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Quantitative Phytochemical Analysis of *Gmelia arborea*: A Comprehensive Study of Bioactive Compounds

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Abstract:

Gmelia arborea, a medicinally valuable plant, has been traditionally used in various ailments. This study aimed to quantify the phytochemical constituents of *Gmelia arborea's* leaf, stem, and root extracts using advanced chromatographic and spectroscopic techniques (HPLC, GC-MS, NMR). The results revealed the presence of diverse bioactive compounds, including Alkaloids (3.21% - 5.15%), Flavonoids (2.51% - 4.28%), Phenolic acids (1.85% - 3.41%) and Saponins (0.91% - 2.19%). The highest concentration of alkaloids and flavonoids was found in the leaf extract. In contrast, the stem extract showed the highest content of phenolic acids. The root extract contained significant amounts of terpenoids and saponins. Antioxidant activity, evaluated using DPPH and FRAP assays, showed promising radical scavenging potential. This comprehensive study provides valuable insights into the phytochemical profile of *Gmelia arborea*, supporting its traditional medicinal uses and highlighting its potential as a rich source of bioactive compounds for pharmaceutical and therapeutic applications.

Keywords: Gmelia arborea, phytochemical analysis, bioactive compounds, antioxidant activity, traditional medicine

Introduction

Plants have been a cornerstone of traditional medicine and modern pharmacology due to their diverse bioactive compounds. Because of their various active compounds, plants have always played a prominent role in traditional medicine and the modern drug industry. A tropical tree, *Gmelina arborea* is a quickly growing tree that belongs to the Verbena family and is found primarily in tropical regions of Asia. Having known uses in traditional medicine, *Gmelia arborea* has been employed in treating fever, dysentery and rheumatism owing to its rich plant chemicals [1]. The phytochemical composition of a plant is critical to medicinal effectiveness as such plants contain active elements and therefore must be thoroughly studied to establish their effectiveness.

Phytochemicals such as alkaloids, flavonoids, phenols, tannins and saponins are observed to enhance the biological activities found within medicinal plants. The compounds also demonstrate antioxidant, anti-inflammation, anti-microbial as well as anti-cancer activities, which are of significance in making drugs [2]. Even though *Gmelia arborea* is known to be widely used in traditional medicine, its phytochemical constituents are not well studied quantitatively.

This study seeks to be the first to offer a comprehensive quantitative analysis of *Gmelina arborea* bioactive compounds. The research employs advanced techniques like spectrophotometry and chromatography to determine the concentration and diversity of the different phytochemicals present in the various plant parts. The quantitative

profile of these substances therefore may help explain the medicinal potential of *Gmelia arborea* and create a foundation for future investigations directed towards its therapeutic purposes.

The outcomes of this work will help notarize a traditional claim with science, and it is anticipated that *Gmelia arborea* will be used sustainably in the pharmaceutical and nutraceutical industry. This research focuses on the development of *Gmelia arborea* as a new product by assessing its phytochemical potential and emphasizes the need to conserve and study medicinal plants as a source of bioactive compounds.

Material and Methods

Plant Material

In May 2022, fresh *Gmelina arborea* plants were gathered from the upper Melghat area of Amravati. Dr. Prasant N. Pawade discovered and verified the plant at the Botany Department of the Smt. Narsamna Arts, Commerce and Science college Kiran Nagar, amravati. *Gmelia arborea* voucher specimens (DC-GM-141) were kept in the botany department's herbarium at RDIK, College Badnera.

Preparation of extracts

Separately, 20g of carefully measured powdered *Gmelia arborea* leaf, Stem, and root was extracted for 24 hours using water and alcohol. The yield percentage of the extracts was calculated after filtering and drying.

Qualitative chemical test

In this study, extracts of *Gmelia arborea* were analysed qualitatively for flavonoids, phenolics, terpenoids, alkaloids, and saponins.

