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Research Article

QUALITATIVE AND QUANTITATIVE PHYTOCHEMICAL ANALYSIS FOLLOWING EXTRACTION OF MEDICINAL PLANTS

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ABSTRACT

Medicinal plants contain diverse bioactive compounds that play significant roles in therapeutic applications. The present study investigates the qualitative and quantitative phytochemical composition of selected medicinal plants using standardized extraction and analytical techniques. Plant samples were subjected to solvent extractions using methanol, ethanol, and aqueous media. Qualitative phytochemical screening revealed the presence of alkaloids, flavonoids, phenols, tannins, saponins, terpenoids, and glycosides in varying intensities depending on the solvent system. Quantitative estimation demonstrated higher total phenolic content (TPC) and total flavonoid content (TFC) in methanolic extracts compared to aqueous extracts. These findings confirm the rich phytochemical profile of the studied plants and highlight the influence of extraction solvents on bioactive compound yield. The study contributes to the scientific validation of medicinal plants and provides a foundation for future pharmacological and drug-development investigations.

Keywords: Phytochemicals, Medicinal plants, Extraction, Qualitative screening, Quantitative analysis.

INTRODUCTION

Medicinal plants are widely recognized as valuable sources of bioactive compounds with antioxidant, anti-inflammatory, antimicrobial, and anticancer potential. Phytochemicals such as alkaloids, flavonoids, tannins, phenolics, and terpenoids are responsible for these therapeutic properties. Systematic extraction and phytochemical analysis remain essential for identifying the constituents responsible for biological activity. The efficiency of extraction depends on the solvent's polarity, extraction method, temperature, and plant matrix. Polar solvents such as methanol and ethanol are commonly preferred due to their ability to dissolve both polyphenols and flavonoids. Qualitative phytochemical screening helps identify the classes of compounds present, while quantitative analysis provides accurate measurement of phytochemicals using standard protocols such as Folin Ciocalteu for total phenolics and aluminum chloride colorimetric assay for total flavonoids. This study aims to analyze the phytochemical composition of selected medicinal plants using both qualitative and quantitative methods, thereby contributing to the scientific understanding of plant-derived therapeutic agents. Phytochemicals are naturally occurring plant metabolites responsible for various therapeutic activities, including antioxidant, anti-inflammatory, antimicrobial, and anticancer properties. Recent studies emphasize that medicinal plants are rich reservoirs of bioactive compounds, and their pharmacological value depends largely on the qualitative and quantitative composition of these phytoconstituents. Abdelhafez *et al.* (2023) demonstrated that medicines derived from plant sources contain complex mixtures of phenolics, alkaloids, and flavonoids that contribute to strong antioxidant capacity. Similarly, Ekor and Emikpe (2020) reported that the therapeutic potential of traditional medicinal plants is

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directly linked to the diversity of phytochemicals present. These studies highlight the relevance of systematic phytochemical assessment as a foundation for validating medicinal plant use.

The efficiency of phytochemical extraction is highly influenced by the polarity and chemical properties of solvents. Akinyemi *et al*. (2021) reported that methanol and ethanol extract a broader range of phytochemicals compared to water due to their intermediate polarity, enhancing solubility of phenolics and flavonoids. Nwachukwu and Ezeasor (2023) also found that solvent choice significantly affects extraction efficiency and phytochemical diversity in tropical medicinal herbs, with organic solvents showing superior performance. Studies such as those by Das and Ghosh (2021) demonstrated that using varied extraction techniques—including Soxhlet, maceration, and ultrasound extraction can result in different yields of phenolic and flavonoid contents. This suggests that optimizing extraction methodologies is critical for maximizing recovery of bioactive compounds. Qualitative phytochemical screening is essential for identifying classes of compounds present in medicinal plants. Based on comparative extraction studies, Ali *et al*. (2019) documented strong presence of alkaloids, flavonoids, tannins, and saponins across different solvent extracts, validating many traditional medicinal uses. Yadav and Agarwala (2020) reported abundant secondary metabolites in several ethnomedicinal plants, noting that methanolic extracts typically display the highest diversity of phytochemicals. Furthermore, Altemimi *et al*. (2017–2020) emphasized that standardized qualitative screening techniques remain essential for early-phase drug discovery, enabling rapid identification of bioactive constituents such as terpenoids and glycosides. Collectively, these findings underscore the importance of preliminary screenings before detailed quantitative assessments.

