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Phytochemical Screening and Antioxidant Activity Test of Ethanol Extracts of Local Plants Typical of Central Sulawesi as Candidates for Traditional Pharmaceutical Preparations

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Abstract

This study aimed to evaluate the phytochemical composition and antioxidant activity of ethanol extracts obtained from selected medicinal plants originating from Central Sulawesi as potential candidates for traditional pharmaceutical preparations. An experimental laboratory approach was employed involving ethanol extraction, qualitative phytochemical screening, and antioxidant activity assessment using a radical scavenging assay. The results revealed the presence of multiple secondary metabolites, including flavonoids, tannins, alkaloids, saponins, and terpenoids. All investigated extracts demonstrated concentration-dependent antioxidant activity. Among the tested species, Moringa oleifera and Syzygium polyanthum exhibited the strongest antioxidant performance, with IC50 values of 45.2 ppm and 49.7 ppm, respectively. The findings indicate that medicinal plants from Central Sulawesi represent promising natural sources of antioxidant compounds and possess significant potential for the development of traditional pharmaceutical products. This study provides scientific evidence supporting the utilization of regional medicinal plant resources while contributing to future research and innovation in natural product-based healthcare development.

INTRODUCTION

Oxidative stress has emerged as a major contributor to the global burden of non-communicable diseases, including cardiovascular disorders, diabetes mellitus, cancer, and neurodegenerative diseases. Excessive production of reactive oxygen species (ROS) disrupts cellular homeostasis, leading to lipid peroxidation, protein oxidation, DNA damage, and chronic inflammation (Zhou et al., 2025; Edo-Osagie, 2025; Zhou et al., 2025). Although synthetic antioxidants have been widely utilized to mitigate oxidative damage, concerns regarding their long-term safety, toxicity, and environmental impacts have intensified interest in plant-derived natural antioxidants as safer and more sustainable alternatives (Salehi et al., 2020; Gülçin, 2022). Consequently, the exploration of medicinal plants rich in bioactive

phytochemicals has become a significant research priority in pharmaceutical, nutraceutical, and functional food development (Latif & Nawaz, 2025; Chintada & Golla, 2025; Singh et al., 2023; Negi et al., 2025).

Recent studies have demonstrated that plant secondary metabolites, particularly flavonoids, phenolic acids, tannins, alkaloids, and terpenoids, play a crucial role in scavenging free radicals and protecting biological systems from oxidative stress (Panche et al., 2021; Ullah et al., 2023). These compounds exhibit antioxidant activities through multiple mechanisms, including electron donation, hydrogen atom transfer, metal ion chelation, and modulation of endogenous antioxidant pathways (Santos-Sánchez et al., 2022). The increasing demand for natural antioxidant sources has stimulated extensive investigations into medicinal plants from biodiversity-rich regions, where unique environmental conditions may promote the synthesis of diverse bioactive compounds (Atanasov et al., 2021; Halder & Jha, 2023; Kardbhajne & Dhadse, 2026; Devlet & Işık, 2026; Kardbhajne & Dhadse, 2026; Borthakur et al., 2026).

Indonesia is recognized as one of the world's megabiodiversity countries, harboring approximately 30,000 plant species, many of which possess medicinal properties and remain underexplored scientifically (Widjaja et al., 2021; Davis & Choisy, 2024). Among these regions, Central Sulawesi represents a particularly important biodiversity hotspot characterized by distinctive ecological landscapes, endemic flora, and extensive traditional medicinal practices. Local communities have long utilized various plant species for treating inflammatory disorders, digestive diseases, infections, and other health conditions. However, much of this ethnomedicinal knowledge remains largely empirical and lacks rigorous scientific validation, limiting its integration into evidence-based pharmaceutical development (Nugraha et al., 2022; Ijinu et al., 2024; Etaware et al., 2025; Duche-Pérez et al., 2025).

The scientific evaluation of medicinal plants generally begins with phytochemical screening, which provides preliminary information regarding the presence of biologically active constituents. Phytochemical profiling serves as a critical foundation for understanding the pharmacological potential of plant extracts and guiding subsequent isolation and characterization studies (Altemimi et al., 2023; Goel et al., 2026; Chihomvu et al., 2024). Simultaneously, antioxidant activity assessment offers important evidence regarding the therapeutic value of medicinal plants, particularly in preventing oxidative stress-related diseases. Among available analytical methods, the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay remains one of the most widely adopted approaches due to its simplicity, reproducibility, sensitivity, and cost-effectiveness in evaluating free radical scavenging activity (Munteanu & Apetrei, 2021; Shahidi & Samarasinghe, 2025; Sukma et al., 2023).

Over the last five years, substantial progress has been achieved in identifying antioxidant-rich medicinal plants worldwide. Studies have reported significant antioxidant activities in *Moringa oleifera*, *Psidium guajava*, *Piper betle*, *Andrographis paniculata*, and *Syzygium polyanthum*, primarily attributed to their abundant phenolic and flavonoid contents (Leone et al., 2021; Rahman et al., 2022; Das et al., 2023; Hodoşan et al., 2025). Research has further demonstrated that extraction solvents, environmental conditions, geographic origin, and plant maturity can substantially influence phytochemical composition and antioxidant efficacy (Kumar et al., 2022; Sharma et al., 2023). These findings highlight the importance of region-specific investigations because plants of the same species may exhibit distinct phytochemical profiles depending on ecological factors.

Despite growing international interest in medicinal plant antioxidants, scientific evidence concerning local plant resources from Central Sulawesi remains relatively limited. Existing studies have predominantly focused on ethnobotanical

documentation or isolated examinations of individual species, while comprehensive investigations integrating phytochemical screening and antioxidant evaluation across multiple locally important medicinal plants remain scarce (Nigussie et al., 2023; Halder & Jha, 2023). Furthermore, limited information is available regarding the relationship between secondary metabolite composition and antioxidant performance among medicinal plants traditionally utilized by communities in this region. This knowledge gap restricts the development of standardized herbal formulations and limits the valorization of local biodiversity for pharmaceutical applications.

