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Medicinal application of bark and leaf of Rosewood (Dalbergia sissoo): A brief study

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Abstract: Dalbergia sissoo Roxb. (Indian Rosewood), a prominent member of the Fabaceae family, has long been recognized in traditional medicinal systems for its diverse therapeutic potential. The present study critically examines the medicinal applications of the bark and leaf of *D. sissoo* through an integrative evaluation of its phytochemical composition and experimentally validated pharmacological activities. Particular emphasis is placed on bioactive constituents such as flavonoids, phenolic compounds, and neoflavonoids, which are considered fundamental to its biological efficacy.

Experimental evidence indicates that ethanolic bark extracts exhibit significant dose-dependent antinociceptive activity, along with marked antioxidant potential demonstrated through in vitro assays, including DPPH radical scavenging and metal ion chelation. In parallel, leaf extracts have been associated with pronounced anti-inflammatory and anti-arthritic effects, suggesting their relevance in the management of chronic inflammatory conditions. Mechanistically, these effects are closely linked to oxidative stress modulation and nitric oxide inhibition pathways.

By synthesizing traditional knowledge with contemporary experimental findings, the study establishes a coherent pharmacological framework for *D. sissoo*, thereby underscoring its significance as a potential source of safe and plant-based therapeutic agents in modern medicine [1]–[5].

Keywords: Dalbergia sissoo, Bark extract, Leaf extract, Antioxidant activity, Antinociceptive effect, Phytochemicals, Oxidative stress.

Introduction - The systematic exploration of plant-derived therapeutics has gained considerable prominence in modern biomedical research, primarily due to the limitations and adverse effects associated with synthetic pharmacological agents. Within this evolving paradigm, medicinal plants serve as a crucial interface between traditional healing practices and contemporary drug discovery. Among such plants, *Dalbergia sissoo*Roxb., commonly known as Indian Rosewood, occupies a distinctive position owing to its extensive ethnomedicinal relevance and increasing scientific validation [1].

Botanically classified under the family Fabaceae, *D. sissoo* is a deciduous perennial tree predominantly distributed across the sub-Himalayan region and adjoining areas of the Indian subcontinent. Its ecological adaptability and wide availability have facilitated its integration into indigenous healthcare systems, where various plant parts—particularly bark and leaves—are traditionally utilized for therapeutic purposes. These components have been employed in the management of gastrointestinal disorders, dermatological conditions, inflammatory states, and infectious diseases, reflecting a broad pharmacological spectrum [2], [3].

The transition from traditional usage to scientific validation necessitates a detailed understanding of the plant's phytochemical architecture. Studies have revealed that *D. sissoo* contains a diverse array of bioactive compounds, including flavonoids, phenolic acids, isoflavones, and neoflavonoids such as dalbergin and dalbergenone. These constituents are known to exert significant biological effects, particularly through the modulation of oxidative stress and inflammatory pathways [4]. This becomes especially relevant in the context of oxidative stress-mediated pathologies, where reactive oxygen species (ROS) play a central role in cellular damage and disease progression.

From a pharmacological perspective, experimental investigations provide substantial evidence supporting the medicinal efficacy of *D. sissoo*. Bark extracts, in particular, have demonstrated pronounced antinociceptive activity in animal models, exhibiting dose-dependent responses without acute toxicity at higher concentrations. These findings suggest the involvement of flavonoid-mediated pathways in pain modulation and inflammation control [5]. Concurrently, in vitro antioxidant assays confirm the plant's ability to neutralize free radicals and reduce oxidative

burden, thereby reinforcing its therapeutic relevance. Parallel investigations on leaves further substantiate their medicinal significance, particularly in relation to anti-inflammatory and anti-arthritic effects. These properties are of considerable importance in chronic disease conditions, where persistent inflammation acts as a major pathological driver. Collectively, these observations indicate that both bark and leaf components contribute synergistically to the overall pharmacological profile of the plant.

In this context, the present study is designed to provide a focused yet comprehensive evaluation of the medicinal applications of *Dalbergia sissoo*, with specific emphasis on its bark and leaf. By integrating traditional knowledge with phytochemical insights and experimental pharmacology, the study aims to establish a coherent understanding of its therapeutic potential within the broader framework of plant-based medicinal research.

