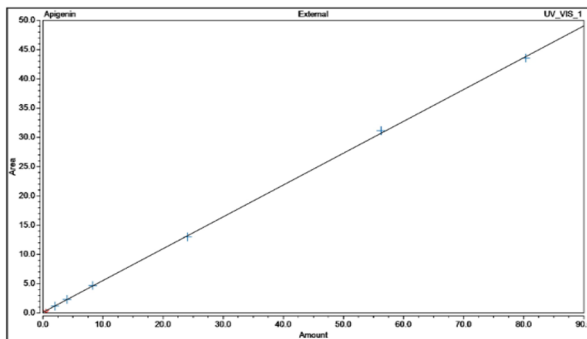


Figure 5. Standard working curve of Apigenin

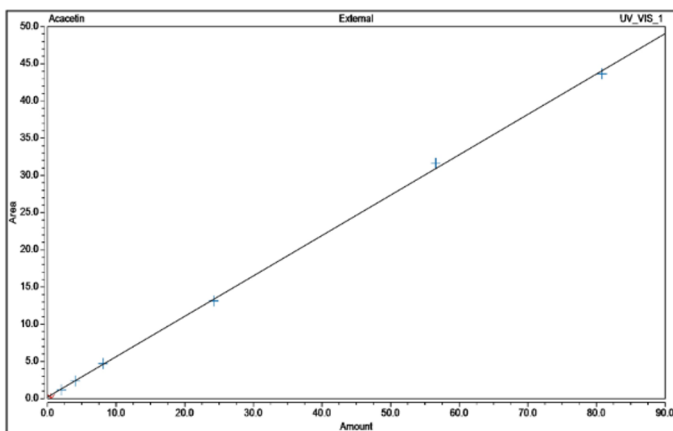


Figure 6. Standard working curve of Acacetin

Flavonoids reference standards had strong linear relationships within the standard curve range. The regression equations and correlation coefficients are shown in **Table 3**.

Table 3. Regression equation of rutin, luteolin, apigenin, and acacetin

Compound	Amount (µg/ml)	Area (mAU*min)	Regression Equation	Correlation Coefficient
Rutin	1.2538	0.327	Y=0.2221X+0.1370	0.9995
	2.5075	0.602		
	5.0150	1.216		
	10.0300	2.410		
	30.0900	6.699		
	70.2100	16.125		
	100.3000	22.178		
Luteolin	2.5000	1.525	Y=0.5629X+0.2929	0.9994
	5.0000	2.982		
	10.0000	6.089		
	30.0000	16.934		
	70.0000	40.739		
	100.0000	55.923		
Apigenin	2.0080	1.182	Y=0.5439X+0.1196	0.9998
	4.0160	2.312		

	8.3032	4.692		
	24.0960	12.993		
	56.2240	31.149		
	80.3200	43.560		
Acacetin	2.0200	1.201	Y=0.5426X+0.2238	0.9995
	4.0400	2.368		
	8.0800	4.729		
	24.2400	13.147		
	56.5600	31.630		
	80.8000	43.631		

Determination of some flavonoid contents

Each test sample solution was injected three times into the HPLC system according to the chromatographic conditions given in the section on chromatographic procedures. The chromatograms were recorded, and the content of four flavonoids was calculated. The average contents of rutin, luteolin, apigenin, and acacetin in the wild-grown and cultivated *C. mongolica* and RSDs are shown in **Table 4**.

Table 4. Contents of some flavonoids in the methanol extract of the aerial part of wild-grown and cultivated *C. mongolica* (mg/g dry weight)

Component	Sample	Amount (µg/ml)	Content (mg/g)	Average content (mg/g)	RSD (%)
Rutin	Wild-grown	0.510	0.00510	0.00471	9.64
		0.481	0.00481		
		0.421	0.00421		
	Cultivated	2.423	0.02423	0.02371	3.44
		2.277	0.02277		
		2.413	0.02413		
Luteolin	Wild-grown	11.597	0.11597	0.11999	3.41
		11.986	0.11986		
		12.415	0.12415		
	Cultivated	9.603	0.09603	0.09971	3.34
		10.057	0.10057		
		10.252	0.10252		
Apigenin	Wild-grown	11.161	0.11161	0.11468	2.76
		11.794	0.11794		
		11.449	0.11449		
	Cultivated	34.836	0.34836	0.35149	0.82
		35.407	0.35407		
		35.204	0.35204		
Acacetin	Wild-grown	6.829	0.06829	0.06831	1.32
		6.922	0.06922		
		6.741	0.06741		
	Cultivated	32.802	0.32802	0.32529	1.18
		32.090	0.32090		

		32.693	0.32693		
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The moisture and total flavonoid content of the aerial parts of wild-grown and cultivated *C. mongolica* were determined and shown in **Table 5**.