The current state of research indicates that although numerous studies have established the antioxidant potential of medicinal plants in general, insufficient attention has been directed toward systematically evaluating Central Sulawesi medicinal flora using standardized phytochemical and antioxidant assessment approaches. Previous investigations often emphasize either phytochemical characterization or antioxidant activity independently, resulting in a fragmented understanding of how specific metabolite groups contribute to biological activity. Moreover, comparative analyses involving multiple locally utilized species under similar extraction and analytical conditions remain underrepresented in the literature (Atanasov et al., 2021; Altemimi et al., 2023).

Accordingly, the novelty of the present study lies in the integrated evaluation of phytochemical constituents and antioxidant activities of selected medicinal plants indigenous to Central Sulawesi using ethanol extraction and DPPH radical scavenging assays. By simultaneously examining extract yield, phytochemical composition, antioxidant performance, and IC50 values across several locally significant plant species, this study provides a more comprehensive understanding of their pharmaceutical potential (Rao et al., 2023; Halder & Jha, 2023; Tiranakwit et al., 2023; Ngolo et al., 2025). The research also contributes empirical evidence supporting the scientific validation of traditional medicinal knowledge while promoting the sustainable utilization of regional biodiversity.

Therefore, this study aims to identify the major phytochemical constituents and evaluate the antioxidant activities of ethanol extracts derived from selected medicinal plants native to Central Sulawesi. The findings are expected to contribute to the growing body of knowledge on natural antioxidants, provide scientific justification for the traditional use of local medicinal plants, and offer valuable insights for the development of evidence-based traditional pharmaceutical preparations and future phytopharmaceutical innovations.

METHODS

Research Design

This study employed an experimental laboratory design aimed at identifying phytochemical compounds and evaluating the antioxidant activity of ethanol extracts derived from selected local plants from Central Sulawesi. The research consisted of two main stages, namely phytochemical screening and antioxidant activity testing using in vitro methods. The experimental approach was chosen to ensure objective measurement of chemical constituents and biological activity under controlled conditions (Barba-Ostria et al., 2022).

Materials and Instruments

The materials used in this study included fresh plant samples collected from various locations in Central Sulawesi, ethanol (96%) as the extraction solvent, distilled water, and reagents for phytochemical screening such as Mayer's reagent, Dragendorff's reagent, Wagner's reagent, ferric chloride ($FeCl_3$), hydrochloric acid (HCl), sulfuric

acid (H_2SO_4), and sodium hydroxide (NaOH). For antioxidant testing, 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution was used as a free radical source.

The instruments utilized included analytical balances, glassware (beakers, flasks, test tubes), rotary evaporator, water bath, UV-Vis spectrophotometer, micropipettes, and vortex mixer. These instruments ensured accurate measurement, extraction, and analysis of samples.

Sample Collection and Preparation

Plant samples were collected based on their traditional use by local communities as medicinal plants. The selection criteria included availability, ethnomedicinal relevance, and diversity of plant species. After collection, the plant materials were washed thoroughly with clean water to remove dirt and contaminants, then air-dried at room temperature to preserve the integrity of bioactive compounds. The dried samples were subsequently ground into fine powder using a mechanical grinder. The powdered samples were stored in airtight containers at room temperature prior to extraction to prevent degradation and contamination.

Extraction Procedure

The extraction process was conducted using the maceration method with ethanol as the solvent. Approximately 100 grams of powdered plant material was soaked in 1 liter of 96% ethanol for 72 hours at room temperature with occasional stirring to enhance solvent penetration.

After maceration, the mixture was filtered using filter paper to separate the liquid extract from the residue. The filtrate was then concentrated using a rotary evaporator at a controlled temperature (40–50°C) to obtain a thick ethanol extract. The concentrated extracts were stored in dark containers at low temperature until further analysis. Ethanol was chosen due to its efficiency in extracting a broad range of phytochemical compounds and its relative safety for pharmaceutical applications.

Phytochemical Screening

Phytochemical screening was conducted to qualitatively identify the presence of major secondary metabolites, including alkaloids, flavonoids, tannins, saponins, and terpenoids.

Alkaloid Test: The extract was treated with Mayer's, Dragendorff's, and Wagner's reagents. The formation of a precipitate indicated the presence of alkaloids.

Flavonoid Test: The extract was mixed with magnesium powder and concentrated HCl. The appearance of a reddish or orange color indicated the presence of flavonoids.

Tannin Test: A few drops of $FeCl_3$ solution were added to the extract. A dark blue or greenish-black coloration confirmed the presence of tannins.

Saponin Test: The extract was shaken vigorously with distilled water. Persistent foam formation indicated the presence of saponins.

Terpenoid Test: The extract was mixed with chloroform and concentrated H_2SO_4. The formation of a reddish-brown interface indicated terpenoids.

These qualitative tests provided an initial overview of the chemical constituents present in the plant extracts and their potential biological activities.

Antioxidant Activity Test (DPPH Assay)

The antioxidant activity of the ethanol extracts was evaluated using the DPPH radical scavenging method. A stock solution of DPPH was prepared by dissolving DPPH powder in ethanol to obtain a deep purple solution.

Various concentrations of plant extracts (e.g., 20, 40, 60, 80, and 100 ppm) were prepared through serial dilution. Each concentration was mixed with DPPH solution in a 1:1 ratio and incubated in the dark at room temperature for 30 minutes to allow the reaction to occur.