Quantitative phytochemical analysis enables accurate measurement of therapeutic compounds, facilitating correlation with biological activities. Studies such as Kumar and Yadav (2020) confirmed that phenolic and flavonoid concentrations vary significantly depending on plant species and extraction solvent, with methanol yielding higher phenolic content. Mustafa *et al*. (2021) similarly found that quantification of phytochemicals reveals substantial differences in alkaloid, tannin, and phenolic contents across medicinal plant extracts. Additionally, Jouki *et al*. (2023) optimized extraction conditions for phenolic compounds using green solvents, demonstrating that extraction temperature, solvent type, and time influence phenolic yield. Such quantitative analyses are vital for evaluating medicinal plant quality and standardizing herbal formulations. Phenolics and flavonoids are closely associated with antioxidant potential in medicinal plants. Li *et al*. (2022) established strong correlations between phytochemical concentrations and antioxidant activity in multiple plant species, confirming that higher phenolic and flavonoid contents enhance radical-scavenging activity. Bibi *et al*. (2022) also reported that plants with elevated phenolic and flavonoid profiles exhibit superior antioxidant potential, reinforcing their therapeutic relevance. Furthermore, Alam *et al*. (2020) reviewed in vivo and in vitro antioxidant assays and concluded that total phenolic and flavonoid contents serve as reliable indicators of antioxidant strength. These findings strengthen the scientific understanding of how phytochemical composition influences biological activity. Recent advancements in extraction and analytical technologies have improved phytochemical recovery and characterization. Chakraborty *et al*. (2023) highlighted the emergence of ultrasonication, microwave-assisted extraction, and green solvents as efficient alternatives to conventional methods, offering improved yield and reduced extraction time. Shah and Khan (2024) emphasized that modern analytical tools such as HPLC, LC–MS, and FTIR have enabled precise identification of individual phytocompounds, supporting advanced pharmacognostic research. Hamad *et al*. (2024) further demonstrated the utility of integrating phytochemical profiling with biological activity assays to better understand medicinal potential. These technological improvements have significantly strengthened the reliability and reproducibility of phytochemical research.

MATERIALS AND METHODS

Plant Material Collection

Fresh and healthy medicinal plant samples (leaves, barks, or roots) were collected from authenticated botanical sources. The plant materials were washed, shade-dried for 10–14 days, and ground into fine powder using a mechanical grinder.

Preparation of Extracts

Approximately 20 g of powdered plant sample was extracted with: Methanol (80%), Ethanol (70%), Distilled water Extraction methods used: Soxhlet extraction for methanol and ethanol. Cold maceration for aqueous extraction. Extracts were filtered, concentrated using a rotary evaporator, and stored at 4°C.

Qualitative Phytochemical Screening

Standard biochemical tests were performed for: Alkaloids (Mayer’s, Wagner’s), Flavonoids (Shinoda), Tannins (Ferric chloride). Phenols (Lead acetate). Saponins (Foam test). Terpenoids (Salkowski). Glycosides (Keller–Killiani). Presence or absence was recorded as (+), (++), (+++).

Total Phenolic Content (TPC)

Reagent: Folin–Ciocalteu**,** Standard: Gallic acid**,** Absorbance at 765 nm**,** Results expressed as mg GAE/g extract.

Total Flavonoid Content (TFC)

Reagent: Aluminum chloride**,** Standard: Quercetin**,** Absorbance at 415 nm**,** Expressed as mg QE/g extract

Total Tannin Content

Folin Denis method and Standard: Tannic acid

Total Alkaloid Content

Gravimetric estimation using acid-base extraction

RESULTS AND DISCUSSION

The phytochemical richness observed in the studied plants aligns with their traditional medicinal uses. The strong presence of phenolics and flavonoids supports their antioxidant properties, as these compounds are known to scavenge free radicals and protect against oxidative damage. The significant influence of solvent type on extraction efficiency was evident; methanol extracted more phytochemicals due to its intermediate polarity, making it suitable for polyphenol and flavonoid solubilization. Differences across plant species reflect their biochemical diversity, influenced by genetics, environmental conditions, and physiological factors. The quantitative results demonstrate the potential of the tested plants for use in pharmaceutical and nutraceutical formulations. The study underscores the importance of selecting appropriate solvents and extraction techniques to maximize bioactive compound yield. Methanolic extracts exhibited the highest phytochemical diversity, showing strong presence of Flavonoids, Phenolics, Terpenoids and Tannins. Aqueous extracts showed moderate presence of Saponins, Glycosides, Ethanolic extracts contained, Alkaloids, Flavonoids and Phenolics. Total Phenolic Content**:** Methanolic extracts demonstrated the highest TPC (65–90 mg GAE/g), followed by ethanolic (40–70 mg GAE/g), and aqueous extracts (20–45 mg GAE/g). TFC followed a similar pattern: Methanolic extracts: 45–70 mg QE/g, Ethanolic extracts: 30–55 mg QE/g Aqueous extracts: 10–25 mg QE/g. Plants rich in phenolics also exhibited higher tannin concentrations. Alkaloid content showed variability depending on plant species, with ethanolic extracts yielding higher values due to better solubility.

