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Comparative GC-MS Profiling, Phytochemical Screening, and Antioxidant Activity of Leaf and Flower Extracts of *Bauhinia purpurea* L. From Indonesia

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ABSTRACT
The search for natural antioxidants has intensified due to their potential role in reducing oxidative stress–related diseases. *Bauhinia purpurea* L. is a medicinal plant traditionally used in various regions; however, comparative information regarding the phytochemical composition and antioxidant activity of different plant organs remains limited. This study aimed to evaluate and compare the phytochemical profile and antioxidant activity of methanolic extracts obtained from the leaves and flowers of *B. purpurea*. Plant materials were extracted by maceration using methanol. Chemical constituents were identified using Gas Chromatography–Mass Spectrometry (GC–MS), while qualitative phytochemical screening was performed to detect major secondary metabolites. Antioxidant activity was assessed using the DPPH radical scavenging assay and expressed as IC_{50} values. GC–MS analysis identified 19 compounds in both leaf and flower extracts, with myo-inositol detected as the dominant component. Phytochemical screening revealed the presence of alkaloids and saponins in both organs, while flavonoids were detected exclusively in the flower extract. The flower extract exhibited stronger antioxidant activity (IC_{50} = 88.85 ppm) compared to the leaf extract (IC_{50} = 169.96 ppm). The higher antioxidant activity observed in the flower extract is likely associated with its flavonoid content and more diverse chemical composition. These results indicate that *B. purpurea* flowers represent a promising natural source of antioxidant compounds.

Keywords: *Bauhinia purpurea;* antioxidant; secondary metabolite

INTRODUCTION
Oxidative stress arises from an imbalance between the production of reactive oxygen species (ROS) and the ability of biological systems to neutralize them. Excessive ROS levels have been linked to the development of various chronic and degenerative diseases, including cardiovascular disorders, cancer, and inflammatory conditions [1,2]. Antioxidants are therefore essential in protecting cellular components from oxidative damage by scavenging free radicals or inhibiting their formation [3].

Although the human body possesses endogenous antioxidant mechanisms, these defenses are often insufficient under pathological or environmental stress conditions. Consequently, exogenous antioxidants derived from dietary or natural sources are required to support redox homeostasis [4]. Medicinal plants are recognized as important sources of natural antioxidants due to their rich content of secondary metabolites such as flavonoids, phenolics, alkaloids, and terpenoids [5].

Bauhinia purpurea L. (Fabaceae) is a medicinal plant widely used in traditional medicine for the treatment of inflammation, infections, and metabolic disorders [6]. Previous studies have reported antioxidant, anti-inflammatory, and antimicrobial activities of *B. purpurea* extracts [7–9]. However, most studies focus on a single plant organ, while comparative evaluations between leaves and flowers are still limited, particularly for plant materials collected in Indonesia. Understanding organ-specific differences in phytochemical composition is important for identifying plant parts with the highest bioactivity.

Therefore, this study aimed to comparatively analyze the phytochemical composition and antioxidant activity of methanolic extracts of *B. purpurea* leaves and flowers. The results are expected to provide scientific support for the optimal utilization of this plant as a natural antioxidant source.

MATERIALS AND METHODS

Plant Material and Extraction

Leaves and flowers of *Bauhinia purpurea* L. were collected from Surabaya, Indonesia. The plant materials were washed, air-dried at room temperature, and ground into fine powder. Each powdered sample (20 g) was extracted separately by maceration using methanol for nine days at room temperature with occasional stirring. The extracts were filtered and concentrated to obtain crude methanolic extracts.

GC-MS Analysis

GC–MS analysis was carried out using a DB-5 fused silica capillary column (30 m × 0.25 mm internal diameter, 0.25 µm film thickness). The oven temperature was initially set at 80 °C and increased to 200 °C at a rate of 10 °C/min, followed by a further increase to 260 °C at 12 °C/min with a final holding time of 30 minutes. Helium gas (99.999% purity) was used as the carrier gas at a constant flow rate of 1 mL/min. A volume of 1 µL of each extract was injected in split mode with a split ratio of 10:1. The injector temperature was maintained at 250 °C, while the ion source temperature was set at 280 °C. Mass spectra were recorded in the range of 50–550 amu. Compound identification was performed by comparing the obtained mass spectra with those in the National Institute of Standards and Technology (NIST) mass spectral library to determine the molecular weight and structural characteristics of the detected compounds [10].

Phytochemical Screening

Qualitative phytochemical screening was conducted to detect the presence of alkaloids, flavonoids, saponins, terpenoids, and steroids using standard qualitative tests according to established procedures [11–13].