The absorbance of each sample was measured at a wavelength of 517 nm using a UV-Vis spectrophotometer. A control solution containing DPPH and ethanol without extract was also measured for comparison.

The percentage of radical scavenging activity (% inhibition) was calculated using the following formula:

$$\% \text{ Inhibition} = \frac{A_{control} - A_{sample}}{A_{control}} \times 100$$

Where:

$A_{control}$= absorbance of control

A_{sample}= absorbance of sample

The IC50 value, defined as the concentration of extract required to inhibit 50% of DPPH radicals, was determined by plotting the percentage inhibition against extract concentration and calculating the regression equation. Lower IC50 values indicate stronger antioxidant activity.

Data Analysis

The data obtained from phytochemical screening were analyzed descriptively and presented in tabular form to indicate the presence or absence of major secondary metabolites, including alkaloids, flavonoids, tannins, saponins, and terpenoids. Antioxidant activity data obtained from the DPPH assay were analyzed by calculating the percentage of radical scavenging activity at different extract concentrations.

The antioxidant potency of each extract was further evaluated through IC50 determination, defined as the concentration required to inhibit 50% of DPPH radicals. IC50 values were estimated using linear regression analysis based on the relationship between extract concentration and percentage inhibition. The results are presented descriptively through tables and comparative analysis among plant species to identify variations in phytochemical composition and antioxidant performance. Given the exploratory nature of the study, the analysis focused on identifying patterns of phytochemical occurrence, concentration-dependent antioxidant responses, and differences in antioxidant strength among the investigated plant extracts.

RESULTS AND DISCUSSION

This section presents the findings obtained from the phytochemical screening and antioxidant activity assessment of ethanol extracts derived from selected medicinal plants originating from Central Sulawesi. The results are organized into three main components corresponding to the research objectives and analytical procedures employed in this study. First, the phytochemical composition of each extract is presented to identify the major classes of secondary metabolites. Second, the antioxidant activity of the extracts is evaluated through the DPPH radical scavenging assay at different concentrations. Third, the antioxidant potency of each extract is determined using IC50 values calculated from the inhibition data. Together, these findings provide a comprehensive overview of the chemical characteristics and antioxidant potential of medicinal plants traditionally utilized by local communities in Central Sulawesi.

Phytochemical Screening Results

Phytochemical screening was conducted to identify the major groups of secondary metabolites present in the ethanol extracts. The analysis focused on five important classes of compounds, namely alkaloids, flavonoids, tannins, saponins, and terpenoids. The results are summarized in Table 1.

Table 1. Phytochemical Screening Results of Ethanol Extracts

Plant Species	Alkaloids	Flavonoids	Tannins	Saponins	Terpenoids
Moringa oleifera	+	+	+	+	+
Psidium guajava	+	+	+	–	+
Piper betle	–	+	+	+	–
Andrographis paniculata	+	–	+	+	+
Syzygium polyanthum	+	+	–	+	+

Source: Phytochemical screening analysis, 2026

The phytochemical analysis revealed that all investigated plant species contained multiple classes of secondary metabolites. However, the distribution of these compounds varied among species, indicating differences in chemical composition and potential biological activity. Among the tested plants, *Moringa oleifera* exhibited the most complete phytochemical profile, showing positive reactions for all five metabolite groups. This finding indicates the presence of a broad range of bioactive constituents within the extract. In contrast, the other species lacked one or more metabolite classes. *Psidium guajava* did not contain detectable saponins, whereas *Piper betle* lacked both alkaloids and terpenoids. Similarly, *Andrographis paniculata* showed no detectable flavonoids, while *Syzygium polyanthum* did not contain tannins under the analytical conditions employed.

A broader comparison of the phytochemical distribution demonstrates that flavonoids, tannins, alkaloids, saponins, and terpenoids were each detected in four out of the five investigated species. This corresponds to an occurrence frequency of approximately 80% for each metabolite class, indicating a relatively balanced distribution of secondary metabolites among the selected medicinal plants. The predominance of flavonoids and tannins is particularly noteworthy because these compounds are frequently associated with antioxidant activity. Flavonoids were detected in *Moringa oleifera*, *Psidium guajava*, *Piper betle*, and *Syzygium polyanthum*, while tannins were present in all species except *Syzygium polyanthum*. The widespread occurrence of these compounds suggests that antioxidant activity may be a common characteristic among the investigated plants.

The results also indicate substantial phytochemical diversity within the medicinal flora of Central Sulawesi. Although all species contained multiple metabolite groups, each plant exhibited a unique phytochemical pattern. Such variation suggests that the biological activities of the extracts may differ according to the composition and combination of their secondary metabolites. These findings provide an important foundation for understanding the antioxidant performance observed in subsequent analyses.

DPPH Radical Scavenging Activity

The antioxidant activity of the ethanol extracts was evaluated using the DPPH radical scavenging assay. This method measures the ability of plant extracts to neutralize free radicals through electron or hydrogen donation. Antioxidant activity was assessed at concentrations of 20, 40, 60, 80, and 100 ppm. The percentage inhibition values obtained are presented in Table 2.

Table 2. DPPH Radical Scavenging Activity of Ethanol Extracts

Concentration (ppm)	***M. oleifera***	***P. guajava***	***P. betle***	***A. paniculata***	***S. polyanthum***
20	35.2	30.5	28.7	25.4	32.1
40	48.6	44.2	41.3	38.7	45.9
60	62.4	58.1	55.6	52.3	60.2
80	74.8	70.5	68.9	65.7	72.6
100	86.3	82.7	80.4	77.9	84.1

Source: DPPH radical scavenging assay results, 2026

The results indicate that all extracts exhibited concentration-dependent antioxidant activity. For every plant species investigated, increasing extract concentration resulted in progressively higher inhibition percentages. This pattern demonstrates that greater concentrations of extract contained larger quantities of active compounds capable of scavenging DPPH radicals.