1. Phytochemical Architecture of *Dalbergia sissoo:* The pharmacological significance of *Dalbergia sissoo*Roxb. is fundamentally rooted in its complex and diverse phytochemical architecture, which governs its broad-spectrum medicinal efficacy. In phytopharmacological research, the therapeutic potential of medicinal plants is primarily attributed to secondary metabolites—bioactive compounds that, although not essential for primary metabolism, play a critical role in biochemical defense and interaction mechanisms. In *D. sissoo*, these metabolites constitute the biochemical foundation underlying its extensive medicinal applications [6].

Comprehensive phytochemical profiling reveals the presence of a wide spectrum of bioactive constituents, including flavonoids, phenolic compounds, neoflavonoids, alkaloids, tannins, saponins, phytosterols, and polysaccharides. Among these, flavonoids and phenolics are of particular pharmacological importance due to their well-established antioxidant and anti-inflammatory properties. Compounds such as dalbergin, dalbergenone, methyl dalbergin, and dalbergichromene—primarily isolated from the stem bark—represent the characteristic neoflavonoid framework of the species and contribute significantly to redox regulation and cellular protection [7], [8].

A notable feature of *D. sissoo* is the organ-specific variation in its phytochemical composition, especially between bark and leaves. The bark is predominantly enriched with neoflavonoids, chromene derivatives, and tannins, along with substantial phenolic content. These constituents are closely associated with protective functions and are reflected pharmacologically in its pronounced antinociceptive, anti-inflammatory, and antioxidant activities. Chromatographic studies have identified compounds such as dalberginine, 4-phenylchromene, and isodalbergin, thereby establishing the biochemical distinctiveness of bark extracts [6], [9].

In contrast, the leaves exhibit a comparatively diverse phytochemical profile characterized by flavonoids (biochanin-A, genistein), sterols (â-sitosterol, stigmasterol), triterpenoids (â-amyrin), and water-soluble polysaccharides such as rhamnose, galactose, and glucuronic acid. These constituents are functionally associated with anti-inflammatory, anti-arthritic, and immunomodulatory activities. The higher proportion of polysaccharides and glycosidic compounds further indicates their role in metabolic regulation and cellular signaling processes [8], [10].

To illustrate the biochemical composition of leaves, Table 1 presents a representative overview of their primary nutritional and mineral constituents.

Table 1: Biochemical Composition of *Dalbergia sissoo* Leaves (Dry Weight Basis)

Component	Percentage / Concentration
Crude Protein	18.4 – 24.1%
Fat	3.5 – 4.9%
Nitrogen-Free Extract	~48.5%
Crude Fiber	19.3 – 26.1%
Ash Content	8.43 – 12.0%
Calcium	1855.5 mg/100 g
Phosphorus	270 mg/100 g

While these macro- and micro-nutrients contribute to the nutritional value of the plant, the therapeutic specificity is primarily governed by secondary metabolites. These compounds actively participate in multiple biochemical pathways that define the pharmacodynamics of *D. sissoo*. Flavonoids and phenolics function as potent free radical scavengers, mitigating oxidative stress implicated in chronic diseases such as cancer, cardiovascular disorders, and neurodegenerative conditions. Tannins contribute to antimicrobial and astringent properties, whereas alkaloids are often associated with analgesic and anti-inflammatory responses [7], [10].

Importantly, the synergistic interaction among these phytochemicals enhances the overall therapeutic efficacy of the plant. Unlike synthetic drugs, which typically act via a single active compound, *D. sissoo* exemplifies a polypharmacological model in which multiple constituents collectively modulate diverse biological targets. This integrative mechanism not only improves therapeutic outcomes but also reduces the likelihood of adverse effects. In summary, the phytochemical architecture of *Dalbergia sissoo* is characterized by a structurally diverse and functionally integrated network of bioactive compounds, with distinct yet complementary profiles in bark and leaves. This biochemical complexity forms the foundational basis for its extensive medicinal applications and supports its continued exploration in pharmacological and clinical research.

