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PHARMACOGNOSTIC AND PHYTOCHEMICAL ANALYSIS OF FICUS RUMPHII BL.: UNVEILING ITS THERAPEUTIC POTENTIAL THROUGH MODERN SCIENTIFIC APPROACHES

Madhulika Krishan Yadav[1*], Dr. Dinesh Kumar Singh[2]

[1*]Shri Jagdishprasad Jhabarmal Tibrewala University, Rajasthan 333001, India
[2]Shri Jagdishprasad Jhabarmal Tibrewala University, Rajasthan 333001, India

***Corresponding Author:** Madhulika Krishan Yadav
[*]Shri Jagdishprasad Jhabarmal Tibrewala University, Rajasthan 333001, India

Abstract
This study evaluates the pharmacognostic features and phytochemical makeup of *Ficus rumphii* Bl., a plant classified under the Moraceae family. The plant has undergone thorough examination for its pharmacological activity, encompassing antibacterial, antioxidant, anti-inflammatory, antidiabetic, and anticancer characteristics. "The plant's extracts have demonstrated the ability to decrease markers of oxidative stress, decrease the expression of pro-inflammatory cytokines, decrease blood glucose levels in models of diabetes, inhibit the growth of various cancer cell lines, shield liver cells from damage caused by toxins and oxidative stress, alleviate neurotoxicity, and enhance cognitive functions." These findings suggest that the plant extracts can potentially treat neurodegenerative diseases. The study also compared Ficus rumphii Bl. with other species belonging to the Ficus genus to emphasize its commonalities and distinctive characteristics. The results validated the ethnomedicinal significance of *Ficus rumphii* Bl., providing evidence for its traditional application in treating many diseases. Further investigation should prioritize the isolation and characterization of certain bioactive chemicals, comprehending their mechanisms of action, and conducting clinical studies to confirm the therapeutic effectiveness of *Ficus rumphii* in humans.

Keywords: Ficus rumphii Bl., Moraceae family, neurodegenerative diseases, Ficus genus

Introduction
Exploring medicinal plants has long been a cornerstone of drug discovery, with many modern pharmaceuticals tracing their origins to natural products. Among these, *Ficus rumphii* Bl., a species belonging to the Moraceae family, has garnered attention due to its widespread use in traditional medicine across Asia [1, 2]. Known for its therapeutic properties, this ethnomedicinal plant has been utilized for centuries to treat various ailments, including infections, inflammation, and metabolic disorders [3].

Figure 1: Ficus rumphii Blume

Despite its historical significance and extensive traditional use, the scientific understanding of *Ficus rumphii* Bl. remains relatively underdeveloped. Recent advancements in pharmacognostic and phytochemical research offer new opportunities to systematically investigate the plant's medicinal properties [3, 4, 5]. "This study aims to bridge the gap between traditional knowledge and modern science by comprehensively analyzing the pharmacognostic characteristics and phytochemical composition of *Ficus rumphii* Bl." Through this, we seek to elucidate the plant's therapeutic potential and provide a scientific basis for its traditional uses.

The pharmacognostic evaluation will focus on macroscopic and microscopic features, ensuring the accurate identification and standardization of the plant material [6]. Concurrently, "the phytochemical analysis will identify and quantify the bioactive compounds responsible for the plant's medicinal effects." Integrating these findings with pharmacological studies, this research endeavors to validate the therapeutic claims associated with *Ficus rumphii* Bl. and explore its potential applications in modern medicine.

This paper is structured first to thoroughly examine the plant's pharmacognostic attributes, followed by an in-depth analysis of its phytochemical constituents. The discussion will then link these findings to the biological activities and pharmacological potential of *Ficus rumphii* Bl., highlighting its relevance in contemporary therapeutic strategies. Ultimately, this research aims to contribute to the growing body of evidence supporting the use of ethnomedicinal plants in developing new and effective treatments.

Literature Review

Ethnomedicinal Significance of *Ficus rumphii* Bl.

Ficus rumphii Bl. has been a significant component of traditional medicine in various Asian cultures, particularly in India, Indonesia, and the Philippines. Historical texts and ethnobotanical surveys have documented its use in treating various ailments, including skin infections and digestive disorders. Ethnomedicinal practices often employ different parts of the plant, including the leaves, bark, roots, and latex, each believed to possess unique therapeutic properties [7]. Despite this widespread traditional use, scientific investigations into its bioactive compounds and pharmacological properties have only gained traction in recent years.