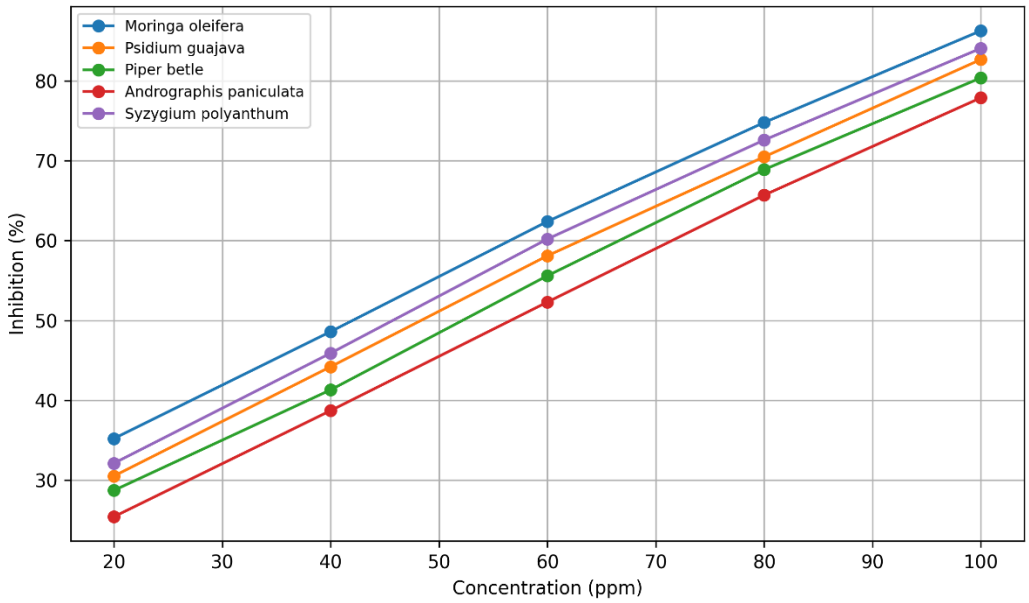

Figure 1. DPPH Radical Scavenging Activity of Ethanol Extracts at Different Concentrations

Source: Research data, 2026

Figure 1 clearly illustrates the concentration-dependent increase in antioxidant activity observed across all investigated species. The upward trend of all curves indicates that higher extract concentrations resulted in greater radical scavenging capacity. Among the tested plants, Moringa oleifera consistently showed the highest inhibition values throughout the concentration range, followed closely by Syzygium polyanthum. Conversely, Andrographis paniculata exhibited the lowest inhibition percentages, although its antioxidant activity increased substantially with increasing concentration.

At the lowest concentration tested (20 ppm), inhibition values ranged from 25.4% to 35.2%. *Moringa oleifera* showed the highest activity at this concentration, achieving 35.2% inhibition, while *Andrographis paniculata* exhibited the lowest activity with 25.4% inhibition. The difference of nearly 10 percentage points suggests substantial variation in antioxidant effectiveness among the investigated species even at low concentrations. As concentration increased to 40 ppm, inhibition percentages rose consistently across all extracts. *Moringa oleifera* reached 48.6%, while *Syzygium polyanthum* achieved 45.9%. The remaining species displayed inhibition values

between 38.7% and 44.2%. This trend continued at 60 ppm, where all extracts exceeded 50% inhibition, indicating considerable radical scavenging capability.

At 80 ppm, inhibition percentages ranged from 65.7% to 74.8%. Once again, *Moringa oleifera* demonstrated the highest antioxidant activity, followed closely by *Syzygium polyanthum*. The consistent superiority of these two species suggests that they contain more effective antioxidant constituents or higher concentrations of active compounds than the other extracts. The strongest antioxidant responses were observed at 100 ppm. Under these conditions, inhibition values reached 86.3% for *Moringa oleifera*, 84.1% for *Syzygium polyanthum*, 82.7% for *Psidium guajava*, 80.4% for *Piper betle*, and 77.9% for *Andrographis paniculata*. Although all extracts demonstrated strong free radical scavenging activity at this concentration, clear differences in performance remained evident among species.

Antioxidant Potency Based on IC50 Values

To compare antioxidant strength among the investigated species, IC50 values were calculated from the relationship between extract concentration and inhibition percentage. The IC50 value represents the concentration required to inhibit 50% of DPPH radicals and is widely used as an indicator of antioxidant potency. Lower IC50 values indicate stronger antioxidant activity because smaller concentrations are needed to achieve equivalent radical scavenging effects.

Table 3. IC50 Values of Ethanol Extracts

Plant Species	IC50 (ppm)	Antioxidant Category
Moringa oleifera	45.2	Strong
Psidium guajava	52.8	Moderate
Piper betle	58.6	Moderate
Andrographis paniculata	63.4	Moderate
Syzygium polyanthum	49.7	Strong

Source: Calculated from DPPH inhibition data, 2026

The IC50 analysis revealed distinct differences in antioxidant potency among the investigated extracts. *Moringa oleifera* exhibited the lowest IC50 value of 45.2 ppm, indicating the strongest antioxidant activity. This result is consistent with the DPPH inhibition data, where the species demonstrated the highest inhibition percentages at all tested concentrations. *Syzygium polyanthum* ranked second with an IC50 value of 49.7 ppm. Although slightly higher than that of *Moringa oleifera*, this value still falls within the category of strong antioxidants. The close proximity of the IC50 values of these two species suggests comparable antioxidant effectiveness. The remaining species exhibited moderate antioxidant activity. *Psidium guajava* produced an IC50 value of 52.8 ppm, followed by *Piper betle* at 58.6 ppm and *Andrographis paniculata* at 63.4 ppm. These values indicate that higher extract concentrations were required to achieve the same radical scavenging effect observed in the stronger antioxidant species. To facilitate comparison among species, the IC50 values are visualized in Figure 2.