2. Ethnomedicinal and Traditional Perspectives: The ethnomedicinal significance of *Dalbergia sissoo*Roxb. is deeply rooted in the classical traditions of Ayurveda and diverse regional folk medical systems of the Indian subcontinent. Historically, medicinal plants have functioned

not merely as therapeutic agents but as integral components of a holistic healthcare framework, wherein disease is conceptualized as an imbalance of physiological, environmental, and metabolic factors. Within this paradigm, *D. sissoo* has been consistently acknowledged for its multifaceted therapeutic applications, particularly in conditions associated with inflammation, gastrointestinal disturbances, dermatological disorders, and systemic toxicity. Ayurvedic interpretations associate its actions with properties such as *shothahara* (anti-inflammatory) and *krimighna* (antimicrobial), indicating its enduring clinical relevance.

In traditional practices across rural and tribal communities, the bark and leaves are utilized in formulations such as decoctions, poultices, and infusions. The bark is commonly employed as a blood purifier and in the treatment of piles, ulcers, and skin diseases, whereas the leaves are applied in managing joint pain, swelling, and inflammatory conditions. These applications reflect region-specific adaptations based on ecological availability and cumulative empirical knowledge. Importantly, such traditional uses exhibit strong concordance with contemporary pharmacological findings, suggesting a meaningful convergence between indigenous knowledge systems and modern scientific validation [6], [11].

The transition from traditional knowledge to empirical scientific frameworks represents a critical evolution in understanding *D. sissoo*. While traditional systems rely on experiential observations, modern research employs analytical and experimental methodologies to elucidate mechanisms of action and isolate bioactive compounds. This transition has enabled the scientific validation of traditional claims, positioning *D. sissoo* as a model example where ethnomedicinal knowledge informs and guides pharmacological investigation.

3. Pharmacological Profile of Bark: The bark of *Dalbergia sissoo* constitutes a pharmacologically active component, enriched with neoflavonoids, phenolics, and tannins that contribute to its diverse biological activities. Among these, antinociceptive activity has been extensively evaluated using experimental models such as the tail flick method in Wistar rats. Administration of ethanolic bark extracts at graded doses (300–1000 mg/kg) produces a significant, dose-dependent increase in pain threshold, comparable to standard analgesic agents. This effect is largely attributed to the modulation of prostaglandin synthesis pathways mediated by flavonoid constituents, indicating both peripheral and central analgesic mechanisms [2], [7].

In addition to its analgesic potential, the bark demonstrates substantial anti-inflammatory activity, as evidenced by carrageenan-induced paw edema models. The observed reduction in inflammation is associated with inhibition of inflammatory mediators and stabilization of cellular membranes. Phytochemical analyses further reveal the presence of proteins, amino acids, and phenolic compounds that synergistically contribute to these effects. Moreover, antioxidant capacity has been confirmed through multiple in vitro assays, including DPPH radical scavenging, ferric reducing antioxidant power (FRAP), and metal ion chelation. These findings indicate a strong ability of bark extracts to neutralize reactive oxygen species and mitigate oxidative stress-induced cellular damage [12], [13].

Toxicological studies suggest a high safety margin, with no significant acute toxicity observed up to 3000 mg/kg body weight. This reinforces the therapeutic potential of bark extracts, particularly in comparison with synthetic pharmacological agents that often exhibit adverse effects.

4. Pharmacological Profile of Leaf : The leaves of *Dalbergia sissoo* exhibit a distinct yet complementary pharmacological profile, primarily characterized by anti-inflammatory, anti-arthritic, and immunomodulatory activities. Experimental investigations using aqueous and alcoholic extracts have demonstrated significant inhibition of inflammatory responses, thereby validating their traditional use in managing joint disorders and chronic inflammatory conditions. Isoflavones such as biochanin-A and genistein play a central role in modulating inflammatory pathways and enhancing cellular resilience [14], [15].

Beyond inflammatory conditions, leaf extracts have shown promising efficacy in chronic and metabolic disorders. Anti-diabetic studies report reductions in blood glucose levels and improvements in lipid profiles, suggesting a regulatory role in metabolic homeostasis. Additionally, neuroprotective and cardioprotective effects observed in experimental models highlight the broader systemic relevance of leaf-derived phytochemicals.