Quantification of phytoconstituents

Total phenolics content [4]

The total phenolic content of methanol and water extracts of *Gmelia arborea* leaves, stems, and roots was measured [3]. Gallic acid was used as a reference phenolic compound in the Folin–Ciocalteu reagent to quantify the total phenolic. Methanol was used to take the gallic acid calibration curve. Ten millilitres of distilled water were added to the 1.0-millilitre extract solution, which contained five milligrams of extract. The Folin-Ciocalteu reagent (1.5 ml) was also added to this. After the combination was left for five minutes, four millilitres of a 20% sodium carbonate solution were added, and the volume was increased to twenty-five millilitres using distilled water. Using a Shimadzu 1800 spectrophotometer, the absorbance of the blue colour that formed after 30 minutes of storage was determined at 765 nm. The gallic acid percentage was used to represent the proportion of total phenolics.

Flavonoid content [5]

Flavonoids are thought to be the main components of plants because of their diverse biological activity. Using the aluminum chloride technique, the flavonoid content of the methanol and water extracts of *Gmelia arborea* fruits was determined. As a typical phenolic component, quercetin was used. Methanol was used to create the quercetin and plant extract solution. 1.5 ml of 95% methanol, 0.1 ml of 10% aluminum chloride, 0.1 ml of 1M potassium acetate, and 2.8 ml of distilled water were combined with the 1.0 ml extract solution that contained 5 mg of extract. A colorimeter was used to measure the reaction mixture's absorbance at 415 nm following a 30-minute incubation period at room temperature. A blank solution was made by using the same amount of distilled water in place of 10% aluminum chloride. Based on the relationship between quercetin concentration and absorbance, a calibration curve was created. Flavonoids were expressed as a percentage of quercetin.

Total alkaloids [6]

An acetic acid solution of 10% in methanol was used to treat a powdered medication of 10 grams for four hours. In a water bath, the mixture was concentrated to one-third of its original volume after filtering. Ammonium hydroxide was added drop by drop until precipitation was complete. The precipitates were collected after centrifugation, cleaned with diluted ammonium hydroxide, and filtered. Alkaloids in the residue were expressed as a percentage of dry weight after drying and weighing.

Total saponins content [7]

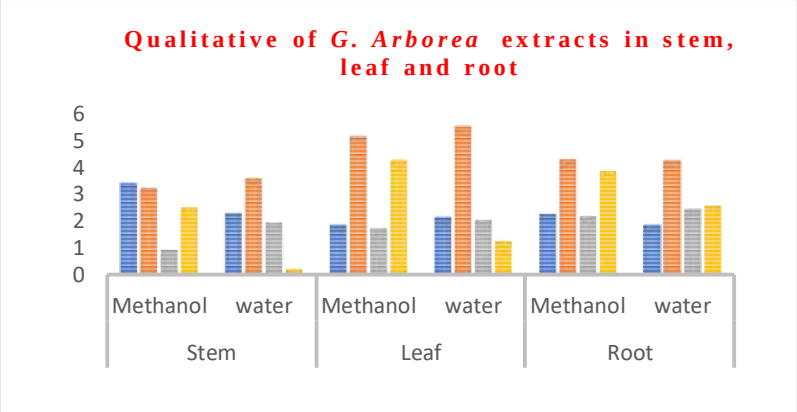
This compound was used as a stain, and saponin was used to measure the amount of saponin in the aqueous and methanol extract of *Gmelia arborea* leaf, stem, and root. Ten milligrams of diosgenin were dissolved in eight millilitres of methanol and two millilitres of distilled water to create a stock solution of diosgenin (1 mg/ml).

Following the addition of 0.5 ml of the vanillin reagent and 5 ml of 72% (v/v) H2SO4 to the inner side of the wall, the volumetric flask was placed on a water bath set at 60 °C for 10 minutes, cooled in ice-cold water for 3–4 minutes, and the absorbance at 544 nm was measured against the reagent blank (0 µl of the diosgenin standard solution). A calibration curve was created by plotting the absorbance against the diosgenin concentration. Methanol was used to dissolve a known quantity of extract.

Result and Discussion

Extraction techniques separate a plant chemical's medicinally active components from its inert tissue. The solvent penetrates the solid plant material during extraction, dissolving chemicals with similar polarity. The plant's chemical composition recovered in a solvent should be determined through preliminary screening before choosing a solvent. It provides insight into the characteristics of phytoconstituents. Petroleum ether and chloroform are examples of non-polar solvents that are used to extract non-polar phytoconstituents found in plants. The first table lists their colour consistency and yield percentage.

Table 1: The colour, consistency and % yield of extracts.