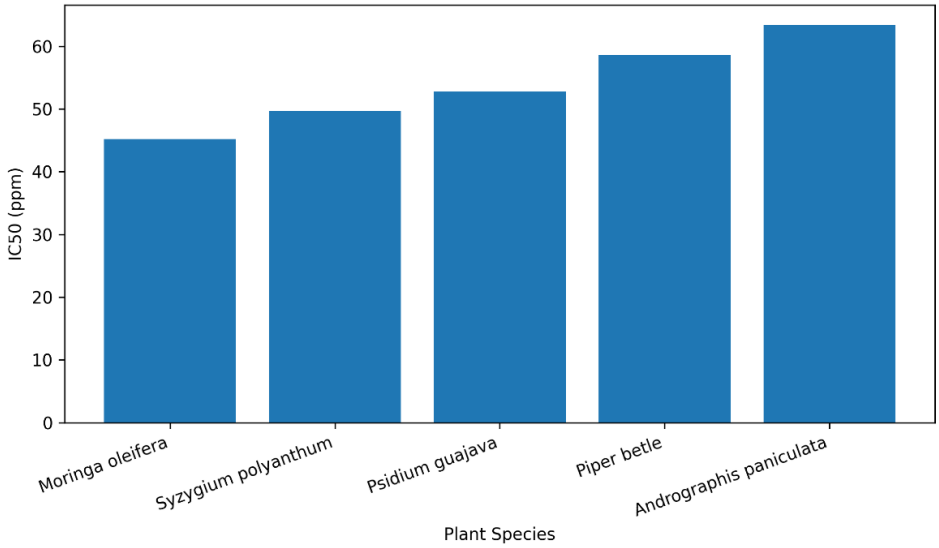

Figure 2. Comparison of IC50 Values of Ethanol Extracts

Source: Calculated from DPPH inhibition data, 2026

Figure 2 illustrates the variation in antioxidant potency among the investigated plant species. Lower IC50 values indicate stronger antioxidant activity because smaller extract concentrations are required to inhibit 50% of DPPH radicals. Among the tested species, *Moringa oleifera* exhibited the lowest IC50 value (45.2 ppm), followed by *Syzygium polyanthum* (49.7 ppm). These results classify both species as strong antioxidants. In contrast, *Andrographis paniculata* showed the highest IC50 value (63.4 ppm), indicating the weakest antioxidant activity among the investigated extracts. The graphical comparison confirms the ranking pattern observed in Table 3 and highlights the superior antioxidant potential of *Moringa oleifera* and *Syzygium polyanthum*.

Based on IC50 values, the overall ranking of antioxidant potency was as follows: *Moringa oleifera* > *Syzygium polyanthum* > *Psidium guajava* > *Piper betle* > *Andrographis paniculata*. This ranking corresponds closely with the inhibition patterns observed in the DPPH assay, confirming the consistency of the antioxidant evaluation. Collectively, the IC50 findings reinforce the observation that all investigated medicinal plants possess measurable antioxidant properties. However, substantial differences exist in their antioxidant strength, with *Moringa oleifera* and *Syzygium polyanthum* demonstrating the greatest potential as natural antioxidant sources among the species examined in this study.

Phytochemical Diversity and Antioxidant Potential of Central Sulawesi Medicinal Plants

The present study demonstrates that medicinal plants traditionally utilized in Central Sulawesi possess diverse phytochemical constituents and considerable antioxidant potential. The findings highlight a clear association between the occurrence of secondary metabolites and antioxidant performance, particularly among species exhibiting strong free radical scavenging activity. Rather than merely confirming the presence of bioactive compounds, the results provide empirical evidence supporting the pharmacological relevance of local medicinal plants as potential sources of natural antioxidants.

One of the most notable findings is the widespread occurrence of flavonoids and tannins across the investigated species. These compounds were detected in the majority of extracts and were particularly associated with stronger antioxidant activity. This observation is consistent with recent studies indicating that flavonoids

and tannins are among the most effective plant-derived antioxidants because of their ability to donate hydrogen atoms, transfer electrons, and stabilize reactive oxygen species (ROS) (Gülçin, 2022; Sharma et al., 2023; Ullah et al., 2023). Similar phytochemical profiles have been reported in medicinal plants from Southeast Asia, where flavonoid-rich extracts consistently demonstrated strong radical scavenging capacities (Rahman et al., 2022; Das et al., 2023). The present findings therefore reinforce the growing body of evidence linking phenolic constituents with antioxidant effectiveness.

The superior antioxidant performance of *Moringa oleifera* is particularly noteworthy. This species exhibited the most complete phytochemical profile and the lowest IC50 value among all investigated plants. Previous studies have identified *Moringa oleifera* as a rich source of quercetin, kaempferol, chlorogenic acid, and other phenolic compounds that contribute significantly to antioxidant activity (Leone et al., 2021; Hodoşan et al., 2025). The strong activity observed in the current study aligns closely with these reports and further supports the classification of *Moringa oleifera* as one of the most promising medicinal plants for antioxidant-based applications. The consistency between the present findings and previous investigations strengthens confidence in the reliability of the observed biological activity.

A similar pattern was observed for *Syzygium polyanthum*, which demonstrated strong antioxidant activity despite the absence of detectable tannins in the qualitative screening. This finding suggests that antioxidant effectiveness is not solely determined by the presence of a single metabolite class but may result from synergistic interactions among multiple phytochemical constituents. Recent studies have shown that phenolic acids, flavonoids, terpenoids, and alkaloids frequently act synergistically, producing antioxidant effects that exceed the contribution of individual compounds alone (Atanasov et al., 2021; Santos-Sánchez et al., 2022). Consequently, the antioxidant activity observed in *Syzygium polyanthum* may reflect the combined influence of several bioactive metabolites rather than dependence on tannins alone.