Table 5. Contents of moisture and total flavonoid of the aerial part of wild-grown and cultivated *C. mongolica*

Indicators	Samples	Content, %	P value
Moisture content	Wild-grown	6.78 ± 0.03	0.782
	Cultivated	6.88 ± 0.59	
Total flavonoid	Wild-grown	0.328 ± 0.049	0.350
	Cultivated	0.310 ± 0.027	

3.2 Microstructure of the leaves of *C. mongolica*

Leaf anatomy: The leaf is isobilateral in structure. The leaf mesophyll consists of six rows of sparsely arranged palisade tissue. Spongy tissue cells are positioned at an angle on the upper and lower surfaces of the main vascular bundle. Simple hairs and anomocytic stomata are evenly distributed on the leaf's upper and lower surfaces. The epidermal cell walls are angled obtusely. Stomatal cells are arranged at the same level as the epidermal cells (**Figure 7**).

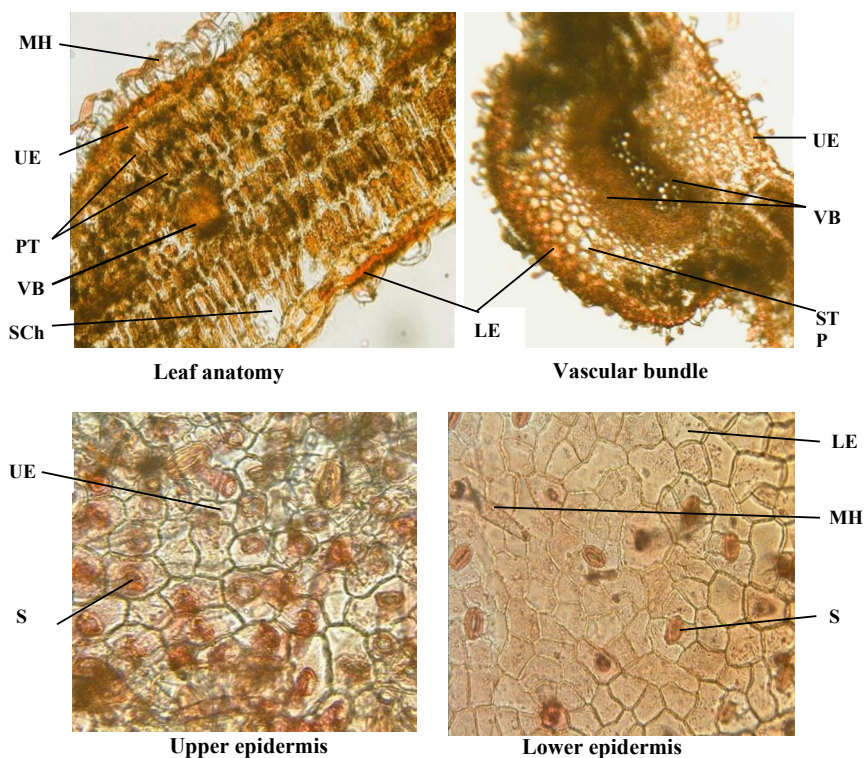


Figure 7. Leaf anatomy (10x40)

UE-Upper epidermis, PT- Palisade tissue, S-Stomata, SCh-Stomatal chamber, MH-Multicellular hair, ST-Spongy tissue, VB-Vascular bundle (X-Xylem, Ph-phloem), LE-Lower epidermis

Anatomy of the leaf petiole: On the outside, there is a single layer of epidermal cells. Simple hairs, at the same level as the epidermal cells, are evenly distributed around the petiole. Inside the epidermal cells, one can find collenchyma and parenchyma cells with unevenly thickened walls. In the centre of the petiole are xylem and phloem, the main components of the collateral-type vascular bundle (Figure 8).