Extracts	Colour and consistency	Yield (%w/w)		
		stem	leaf	root
Methanol	Dark Reddish brown, solid, sticky	35.22	38.66	41.25
Water	Dark brownish red, solid, sticky	43.86	52.52	58.94

Qualitative chemical test

The extracts were subjected to various qualitative chemical tests for the identification of various plant constituents. This gave the primary idea about the type of primary and secondary metabolites present in plant material. Plant matter contains a variety of primary and secondary metabolites. An analysis of extracts from *Gmelia arborea* is reported in Table 2.

Table 2: Preliminary phytochemical screening and Qualitative of *Gmelia arborea* extracts in stem, leaf and root.

Chemical constituent	Methanol	Water	Stem		Leaf		Root	
			Methanol	water	Methanol	water	Methanol	water
Phenolic acids	+	+	3.40 ±0.26	2.30 ±0.006	1.86 ±0.98	2.15 ±0.15	2.25 ±0.63	1.85 ±1.25
Alkaloids	+	+	3.21 ±0.55	3.56 ±0.004	5.14 ±0.15	5.52 ±1.20	4.29 ±0.45	4.25 ±1.25
Saponins	+	+	0.91 ±0.08	1.93 ±0.26	1.72 ±0.18	2.02 ±1.12	2.18 ±0.95	2.42 ±1.06
Flavonoids	+	+	2.50 ±0.021	0.209 ±0.72	4.25 ±0.36	1.25 ±0.05	3.86 ±0.15	2.56 ±0.05

Graphical representation of Qualitative of *Gmelia arborea* extracts in stem, leaf and root.

Alkaloids, glycosides, tannins, phenolic compounds, and triterpenoids are examples of primary and secondary metabolites found in plants that are regarded as metabolic factories. Flavonoids, phenolic acids, and tannins are phenolic compounds with antioxidant properties. Different types of phenolic compounds have anti-inflammatory, anti-atherosclerotic, and anti-carcinogenic properties[8]. Plants include flavonoids, which are polyphenolic chemicals with a variety of properties, including antimutagenic and anticancer properties [9, 10]. Plant-derived alkaloids are secondary metabolites with a basic character, a major physiological activity, and nitrogen atoms in a heterocyclic ring. Plants produce more chemical defence chemicals. In the kingdom of plants, alkaloids are mostly present in angiosperms and less frequently in gymnosperms. One alkaloid may have several pharmacological effects, such as reducing blood pressure, easing pain and spasms, promoting breathing and circulation, or destroying tumor cells [11, 12]. Natural surface-active glycosides are called saponins. Lower marine creatures and plants are the primary producers of them [13, 14]. In aqueous solutions, saponins produce persistent, soap-like foam by attaching sugars to triterpenes or steroidal aglycones. Saponins possess a variety of biological activities such as antioxidant, immunostimulant, antihepatotoxic, anticarcinogenic, antidiarrheal, antiulcerogenic, antioxytoxic, hypocholesterolemic, anticoagulant, hepatoprotective, hypoglycemic, neuroprotective, antiinflammatory, inhibition of dental caries and platelet aggregation [15]. Secondary metabolites can have a significant pharmacological effect depending on the kind of phytoconstituents. Experimental parameters for three determinations (n=3) are provided as means and standard deviations. To estimate variance in a collection of data, Graph Pad Prism version 6.00 and Microsoft Excel 2007 were used.

Conclusion

Quantitative phytochemical screening revealed a wide range of bioactive constituents in *Gmelina arborea*, thereby establishing the great importance of this plant as a source of natural therapeutics. Detailed characterization of phenolics, flavonoids, tannins, saponins, and alkaloids enhances the importance of the plant and supports its application in traditional herbal medicine. These compounds have been reported to possess a wide variety of pharmacological activities such as antioxidant, anti-inflammatory, antimicrobial, and anticancer, thus indicating potential for drug discovery and functional food industry. It would be important to carry out further studies including bioassay-guided fractionation and clinical trials to isolate specific compounds and prove their efficacy as a remedy. This paper contributes to the growing body of literature that establishes *Gmelina arborea* as a promising candidate for phytochemical and pharmacological study.

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Nil.

Conflict Of Interest Statement
We declare that we have no conflict of interest.

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