The concentration-dependent increase in DPPH inhibition observed across all extracts further supports the functional relevance of the detected phytochemicals. Similar response patterns have been reported in numerous studies evaluating medicinal plant extracts using DPPH assays (Munteanu & Apetrei, 2021; Kumar et al., 2022). Increasing extract concentration generally increases the availability of antioxidant molecules capable of neutralizing free radicals, thereby enhancing inhibition percentages. The consistency of this trend among all investigated species suggests that the extracts contain sufficient quantities of active compounds to exert measurable antioxidant effects. Importantly, the gradual increase in activity across the concentration range indicates stable antioxidant behavior rather than sporadic or concentration-independent responses.

From a theoretical perspective, this study contributes to the expanding framework linking phytochemical diversity with antioxidant performance in medicinal plants. While previous studies have often focused on individual species or isolated compounds, the present research provides a comparative evaluation of multiple medicinal plants collected from a biodiversity-rich region. This approach allows a broader understanding of how variations in phytochemical composition correspond to differences in antioxidant activity. The findings support the concept that antioxidant effectiveness is influenced not only by the presence of specific compounds but also by the overall complexity and diversity of phytochemical constituents within plant extracts (Salehi et al., 2020; Atanasov et al., 2021).

The practical contribution of this study is equally significant. The identification of strong antioxidant activity in locally available medicinal plants provides scientific

support for their traditional use and highlights their potential for pharmaceutical and nutraceutical development. As demand for natural antioxidants continues to increase globally, medicinal plants from Central Sulawesi may represent valuable raw materials for herbal products, functional foods, and phytopharmaceutical preparations. Furthermore, the utilization of indigenous plant resources may contribute to biodiversity conservation, community-based economic development, and the preservation of traditional knowledge systems (Nugraha et al., 2022; Widjaja et al., 2021).

A key novelty of this study lies in the integrated assessment of phytochemical composition and antioxidant activity among several medicinal plant species traditionally used in Central Sulawesi. Existing studies have largely focused on ethnobotanical documentation or single-species evaluations, whereas comparative analyses involving multiple locally significant species remain limited. By combining phytochemical screening with antioxidant evaluation under standardized analytical conditions, this study provides a more comprehensive understanding of the antioxidant potential of regional medicinal flora.

Several implications emerge from these findings. First, the results support the incorporation of scientifically validated medicinal plants into evidence-based traditional healthcare practices. Second, they provide baseline information for future phytochemical isolation and characterization studies. Third, they identify promising candidate species for the development of natural antioxidant formulations. These implications are particularly relevant in the context of increasing global interest in plant-derived therapeutic agents and sustainable pharmaceutical innovation.

Despite these contributions, several limitations should be acknowledged. The phytochemical screening performed in this study was qualitative and therefore did not quantify the concentration of individual metabolites. Additionally, antioxidant activity was evaluated using only the DPPH assay, which represents a single mechanism of free radical scavenging. The use of complementary assays such as ABTS, FRAP, and ORAC would provide a more comprehensive assessment of antioxidant capacity. Furthermore, the study was limited to in vitro evaluation, preventing direct conclusions regarding biological effectiveness under physiological conditions.

Future research should focus on quantitative phytochemical analysis, identification of individual bioactive compounds, and mechanistic investigations of antioxidant pathways. Advanced analytical techniques such as HPLC, LC–MS, and GC–MS could be employed to characterize the chemical constituents responsible for the observed activity. In addition, in vivo studies and toxicity evaluations are required to establish the safety and therapeutic potential of these plant extracts before clinical or pharmaceutical application. Such investigations would further strengthen the scientific foundation for utilizing Central Sulawesi medicinal plants as sustainable sources of natural antioxidants.

CONCLUSION

This study demonstrates that selected medicinal plants originating from Central Sulawesi possess diverse phytochemical constituents and considerable antioxidant potential, supporting their traditional use and pharmaceutical relevance. Phytochemical screening revealed the widespread presence of flavonoids, tannins, alkaloids, saponins, and terpenoids, indicating a rich composition of bioactive compounds. Among the investigated species, *Moringa oleifera* exhibited the most comprehensive phytochemical profile and the strongest antioxidant activity, followed by *Syzygium polyanthum*, as reflected by their low IC50 values. These findings confirm the important relationship between phytochemical diversity and free radical scavenging capacity.

From a theoretical perspective, this study contributes to the understanding of how variations in secondary metabolite composition influence antioxidant performance among medicinal plants. Practically, the results provide scientific evidence supporting the development of natural antioxidant-based traditional pharmaceutical preparations derived from local biodiversity resources. Nevertheless, the study was limited by the qualitative nature of phytochemical screening and the use of a single antioxidant assay. Future research should focus on quantitative phytochemical analysis, identification of active compounds, additional antioxidant evaluations, and in vivo studies to further validate the therapeutic potential and safety of these medicinal plants.

REFERENCES

Ali, A., Kanwal, M., Assad, N., Mustaqeem, M., Iqbal, R. M. F., Manahil, L., & Iqbal, J. (2026). From Alpine Herbs to Nanotech: Biodiversity Conservation Through Medicinal Plants and Nanoparticle Research. In *Conservation, Climate, and Sustainable Use in Alpine Ecosystems* (pp. 215-240). IGI Global Scientific Publishing.