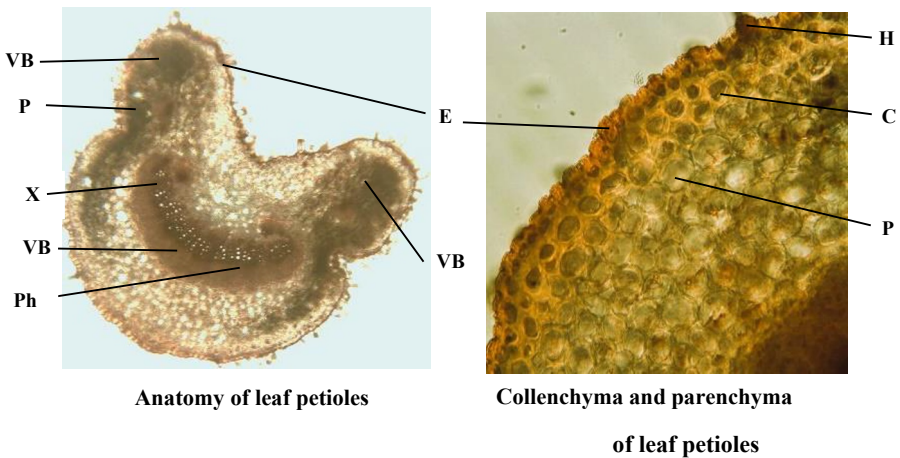


Figure 8. Anatomy of a leaf petiole, (10x10)

E-Epidermis, H-Hair, C-collenchyma, P-parenchyma, VB-Vascular bundle (X-Xylem, Ph-phloem)

4 Discussion

C. mongolica contains abietane-type diterpenoids, steroids, essential oils, pyridine alkaloids, flavonoids, and organic acids, and researchers have suggested that the main active ingredient in the plant is flavonoids.^[3,10] As a result of this study, rutin, apigenin, acacetin, and luteolin were identified in the aerial parts of *C. mongolica* by HPLC. Preliminary studies on the chemical composition of the aerial part of *C. mongolica* have demonstrated that its primary substance is acacetin (5,7-dihydroxy-4-methoxyflavone), and Dumaa, M (2021) isolated acacetin (5,7-dihydroxy-4-methoxyflavone) for the first time from this species, and revealed apigenin, luteolin, and caffeic acid in the aerial parts of the plant.^[8,9] Acacetin exhibits numerous biological properties, including anti-inflammatory, antioxidant, neuroprotective, antiproliferative, and anticancer effects.^[11] Additionally, researchers have confirmed that apigenin is the main active ingredient in

the plant. According to the molecular docking study, scutellarin and apigenin were defined as key bioactive compounds of *C. mongolica*.^[3] Apigenin is a highly biologically active compound, and the mechanisms underlying the potential therapeutic action of apigenin were investigated, including cell cycle arrest, apoptosis, anti-inflammatory activity, and antioxidant function.^[12] Treatment with apigenin can mitigate high glucose-induced injury in renal tubular epithelial cells and reduce oxidative stress and inflammation.^[13] Luteolin serves as an effective regulator of inflammatory diseases, significantly ameliorating various inflammatory conditions by inhibiting pro-inflammatory mediators (interleukin [IL]-1 β , IL-6/8/17/22, TNF- α , and COX-2) and influencing several inflammatory initiating pathways. Luteolin also exhibits protective activity in the skin, nervous system, blood vessels, lungs, kidneys, and liver, making it a promising candidate for treating acute liver, lung, and kidney injuries. Therefore, luteolin could be a promising candidate in the biomedical and pharmaceutical fields.^[14] Rutin possesses a wide range of pharmacological properties for treating various chronic diseases, such as cancer, diabetes, hypertension, and hypercholesterolemia, and traditionally, it is employed as an antimicrobial, antifungal, and anti-allergic agent.^[15]