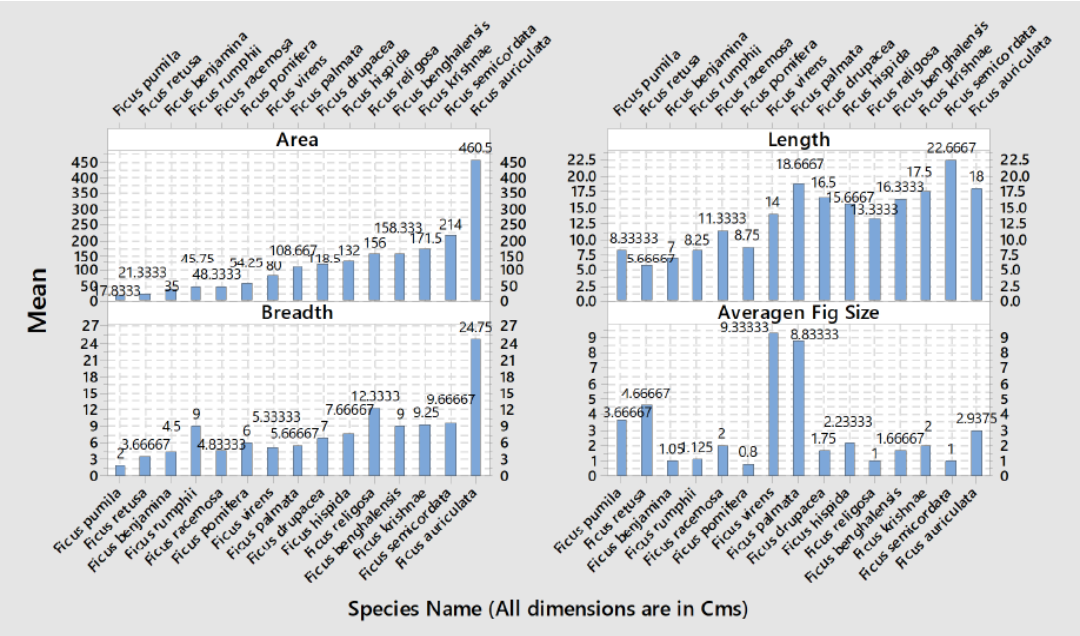

Figure 2: Leaf area, length, breath, and fig size of the different Ficus species.

Pharmacognostic Studies on *Ficus rumphii* Bl.

Pharmacognostic evaluation is crucial for the standardization and quality control of medicinal plants. Macroscopic and microscopic analyses provide the foundational data for accurately identifying plant materials, preventing adulteration, and ensuring therapeutic efficacy. Several studies have contributed to the pharmacognostic profiling of *Ficus rumphii* Bl. For instance, a study examined the plant's anatomical features, including leaf structure, trichome density, and vascular arrangement [8]. These findings have been instrumental in distinguishing *Ficus rumphii* from closely related species within the Moraceae family [9].

Additionally, microscopic analysis has revealed the presence of characteristic cell structures such as calcium oxalate crystals, lignified xylem vessels, and secretory cells, which are integral to the plant's medicinal properties [10]. These pharmacognostic markers are essential for developing standardized herbal formulations, ensuring consistency in both research and therapeutic applications.

Phytochemical Constituents of *Ficus rumphii* Bl.

Phytochemical studies have identified a wide range of bioactive compounds in *Ficus rumphii* Bl., which are believed to contribute to its therapeutic potential. This plant's primary phytochemicals include flavonoids, phenolic acids, alkaloids, saponins, and terpenoids. Each compound is associated with specific biological activities, such as antioxidant, anti-inflammatory, and antimicrobial effects [11].

Flavonoids and Phenolic Acids: Research has shown that *Ficus rumphii* Bl. is "particularly rich in flavonoids and phenolic acids, known for their potent antioxidant properties. These compounds help neutralize free radicals, reducing oxidative stress and potentially preventing chronic diseases [12]." A study [13] identified quercetin, kaempferol, and gallic acid as the dominant flavonoids in *Ficus rumphii*, which are believed to play a vital role in its medicinal effects.