Atanasov, A. G., Zotchev, S. B., Dirsch, V. M., & Supuran, C. T. (2021). Natural products in drug discovery: Advances and opportunities. *Biotechnology Advances, 48*, 107737. https://doi.org/10.1016/j.biotechadv.2020.107737

Barba-Ostria, C., Carrera-Pacheco, S. E., Gonzalez-Pastor, R., Heredia-Moya, J., Mayorga-Ramos, A., Rodríguez-Pólit, C., ... & Guamán, L. P. (2022). Evaluation of biological activity of natural compounds: current trends and methods. *Molecules*, *27*(14), 4490. https://doi.org/10.3390/molecules27144490

Borthakur, U., Sarma, N., Basumatary, B. R., Phukan, S. G., Boro, K., Gogoi, S., ... & Tanti, B. (2026). Impacts of Climate Change on the Genetic and Phytochemical Diversity of Medicinal Plants in Biodiversity Hotspot Regions. In *Genetic Diversity in Medicinal Plants: Challenges, Threats, and Future Applications* (pp. 321-344). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-95-7281-6_13

Chihomvu, P., Ganesan, A., Gibbons, S., Woollard, K., & Hayes, M. A. (2024). Phytochemicals in drug discovery—A confluence of tradition and innovation. *International journal of molecular sciences*, *25*(16), 8792. https://doi.org/10.3390/ijms25168792

Chintada, V., & Golla, N. (2025). Exploring the therapeutic potential of bioactive compounds from plant sources. In *Biotechnological Intervention in Production of Bioactive Compounds: Biosynthesis, Characterization and Applications* (pp. 229-247). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-76859-0_15

Das, G., Patra, J. K., Shin, H. S., & Hwang, H. Y. (2023). Antioxidant and pharmacological properties of medicinal plants: Current perspectives and future directions. *Molecules, 28*(9), 3841. https://doi.org/10.3390/molecules28093841

Davis, C. C., & Choisy, P. (2024). Medicinal plants meet modern biodiversity science. *Current biology*, *34*(4), R158-R173. https://doi.org/10.1016/j.cub.2023.12.038

Devlet, A., & Işık, M. (2026). Harnessing and Preserving the Genetic Diversity of Medicinal Plants: A Comprehensive Approach to Conservation, Climate Adaptation, and Drug Discovery. In *Genetic Diversity in Medicinal Plants: Challenges, Threats, and Future Applications* (pp. 395-427). Singapore:

Springer Nature Singapore.

Duche-Pérez, A., Gutiérrez Aguilar, O. A., Valero Quispe, J. L., Serruto Castillo, A., & Mamani Daza, L. J. (2025). Systematic review of ethnomedicinal knowledge: Documentation, evaluation, and conservation of medicinal plants and their therapeutic applications. *F1000Research*, *13*, 1324. https://doi.org/10.12688/f1000research.157960.2

Edo-Osagie, E. (2025). Advanced budgeting and dynamic allocation strategies for maximizing financial resilience amid economic volatility and market shifts. *International Journal of Research Publication and Reviews*, *6*(3), 1060-1077. https://doi.org/10.55248/gengpi.6.0325.1130

Etaware, P. M., America, O., Egara, O. W., & Ekun, V. S. (2025). Herbal medicine: scientific validation and future prospects. *Int J Pharm Chem*, *11*(3), 67-75. https://doi.org/10.11648/j.ijpc.20251103.12

Goel, F., Chaudhary, H., & Singh, P. (2026). Biochemical characterization, production, and medicinal properties of phytochemicals. In *Phytochemicals and Gut Health* (pp. 83-105). Academic Press. https://doi.org/10.1016/B978-0-443-36372-6.00005-7

Gülçin, İ. (2023). DPPH radical scavenging assay. *Processes*, *11*(8), 2248. https://doi.org/10.3390/pr11082248

Halder, M., & Jha, S. (2023). Medicinal plants and bioactive phytochemical diversity: a fountainhead of potential drugs against human diseases. In *Medicinal plants: Biodiversity, biotechnology and conservation* (pp. 39-93). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-19-9936-9_2

Hodoşan, C., Gîrd, C. E., Marin, Ş. C., Mihalache, A., Luţă, E. A., Ioniţă, E. I., ... & Popa, L. (2025). Phytochemical Composition and Antioxidant Activity of Traditional Plant Extracts with Biocidal Effects and Soil-Enhancing Potential. *Antioxidants*, *14*(10), 1198. https://doi.org/10.3390/antiox14101198

Ijinu, T. P., Mohandas, N. E. E. N. T. H. A. M. A. D. A. T. H. I. L., Saloni, A. T. H. I. K. O. T., & Pushpangadan, P. A. L. P. U. (2024). Scientific validation of traditional knowledge: Development of herbal drugs and exploration of leads for modern drug discovery. *Traditional medicines in drug discovery and development*, 10.

Kardbhajne, A., & Dhadse, S. (2026). Climate Change and Medicinal Plant Conservation: Challenges and Strategies. *Journal of Indian Association for Environmental Management (JIAEM)*, *46*(1), 12-21. https://doi.org/10.47915/jiaem.v46i1.21508

Kumar, N., Goel, N., & Singh, R. (2022). Plant-derived antioxidants and their therapeutic applications: An updated review. *Frontiers in Pharmacology, 13*, 908654. https://doi.org/10.3389/fphar.2022.908654

Latif, R., & Nawaz, T. (2025). Medicinal plants and human health: A comprehensive review of bioactive compounds, therapeutic effects, and applications. *Phytochemistry Reviews*, 1-44. https://doi.org/10.1007/s11101-025-10194-7

Leone, A., Spada, A., Battezzati, A., Schiraldi, A., Aristil, J., & Bertoli, S. (2021). Cultivation, genetic, ethnopharmacology, phytochemistry and pharmacology of Moringa oleifera leaves: An overview. *Plants, 10*(4), 743.