Since this plant is a subendemic, studies have been conducted on its cultivation. Chun Guo (2014) studied the characteristics of seed germination of *C. mongolica* and determined that the effects of various factors, including growing environment, conditions, and temperature, on plant yield, active ingredient content, and plant microstructure varied.^[16] According to a study on the in vitro propagation of *C. mongolica* from seeds, after 7-10 days, initiation of root formation occurred, and 21-28 days later, 95% of the cultured shoots were rooted.^[17] In the frame of this study, plant materials were collected from the Khentii phytogeographical region of Mongolia, and a comparative study of the flavonoid contents (rutin, luteolin, apigenin, acacetin), total flavonoids, and moisture in the aerial parts of both wild-grown and cultivated *C. mongolica* was conducted. The content of apigenin and acacetin was higher than that of the other two flavonoids. Apigenin was found to be 0.115 mg/g in wild-grown samples and 0.351 mg/g in cultivated samples. Acacetin was found to be 0.068 mg/g in wild-grown samples and 0.325 mg/g in cultivated samples. "Rutin content was higher in cultivated samples (0.024 mg/g) than in natural ones (0.0047 mg/g), whereas luteolin was slightly higher in natural samples (0.12 mg/g) compared to cultivated (0.1 mg/g)." The total flavonoid content in the aerial parts of wild-grown and cultivated *C. mongolica* was measured at $0.328 \pm 0.049\%$ and $0.310 \pm 0.027\%$, respectively, with no significant difference ($p = 0.350$). The moisture content was also not significantly different. The key limitation of this study is the absence of age-matched specimens between the cultivated and wild-grown *C. mongolica* plants. Therefore, the results of this study may have been influenced by the age of the plants. Consequently, it may be worthwhile to determine the quantity of substances contained in plants grown from seeds by age and assess the dynamics of substance content. However, the higher content of certain flavonoids in cultivated plants may be attributed to human-influenced growth conditions, such as irrigation and protective measures, which could have affected plant development. Cultivation factors, such as soil nutrients, planting methods, and environmental conditions, can significantly influence the flavonoid content in plants by affecting their metabolic pathways and stress responses. Liu Meiling (2012) studied the flavonoid synthesis and antioxidant system responses of *C. mongolica* plants exposed

to UV-B radiation. The study found that the activities of PAL (phenylalanine ammonia-lyase) and CHI (chalcone isomerase) enzymes increased in response to UV-B stress, and the content of total flavonoids and anthocyanin compounds also increased. This study offers insights into how desert plants adapt to harsh environments characterized by high levels of UV-B radiation.^[8]

Batzaya G (2016) determined the total flavonoid content of *C. mongolica* by expressing it to quercetin. They found that the aerial part of this plant contained more flavonoids than the below-ground part, with the highest content in samples prepared in August. The total flavonoid content of *C. mongolica* was determined to be 0.038-2.15% in natural and cultivated plants.^[18] Currently, a pharmacopoeia monograph for this plant has not been developed, and further studies on standardization and quantification of biologically active compounds are needed to develop the document.

According to the study, *C. mongolica* plants originated from seven different regions, and all of them had isobilateral leaves (with similar structures on both the upper and lower sides).^[19] The upper epidermis and palisade tissue of the leaves were thicker than those on the lower side, which is an adaptation to arid conditions. As temperature increases, the thickness of these layers also increases. It was found that variations in leaf structure are significantly influenced by latitude, longitude, temperature, and precipitation.^[19,20] A comparative anatomical study of the leaves of *C. mongolica* revealed that the leaves exhibit an isolateral structure, multicellular hairs, and well-developed palisade tissues arranged in multiple layers. These anatomical features reflect adaptations to the plant's natural habitat, which is characterized by low precipitation and uneven temperature distribution, supporting the comparative analysis between wild-grown and cultivated conditions.

5 Conclusion

This study demonstrated that while there were no statistically significant differences in total flavonoid content or moisture levels between wild-grown and cultivated *C. mongolica* in Mongolia, certain phenolic compounds were found in higher concentrations in the cultivated plants. These differences may be influenced by human interventions such as irrigation and protective cultivation practices, which can affect plant growth and secondary metabolite accumulation. Further research is recommended to investigate the variation in compound content across plants of different ages. Anatomically, the leaf of *C. mongolica* exhibits an isolateral structure, characterized by multicellular hairs positioned at the same level as the epidermal cells on both the leaf blade and petiole, mesophyll composed predominantly of palisade tissue, and vascular bundles of the collateral type.

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