Antioxidant Activity Assay

Antioxidant activity was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging method as previously described by Molyneux [14]. The percentage of radical scavenging activity was calculated using the following equation:

$$Radical\ scavenging\ activity\ (\%) = \frac{\text{Absorbance control} - \text{Absorbance sample}}{\text{Absorbance control}}\ x\ 100\%$$

where absorbance control represents the absorbance of the DPPH solution without the sample, and absorbance sample represents the absorbance in the presence of the extract or standard. IC_{50} values were determined from linear regression analysis of percentage inhibition versus extract concentration.

RESULTS AND DISCUSSION

GC-MS Analysis of Bioactive Compound

GC–MS analysis showed that both leaf and flower extracts of *B. purpurea* contained 19 identified compounds. The major compounds detected in the leaf extract are presented in Table 1, while those detected in the flower extract are shown in Table 2.

TABLE 1: Bioactive compounds of *B. purpurea* leaf methanol extract.

No	Retention time (min)	Area (%)	Compound
1.	2.547	0.33	2-Hydroxycyclopent-2-en-1-one ;
2.	5.806	1.63	2,3-Dihydro-Benzofuran
3.	7.127	0.79	2-Methoxy-4-vinylphenol
4.	8.618	1.21	5,6-Dimethyl-1,3-Cyclohexadiene
5.	8.719	1.31	(E)-2,3,3-Trimethyl-2-(3'-methyl-1'.3'-butadien-1'-yl)-6-methylidencyclohexanone
6.	8.850	3.23	1,2,4,5,6,7-Hexahydro-3-methyl-3H-indene-7-one
7.	9.142	1.13	Bicyclo[3.3.0]oct-1(2)-en-3-one
8.	9.392	0.72	Nonanoic aci
9.	9.525	0.83	4-Nitro-2,6-dideuterophenol
10.	9.589	1.06	(E,Z)-1,2-diethylidenecyclopentane
11.	10.545	0.53	Aromandendrene
12.	11.778	6.52	4,5-Dideutero Isothiazole
13.	11.976	0.60	1-Propene, 3-[(4-nitrobutyl)thio]
14.	12.813	70.20	Mome inositol
15.	17.448	0.65	2-Hexadecene, 3,7,11,15- tetramethyl-, [R- [R*, R*-(E)]]-
16.	17.673	3.95	Neophytadiene
17.	17.969	0.82	2-Hexadecene, 3,7,11,15- tetramethyl-, [R- [R*, R*-(E)]]-
18.	18.797	0.94	3,7,11,15-Tetramethyl-2-hexadecen-1-ol
19.	19.665	1.71	2-Hexadecen-1-ol, 3,7,11,15-tetramethyl-, [R-[R*, R*-(E)]]-
20.	21.919	1.44	9-Undecen-2-one, 6,10-dimethyl-
21.	22.133	0.42	Hexadecanoic acid, methyl ester

TABLE 2: Bioactive compounds of *B. purpurea* flower methanol extract.

No	Retention time (min)	Area (%)	Compound
1.	2.207	1.32	N-Acetyl-N'-butyrylurea
2.	2.288	4.59	Carbonodithioic acid, S-ethyl O-(1-methylethyl) ester
3.	2.541	1.79	2-Hydroxycyclopent-2-en-1-one
4.	3.064	0.78	2-Pentanamine (CAS); 2-Aminopentane; 2-Pentylamine
5.	4.010	1.40	2,4(1H,3H)-Pyrimidinedione, 5-methyl-
6.	4.719	2.36	4-(Methylthio)-1-butene
7.	4.844	3.31	(Z)-4-chloro-2,3-dimethyl-1,3-hexadiene
8.	5.788	2.67	4-vinylphenol
9.	6.104	1.37	1,1-Diethoxyhept-cis-4-ene
10.	7.123	0.98	2-Methoxy-4-vinylphenol
11.	8.619	12.63	Dimethyl(1-methylvinyl)chlorosilan
12.	8.721	6.46	9,10-Dehydro-Isolongifolene
13.	8.783	8.70	Xanthosine
14.	9.150	2.96	2-Ethoxyphenylacetonitrile
15.	9.392	1.40	1,6-Cyclodecadiene, 1-methyl-5-methylene-8-(1-methylethyl)-, [s-(E,E)]-
16.	9.928	0.86	Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)
17.	10.545	3.54	1,5-Cyclodecadiene, 1,5-dimethyl-8-(1-methylethylidene)-
18.	12.692	13.80	Mome Inositol
19.	12.762	3.30	myo-Inositol, 4-C-methyl-
20.	12.885	8.55	Mome Inositol
21.	12.936	4.08	Mome Inositol
22.	12.983	13.15	Mome Inositol

GC–MS analysis was used to qualitatively identify the chemical constituents present in the methanolic extracts of Bauhinia purpurea leaves and flowers. A total of 19 compounds were identified in each extract based on comparison of their mass spectra with the NIST library, indicating that both plant organs contain a comparable number of detectable metabolites, although their chemical characteristics differ.