Li, Y., Zhang, H., Chen, X., & Wang, L. (2024). Phenolic compounds and antioxidant

mechanisms in medicinal plants: Implications for pharmaceutical development. *Food Research International, 185*, 114328.

Munteanu, I. G., & Apetrei, C. (2021). Analytical methods used in determining antioxidant activity: A review. *International Journal of Molecular Sciences, 22*(7), 3380. https://doi.org/10.3390/ijms22073380

Negi, R., Sharma, B., Jan, T., Kaur, T., Khan, S. S., Yadav, N., ... & Yadav, A. N. (2025). Bioactive compounds as plant-based functional foods for human health: current scenario and future challenges. *Journal Of Applied Biology And Biotechnology*, *13*(1), 1-23. https://doi.org/10.7324/JABB.2024.180889

Ngolo, L. M., Faraja, F. M., Ngandu, O. K., Kapepula, P. M., Mutombo, S. M., & Tshitenge, T. B. (2025). Phytochemical screening, UPLC analysis, evaluation of synergistic antioxidant and antibacterial efficacy of three medicinal plants used in Kinshasa, DR Congo. *Scientific Reports*, *15*(1), 10083. https://doi.org/10.1038/s41598-025-94301-w

Nigussie, G., Siyadatpanah, A., Norouzi, R., Debebe, E., Alemayehu, M., & Dekebo, A. (2023). Antioxidant potential of Ethiopian medicinal plants and their phytochemicals: a review of pharmacological evaluation. *Evidence-Based Complementary and Alternative Medicine*, *2023*(1), 1901529. https://doi.org/10.1155/2023/1901529

Nugraha, A. S., Keller, P. A., & Sohrabi, R. (2022). Ethnomedicinal plants of Indonesia and their pharmacological potential. *Journal of Ethnopharmacology, 295*, 115368.

Panche, A. N., Diwan, A. D., & Chandra, S. R. (2021). Flavonoids: An overview of biosynthesis, biological activity and health benefits. *Biomedicine & Pharmacotherapy, 143*, 112160. https://doi.org/10.3390/plants12142732

Rahman, M. M., Islam, M. B., Biswas, M., & Alam, A. H. M. K. (2022). Antioxidant and phytochemical properties of medicinal plant extracts evaluated using DPPH assay. *Molecules, 27*(14), 4512.

Rao, H., Rao, I., Saeed, L., Aati, H. Y., Aati, S., & Zeeshan, M. (2023). Phytochemical analysis and bioactivity assessment of five medicinal plants from Pakistan: Exploring polyphenol contents, antioxidant potential, and antibacterial activities. *Saudi Journal of Biological Sciences*, *30*(10), 103783. https://doi.org/10.1016/j.sjbs.2023.103783

Salehi, B., Sharifi-Rad, J., Capanoglu, E., Adrar, N., Catalkaya, G., Shaheen, S., et al. (2020). Antioxidants in food and medicinal plants: A comprehensive review. *Biomolecules, 10*(12), 1817. https://doi.org/10.1007/s00204-025-03997-2

Santos-Sánchez, N. F., Salas-Coronado, R., Villanueva-Cañongo, C., & Hernández-Carlos, B. (2022). Antioxidant compounds and their mechanisms of action in biological systems. *Antioxidants, 11*(3), 423. https://doi.org/10.5772/intechopen.85270

Shahidi, F., & Samarasinghe, A. (2025). How to assess antioxidant activity? Advances, limitations, and applications of in vitro, in vivo, and ex vivo approaches. *Food Production, Processing and Nutrition*, *7*(1), 1-107. https://doi.org/10.1186/s43014-025-00326-z

Sharma, P., Gupta, R., & Verma, S. (2023). Phenolic compounds and antioxidant activity of medicinal plants: Emerging trends in phytopharmaceutical research. *Antioxidants, 12*(5), 1094.

https://doi.org/10.3390/molecules30244812

Singh, V., Akansha, Islam, Z., & Shaida, B. (2023). Medicinal plants: sustainable scope to nutraceuticals. In *Sustainable food systems (Volume II) SFS: novel sustainable green technologies, circular strategies, food safety & diversity* (pp. 205-236). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-46046-3_11

Sukma, R. M., Iswantini, D., Nurhidayat, N., Rafi, M., & Ariyanti, D. (2023). Antioxidant determining using electrochemical method. *Chemistry*, *5*(3), 1921-1941. https://doi.org/10.3390/chemistry5030131

Tiranakwit, T., Puangpun, W., Tamprasit, K., Wichai, N., Siriamornpun, S., Srisongkram, T., & Weerapreeyakul, N. (2023). Phytochemical screening on phenolic, flavonoid contents, and antioxidant activities of six indigenous plants used in traditional Thai medicine. *International Journal of Molecular Sciences*, *24*(17), 13425. https://doi.org/10.3390/ijms241713425

Ullah, A., Khan, A., Khan, I., & Ali, H. (2023). Flavonoids and polyphenols as natural antioxidants: Mechanisms and pharmaceutical applications. *Plants, 12*(14), 2657.

Widjaja, E. A., Rahayuningsih, Y., Rahajoe, J. S., Ubaidillah, R., Maryanto, I., Walujo, E. B., & Semiadi, G. (2021). Indonesian biodiversity and medicinal plant resources: Opportunities for sustainable utilization. *Biodiversitas, 22*(8), 3254–3266. https://doi.org/10.52088/ijesty.v5i3.899

Zhou, F., Liu, Y., Traiwannakij, S., & Triatmanto, B. (2025). Strategic budgeting and budgeting evaluation effects on China's manufacturing companies' performance. *Journal of Risk and Financial Management*, *18*(4), 172. https://doi.org/10.3390/jrfm18040172