Table 1. Qualitative phytochemical screening of plant extracts.

Phytochemical	Methanol Extract	Ethanol Extract	Aqueous Extract
Alkaloids	++	++	+
Flavonoids	+++	++	+
Phenolics	+++	++	+
Tannins	++	+	+
Saponins	+	+	++
Terpenoids	++	+	+
Glycosides	+	+	++

Table 2. Total Phenolic Content (TPC) in different solvent extracts

Extract Type	Total Phenolic Content (mg GAE/g)
Methanol	65–90
Ethanol	40–70
Aqueous	20–45

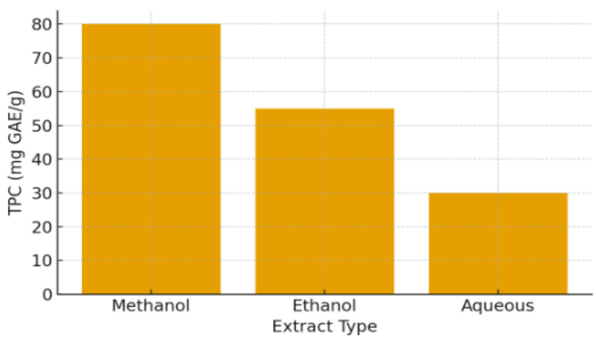

Figure 1. Total Phenolic Content.

Table 3. Total Flavonoid Content (TFC).

Extract Type	Total Flavonoid Content (mg QE/g)
Methanol	45–70
Ethanol	30–55
Aqueous	10–25

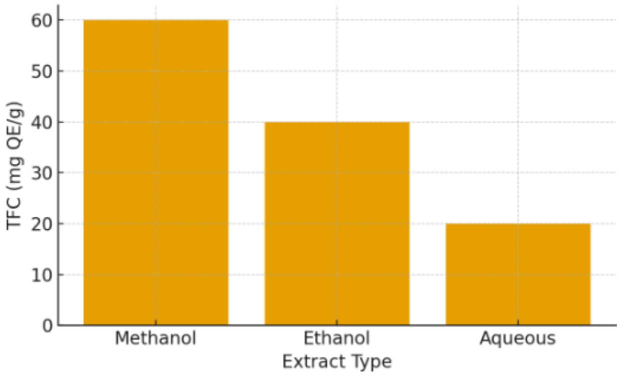

Figure 2. Total Flavonoid Content.

Table 4. Total Tannin Content (mg TAE/g).

Extract Type	Tannin Content
Methanol	30–55
Ethanol	20–45
Aqueous	10–25

Table 5. Total Alkaloid Content (%).

Extract Type	Alkaloid Content (%)
Methanol	0.8–1.4
Ethanol	1.0–1.7
Aqueous	0.2–0.8

CONCLUSION

This study provides comprehensive qualitative and quantitative data on the phytochemical composition of medicinal plants. Methanolic extracts exhibited the highest concentration of phenolics, flavonoids, tannins, and terpenoids. The results confirm the therapeutic potential of these plants and validate their traditional medicinal applications. The findings also highlight the importance of solvent selection in maximizing extraction efficiency. Overall, this work provides a useful foundation for further pharmacological, antioxidant, and drug-development research. Future research should incorporate advanced analytical techniques such as HPLC, LC–MS/MS, and FTIR to identify and quantify individual phytochemicals with greater precision. Antioxidant assays (DPPH, FRAP, ABTS) and antimicrobial or cytotoxicity assays should be performed to correlate phytochemical concentrations with biological activities. Additionally, isolation and characterization of individual compounds through chromatography can facilitate development of standardized herbal formulations. Integration of computational toxicity prediction and molecular docking can further explore the therapeutic potential of active constituents. Overall, systematic in vitro and in vivo validation will strengthen the scientific basis for utilizing these medicinal plants in pharmaceutical applications.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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