In contrast, the flower extract exhibited a more diverse composition of secondary metabolites, including nucleoside derivatives such as xanthosine. Compounds belonging to this class have been reported to exhibit antioxidant and cytoprotective properties through modulation of oxidative stress pathways [15]. The greater diversity of bioactive compounds in the flower extract may enhance antioxidant capacity through synergistic interactions among different metabolites.

Overall, the GC–MS results indicate that differences in antioxidant activity between leaf and flower extracts of B. purpurea are more strongly associated with qualitative differences in metabolite composition rather than the total number of compounds identified. The enrichment of secondary metabolites in the flower extract is likely a key factor contributing to its superior antioxidant performance.

Phytochemical Screening

The qualitative phytochemical screening results of methanolic extracts of Bauhinia purpurea leaves and flowers are presented in Table 3. Alkaloids and saponins were detected in both extracts, whereas flavonoids were exclusively present in the flower extract. Terpenoids and steroids were not consistently detected in both organs.

TABLE 3: Phytochemical screening of methanolic extracts of *B. purpurea.*

Phytochemical Group	Leaf Extract	Flower Extract
Alkaloids	+	+
Flavonoids	-	+
Saponins	+	+
Terpenoids	-	-
Steroids	-	-

Note: + = present; - = absent.

The presence of flavonoids exclusively in the flower extract indicates organ-specific accumulation of secondary metabolites. Flavonoids are well recognized for their strong antioxidant properties due to their ability to donate electrons or hydrogen atoms to neutralize free radicals [16]. The absence of flavonoids in the leaf extract may explain its comparatively lower antioxidant potential.

Antioxidant activity

The antioxidant activity of methanolic extracts of *B. purpurea* leaves and flowers was evaluated using the DPPH radical scavenging assay. The IC_{50} values obtained are summarized in Table 4.

TABLE 4: Antioxidant activity of methanolic extracts of *B. purpurea.*

Sample	IC50 (ppm)	Antioxidant category
Leaf extract	169,96	Weak
Flower extract	88,85	Strong
Silymarin	29,63	Very strong

Antioxidant activity of the methanolic extracts was evaluated using the DPPH radical scavenging assay and expressed as IC_{50} values. The methanolic flower extract of Bauhinia purpurea exhibited an IC_{50} value of 88.85 ppm, while the leaf extract showed a higher IC_{50} value of 169.96 ppm. Silymarin, used as a positive control, demonstrated a markedly stronger antioxidant activity with an IC_{50} value of 29.63 ppm. According to established antioxidant classification criteria, extracts with IC_{50} values below 100 ppm are categorized as strong antioxidants, whereas those with IC_{50} values above 150 ppm are considered weak [14,18]. Based on this classification, the methanolic flower extract of B. purpurea can be classified as a strong antioxidant, the leaf extract as a weak antioxidant, and silymarin as a very strong antioxidant.

The stronger antioxidant activity observed in the flower extract compared to the leaf extract may be attributed to several factors, including the effectiveness of methanol as an extraction solvent and differences in the composition of bioactive compounds present in each plant organ [19,20]. The presence of flavonoids in the flower extract, as confirmed by phytochemical screening, is likely a major contributing factor to its lower IC_{50} value. Flavonoids and phenolic compounds are well known for their ability to neutralize free radicals through hydrogen or electron donation mechanisms [17,21]. Similar findings have been reported in previous studies, where higher flavonoid and phenolic contents were associated with stronger antioxidant activity in methanolic flower extracts of medicinal plants [21].

CONCLUSION

Methanolic extracts of Bauhinia purpurea leaves and flowers contain various bioactive compounds with antioxidant activity. The flower extract demonstrated stronger antioxidant capacity than the leaf extract, which is likely related to the presence of flavonoids and a more diverse chemical composition. These findings support the potential use of B. purpurea flowers as a natural source of antioxidant compounds and provide a basis for further pharmacological studies.

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