Comparatively, while bark exhibits more pronounced localized pharmacological actions such as analgesic and acute anti-inflammatory effects, leaves demonstrate a wider spectrum of systemic activity, particularly in chronic disease modulation. This complementary relationship underscores the integrative therapeutic potential of different plant parts.

5. Mechanistic Insights and Biochemical Pathways: The pharmacological efficacy of *Dalbergia sissoo* is mediated through complex biochemical pathways involving oxidative stress regulation, enzyme modulation, and molecular signaling mechanisms. A central aspect of its activity is the scavenging of reactive oxygen species (ROS), which are critically implicated in the pathogenesis of chronic diseases. Flavonoids and phenolic compounds act as potent antioxidants, neutralizing free radicals and protecting cellular components from oxidative damage [15].

Another key mechanism involves the inhibition of nitric oxide synthesis, a major contributor to inflammatory processes. By modulating nitric oxide levels, *D. sissoo* extracts effectively attenuate inflammation and prevent associated tissue damage. Furthermore, the inhibition of cyclooxygenase (COX) and lipoxygenase (LOX) pathways plays a significant role in reducing inflammatory mediators,

thereby contributing to both anti-inflammatory and analgesic effects.

The therapeutic efficacy is further enhanced by the synergistic interaction of multiple phytochemicals. This polypharmacological mode of action enables simultaneous modulation of diverse biological targets, distinguishing *D. sissoo* from conventional single-compound synthetic drugs and contributing to improved safety and efficacy profiles.

6. Therapeutic Potential and Clinical Relevance : The therapeutic scope of *Dalbergia sissoo* extends across a broad spectrum of pathological conditions, including metabolic, inflammatory, infectious, and degenerative disorders. In the context of diabetes management, both bark and leaf extracts exhibit significant hypoglycemic effects, primarily attributed to polyphenols and related bioactive compounds. Similarly, their anti-inflammatory properties support their application in conditions such as arthritis, skin diseases, and chronic inflammatory disorders. Compared to synthetic drugs, plant-based therapeutics derived from *D. sissoo* offer notable advantages, including lower toxicity, multi-target mechanisms, and improved patient tolerability. However, challenges such as variability in phytochemical composition and lack of standardization limit their direct clinical application.

Despite these limitations, the integration of traditional knowledge with modern pharmacological research provides a strong foundation for the development of novel plant-based therapeutics. Continued research focusing on standardization, clinical validation, and formulation strategies is essential to fully realize the medicinal potential of *D. sissoo*.

7. Limitations and Future Research Directions : Despite the substantial pharmacological evidence supporting the medicinal applications of *Dalbergia sissoo*, several limitations constrain its full clinical translation. A significant proportion of existing studies remain confined to in vitro experiments and animal models, with relatively limited human clinical trials available to conclusively establish efficacy and safety. This gap highlights the necessity for well-designed, controlled clinical investigations to validate its therapeutic potential in human populations.

Additionally, the lack of standardized extraction protocols and variability in phytochemical composition across different plant parts present challenges in reproducibility and consistency. Factors such as geographical variation, seasonal influences, and processing methods further contribute to this inconsistency.

Future research should therefore prioritize the development of standardized formulations, rigorous pharmacokinetic evaluations, and advanced drug delivery systems. In particular, emerging approaches in nanomedicine and phytochemical encapsulation offer promising avenues to enhance bioavailability, stability, and targeted therapeutic action. Addressing these limitations is essential for bridging the gap between experimental evidence and clinical application.

8. Standardization and Extraction Strategies of Dalbergia sissoo: The progression of *Dalbergia sissoo* from a traditionally utilized medicinal plant to a clinically viable therapeutic entity necessitates a robust framework of standardization and extraction optimization. While its phytochemical diversity and pharmacological efficacy have been well established, their reproducibility and translational applicability are fundamentally dependent on consistency in extraction procedures and precise quantification of bioactive constituents.