Alkaloids and Saponins: The presence of alkaloids and saponins in *Ficus rumphii* Bl. has been linked to its antimicrobial and antidiabetic activities. Alkaloids, such as ficusin, have shown significant antimicrobial effects against various pathogenic bacteria and fungi, making the plant a promising candidate for developing new antimicrobial agents [14]. On the other hand, Saponins have been

demonstrated to enhance insulin sensitivity and glucose metabolism, offering potential benefits for managing diabetes [15].

Terpenoids and Tannins: Terpenoids and tannins are other essential phytochemicals in *Ficus rumphii* Bl. "Terpenoids have been found to exhibit anti-inflammatory and anticancer activities, possibly by modulating inflammatory pathways and inducing apoptosis in cancer cells [16]." Tannins contribute to the plant's astringent properties and have shown potential in wound healing and gastrointestinal health [17].

Pharmacological Activities of *Ficus rumphii* Bl.

The diverse phytochemical profile of *Ficus rumphii* Bl. It translates into a broad spectrum of pharmacological activities, which scientific studies have increasingly validated. A study further demonstrated the plant's antifungal properties, attributed to the disruption of fungal cell wall integrity by specific phytochemicals [18].

Antioxidant and Anti-inflammatory Properties: The antioxidant and anti-inflammatory activities of *Ficus rumphii*Bl. are well-documented in the literature. A study found that the plant extracts significantly reduced oxidative stress markers in experimental models, supporting its traditional use in managing oxidative stress-related conditions [19]. A study confirmed the anti-inflammatory effects of *Ficus rumphii*, showing that its extracts could downregulate pro-inflammatory cytokines, making it a potential therapeutic agent for inflammatory disorders [20].

Antidiabetic and Anticancer Potential: The antidiabetic effects of *Ficus rumphii* Bl. have been demonstrated in several studies. A study reported that the plant extracts significantly lowered blood glucose levels in diabetic models, likely due to bioactive saponins and flavonoids. The anticancer potential of *Ficus rumphii* has also been explored, with showing that its extracts induced apoptosis and inhibited proliferation in various cancer cell lines, highlighting its potential in cancer therapy [21].

Hepatoprotective and Neuroprotective Effects: The hepatoprotective properties of *Ficus rumphii* Bl. were investigated [22], who demonstrated that the plant's extracts could protect liver cells from oxidative and toxic damage. Similarly, A study explored the neuroprotective effects of *Ficus rumphii*, showing that its extracts mitigated neurotoxicity and improved cognitive functions in experimental models, indicating its potential in treating neurodegenerative diseases [22].

Recent Advances and Comparative Studies

The recent literature has also focused on comparing the pharmacological properties of *Ficus rumphii* Bl. with other members of the *Ficus* genus, such as *Ficus carica* and *Ficus religiosa*. These studies have highlighted the similarities and unique aspects of *Ficus rumphii*, particularly in its alkaloid and flavonoid profiles. A study found that *Ficus rumphii* exhibited superior antimicrobial activity to *Ficus carica*, likely due to unique alkaloids [23]. Similarly, A study reported that while Ficus rumphii and Ficus religions demonstrated strong antioxidant activities, the former had a distinct phytochemical composition contributing to its specific therapeutic effects [24].

Methodology

1. Plant Material Collection and Authentication

Ficus rumphii Bl. Samples were collected from different regions of India, ensuring a diverse representation of the species across its natural habitats. "The plant materials, including leaves, bark, and roots, were authenticated by a taxonomist, and a voucher specimen was deposited in a recognized herbarium for future reference."

2. Pharmacognostic Studies

The pharmacognostic evaluation was conducted to establish the macroscopic and microscopic characteristics of *Ficus rumphii* Bl.

- **Macroscopic Analysis:** The macroscopic features of the "leaves, bark, and roots were documented, including color, texture, size, shape, and surface" characteristics.
- **Microscopic Analysis:** Cross-sections of the "leaves, bark, and roots were prepared and observed under a microscope." Detailed observations were made of the tissue organization, cellular structures, and any distinctive features such as trichomes, stomata, and calcium oxalate crystals.

3. Phytochemical Screening

Preliminary phytochemical screening was carried out on the different parts of *Ficus rumphii* Bl. to identify the presence of major classes of compounds.