Extraction strategies critically influence the qualitative and quantitative composition of phytochemicals. Solvent systems such as aqueous, methanolic, ethanolic, and non-polar solvents (hexane, ethyl acetate) have been extensively employed to isolate distinct classes of compounds. Among these, ethanolic extracts consistently demonstrate superior pharmacological efficacy, particularly in anti-inflammatory, antinociceptive, and antimicrobial activities, owing to their ability to extract both polar and moderately non-polar compounds. In contrast, aqueous extracts have shown relatively enhanced antioxidant activity in certain assays, reflecting efficient extraction of hydrophilic phenolic constituents [12], [13].

The solvent-dependent variability in phytochemical yield underscores the importance of selecting appropriate extraction methods aligned with specific therapeutic objectives. Methanolic extracts are widely utilized in phytochemical profiling due to their broad extraction capacity, whereas ethyl acetate fractions are enriched with semi-polar flavonoid aglycones, and hexane extracts primarily contain lipophilic constituents such as sterols and terpenoids.

A major challenge in the medicinal application of *D. sissoo* lies in the absence of standardized formulations. Variability arising from environmental conditions, harvesting practices, and processing techniques significantly affects phytochemical composition, thereby influencing therapeutic efficacy and safety. Establishing standardized protocols, including chromatographic fingerprinting, marker compound quantification, and bioactivity validation, is therefore imperative.

Bioavailability further represents a critical consideration. Crude plant extracts often exhibit limited absorption and systemic distribution due to their complex phytochemical matrices. To overcome these limitations, contemporary research increasingly focuses on advanced delivery systems such as nanoparticle-based carriers, liposomal encapsulation, and phytochemical conjugation. These approaches enhance solubility, stability, and targeted delivery, thereby improving therapeutic efficiency.

Integration of traditional extraction knowledge with modern analytical techniques, including high-performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC–MS), and high-performance thin-layer

chromatography (HPTLC), offers a scientifically robust pathway for the development of standardized herbal formulations.

Table 2: Solvent-Based Extraction and Phytochemical Yield in *Dalbergia sissoo*

Solvent Type	Major Compounds Extracted	Primary Pharmacol -ogical Activity
Aqueous	Phenolics, polysaccharides	Antioxidant, free radical scavenging
Methanol	Flavonoids, tannins, phenolics	Antioxidant, anti-inflammatory
Ethanol	Isoflavonoids,flavonoids, glycosides	Analgesic, anti-inflammatory, antimicrobial
Ethyl Acetate	Flavonoid aglycones, semi-polar compounds	Antibacterial, antioxidant
Hexane	Sterols, terpenoids	Mild antimicrobial, lipid-related effects

In summary, standardization and optimized extraction strategies constitute a critical interface between traditional knowledge and modern pharmacological application. Their refinement is essential for ensuring consistency, safety, and efficacy, thereby facilitating the incorporation of *D. sissoo* into evidence-based therapeutic systems.

Conclusion : The present study provides a coherent and evidence-based evaluation of the medicinal applications of the bark and leaf of *Dalbergia sissoo*, integrating traditional knowledge with contemporary pharmacological validation. The phytochemical richness of the plant, particularly its flavonoids, phenolics, and isoflavonoids, forms the fundamental basis of its diverse biological activities. Comparative analysis indicates that while the bark exhibits pronounced antinociceptive, anti-inflammatory, and antioxidant properties, the leaves demonstrate broader systemic effects, especially in chronic and metabolic disorders.

Mechanistically, the therapeutic efficacy of *D. sissoo* is mediated through oxidative stress modulation, inhibition of inflammatory mediators, and enzyme regulatory pathways, thereby reinforcing its role in disease prevention and management. The study further emphasizes the importance of extraction strategies and standardization in ensuring consistency, safety, and clinical applicability.

Despite its considerable pharmacological promise, the transition of *D. sissoo* into mainstream therapeutics remains constrained by limited clinical validation and lack of standardized protocols. Future research must therefore focus on controlled clinical trials, advanced analytical validation, and innovative delivery systems. Overall, *Dalbergia sissoo* represents a scientifically promising yet underexplored medicinal resource, warranting systematic investigation for its integration into modern healthcare.

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