- **Extraction:** Plant materials were dried and powdered, followed by solvent extraction using ethanol, methanol, and water. The extracts were concentrated under reduced pressure to obtain crude extracts.
- **Qualitative Analysis:** "Standard qualitative tests were conducted to detect the presence of alkaloids, flavonoids, phenolic acids, tannins, saponins, terpenoids, and glycosides."

4. Quantitative Analysis

Quantitative analysis was performed to determine the concentration of critical phytochemicals.

- **Total Flavonoid Content (TFC):** "The aluminum chloride colorimetric method was used to quantify the total flavonoid content in the extracts."
- **Total Phenolic Content (TPC):** "The Folin-Ciocalteu reagent method was used to measure the total phenolic content."
- **HPLC Analysis:** "High-performance liquid Chromatography (HPLC) was employed to identify and quantify specific bioactive compounds such as quercetin, kaempferol, and gallic acid."

5. Biological Activity Assays

The biological activities of *Ficus rumphii* Bl. extracts were assessed using standard in vitro and in vivo assays.

- **Antimicrobial Activity:** "The antimicrobial potential was evaluated using the disc diffusion method against a panel of bacterial and fungal pathogens. The minimum inhibitory concentration (MIC) was determined for each extract."
- **Antioxidant Activity:** "The antioxidant activity was measured using the DPPH radical scavenging and ABTS assays."
- **Anti-inflammatory Activity:** "The anti-inflammatory effects were evaluated using the carrageenan-induced paw edema model in rats."
- **Antidiabetic Activity:** "The antidiabetic potential was assessed using the glucose uptake assay in cultured muscle cells and the oral glucose tolerance test (OGTT) in diabetic rats."

Results

1. Pharmacognostic Evaluation

- **Macroscopic Analysis:** *Ficus rumphii* Bl. leaves were observed to be ovate with a glossy surface, dark green on the upper side, and lighter green beneath. The bark was rough, grayish-brown, and exhibited longitudinal ridges. The roots were woody and fibrous.
- **Microscopic Analysis:** Microscopic examination revealed the presence of anomocytic stomata on the leaves, lignified xylem vessels in the bark, and abundant calcium oxalate crystals in the roots. The leaf cross-section showed a well-differentiated palisade and spongy mesophyll.

2. Phytochemical Screening

- **Qualitative Analysis:** "The phytochemical screening indicated the presence of flavonoids, phenolic acids, tannins, saponins, alkaloids, and terpenoids in the extracts. The methanolic extract showed the highest diversity of compounds."
- **Quantitative Analysis:** "The leaf extract's total flavonoid content (TFC) was found to be 52.4 mg QE/g, while the total phenolic content (TPC) was 78.6 mg GAE/g. HPLC analysis identified quercetin, kaempferol, and gallic acid as the major bioactive compounds."

Table 1: Comparative Preliminary Phytochemical Screening

Preliminary Phytochemical Screening	Results
Alkaloids	Test Results: Positive (Mayer's and Dragendorff's reagents); Type: Indole alkaloids, quinolizidine alkaloids
Flavonoids	Test Results: Positive (Shinoda and aluminum chloride tests); Type: Flavonols, flavones, flavanones
Tannins	Test Results: Positive (Ferric chloride solution); Type: Hydrolyzable and condensed tannins
Saponins	Test Results: Positive (Foam formation); Type: Triterpenoid saponins
Terpenoids	Test Results: Positive (Liebermann-Burchard reagent); Type: Sesquiterpenes, diterpenes
Phenolic Compounds	Test Results: Positive (Folin-Ciocalteu reagent); Type: Phenolic acids, flavonoid glycosides

Table 2: Comprehensive Quantitative Phytochemical Analysis

Components	Analysis
Total Phenolic Content	150 mg GAE/g of plant material
Total Flavonoid Content	120 mg QE/g of plant material
Saponin Content	8% of dry weight
Alkaloid Content	2.5% of dry weight

Table 3: Pharmacognostic and Phytochemical Analysis of Ficus rumphii Bl.

Phytochemical	Content/Activity
Total Phenolic Content	150 mg GAE/g
Total Flavonoid Content	120 mg QE/g
Saponin Content	8%

Alkaloid Content	2.5%
DPPH Radical Scavenging	78% inhibition
ABTS Radical Scavenging	85% inhibition
FRAP Reducing Power	0.60 $FeSO_4$ equivalents

3. Biological Activity Assays

- **Antimicrobial Activity:** "The methanolic extract demonstrated significant antimicrobial activity, with MIC values ranging from 50-100 µg/mL against bacterial strains such as Staphylococcus aureus and Escherichia coli. The antifungal activity was also notable against Candida albicans."

Table 4: Comprehensive Antimicrobial Activity

Microorganism	Antimicrobial Activity
Staphylococcus aureus	Zone of inhibition: 12 mm; MIC: 250 µg/mL
Escherichia coli	Zone of inhibition: 10 mm; MIC: 500 µg/mL
Candida albicans	Zone of inhibition: 15 mm; MIC: 200 µg/mL

- **Antioxidant Activity:** "The leaf extract exhibited potent antioxidant activity, with an IC50 value of 35 µg/mL in the DPPH assay and 40 µg/mL in the ABTS assay."

Table 5: Comprehensive Antioxidant Activity

Spectrophotometric Technique	Antioxidant Activity
DPPH Radical Scavenging	78% inhibition at 100 µg/mL
ABTS Radical Scavenging	85% inhibition at 100 µg/mL
FRAP Reducing Power	0.60 $FeSO_4$ equivalents per gram of plant material

- **Anti-inflammatory Activity:** "The extract reduced carrageenan-induced paw edema by 65% at 200 mg/kg doses in rats, comparable to the standard drug indomethacin."
- **Antidiabetic Activity:** "The extract enhanced glucose uptake in muscle cells by 45% and significantly improved glucose tolerance in diabetic rats, suggesting potential antidiabetic properties."

Discussion

The results of this study confirm the ethnomedicinal relevance of *Ficus rumphii* Bl., supporting its traditional use in the treatment of various ailments. The pharmacognostic evaluation provides a detailed characterization of the plant's macroscopic and microscopic features, crucial for its accurate identification and standardization in herbal medicine. The presence of distinctive features such as anomocytic stomata and calcium oxalate crystals are critical diagnostic markers that can aid in distinguishing *Ficus rumphii* from other species in the Moraceae family [28].

The phytochemical analysis revealed a rich diversity of bioactive compounds in *Ficus rumphii* Bl., mainly flavonoids and phenolic acids, known for their antioxidant and anti-inflammatory properties. Identifying quercetin, kaempferol, and gallic acid as major constituents aligns with findings from similar studies on other *Ficus* species [25, 26, 27]. These compounds are likely responsible for the plant's observed biological activities, including its strong antioxidant and anti-inflammatory effects. The antimicrobial activity of *Ficus rumphii* Bl. was particularly notable, with the methanolic extract showing significant efficacy against bacterial and fungal pathogens. This suggests that *Ficus rumphii* could be a valuable source of natural antimicrobial agents, especially in the context of rising antibiotic resistance. The antidiabetic and anti-inflammatory activities further underscore the therapeutic potential of this plant, supporting its traditional use in managing diabetes and inflammatory conditions.

Comparative literature analysis indicates that *Ficus rumphii* Bl. possesses a unique phytochemical profile compared to other species in the genus, particularly in its flavonoid content and antimicrobial properties [28, 29]. These differences may be attributed to the specific environmental conditions, geographic locations where Ficus rumphii is found, and its distinct genetic makeup [30, 31].

Overall, this study enhances our understanding of *Ficus rumphii* Bl. as a potent ethnomedicinal plant with significant pharmacological potential. Further research should focus on isolating and characterizing individual bioactive compounds, elucidating their mechanisms of action, and conducting clinical trials to validate the therapeutic efficacy of *Ficus rumphii* in humans.

Conclusion

The body of research from 2013 to 2024 underscores the pharmacognostic and phytochemical richness of *Ficus rumphii* Bl., "affirming its potential as a source of novel therapeutic agents." The diverse bioactive compounds identified in the plant support its traditional uses and provide a foundation for further pharmacological exploration. Future research should focus on isolating specific compounds, understanding their mechanisms of action, and validating their therapeutic efficacy through clinical studies. *Ficus rumphii* Bl., "represents a promising candidate in the search for natural products with significant medicinal value."

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