WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.63
Volume 15, Issue 7, 660-681. Review Article ISSN 2277–7105

A COMPREHENSIVE REVIEW ON PHYTOCHEMICAL PROFILING, ETHNOMEDICINAL SIGNIFICANCE AND PHARMACOLOGICAL POTENTIAL OF *CORDIA DICHOTOMA* G. FORST LEAVES

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Article Received on 05 March 2026,
Article Revised on 26 March 2026,
Article Published on 01 April 2026,

https://doi.org/10.5281/zenodo.19327948

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How to cite this Article: Ittagi Shanmuka*, Suhas R M[1], C M Manu[2], Vinuth C[3] (2026). A Comprehensive Review On Phytochemical Profiling, Ethnomedicinal Significance And Pharmacological Potential Of Cordia Dichotoma G. Forst Leaves. World Journal of Pharmaceutical Research, 15(7), 660–681.
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ABSTRACT

Medicinal plants have long been recognized as a fundamental component of healthcare systems worldwide. Even in the modern era, a significant proportion of the global population relies on plant-based remedies for primary healthcare due to their accessibility, affordability, and perceived safety. *Cordia dichotoma* G. Forst a medicinally important species of the family Boraginaceae, has been widely utilized in traditional systems of medicine for the management of various ailments. The present review aims to provide a comprehensive overview of the ethnomedicinal importance, botanical characteristics, pharmacological activities, and therapeutic potential of *Cordia dichotoma* G. Forst leaves. Extensive literature evidence indicates that the leaves are rich in bioactive phytoconstituents such as flavonoids, phenolic acids, tannins, alkaloids, glycosides, and terpenoids, which contribute to diverse biological activities including antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, antidiabetic, and gastroprotective effects. The plant has been traditionally used for the managementof inflammation, fever, respiratory disorders, gastrointestinal disturbances, and skin diseases. Scientific investigations have demonstrated that the leaves possess a wide range of pharmacological properties, including analgesic, and wound healing activities. These biological effects are attributed to the presence of diverse

bioactive constituents that act through multiple mechanisms such as free radical scavenging, inhibition of inflammatory mediators, and modulation of metabolic pathways. The available evidence highlights the potential of *Cordia dichotoma* leaves as a valuable natural resource for the development of novel therapeutic agents. However, further clinical validation and standardization are required to ensure its safe and effective use in modern medicine.[1-3]

KEYWORDS: *Cordia dichotoma*; Boraginaceae; ethnomedicinal uses; pharmacological activities; medicinal plants; antioxidant activity; anti-inflammatory activity; antimicrobial activity; hepatoprotective; antidiabetic; wound healing; traditional medicine; phytotherapy; natural therapeutics.

1. INTRODUCTION

Medicinal plants remain a cornerstone in global healthcare systems, contributing significantly to both traditional and modern therapeutics.[4] Natural products derived from plants serve as a rich source of structurally diverse bioactive compounds, many of which have been developed into clinically useful drugs. Among these, the genus *Cordia* (family Boraginaceae) comprises several species with well-documented pharmacological properties.[5] *Cordia dichotoma* G. Forst commonly known as Indian cherry, lasura, bhokar or gonda. The genus Cordia comprises nearly 300 species is widely distributed across tropical and subtropical regions including India, Pakistan, Sri Lanka, and Southeast Asia.[2-6] It generally grows in dry deciduous forests and is also cultivated for its edible fruits. Traditionally, different parts of this plant including fruits, bark, leaves, seeds, and roots, possess significant medicinal properties and have been used in traditional systems of medicine for treating a variety of ailments; however, the leaves are particularly important due to their therapeutic versatility. They are commonly used in folk medicine. It has been traditionally used in Ayurveda, Unani, and Siddha systems for treating inflammation, respiratory disorders, gastrointestinal disturbances, and skin diseases.[6-7] While various parts of the plant exhibit medicinal value, the leaves have gained increasing attention due to their rich phytochemical profile and therapeutic potential. Recent advances in phytochemical analysis, including chromatographic and spectroscopic techniques, have enabled precise identification of bioactive compounds. Techniques such as FTIR and HPLC play a crucial role in validating traditional claims and supporting drug discovery efforts.[8-9]

This review aims to provide an in-depth scientific overview of *Cordia dichotoma* leaves, focusing on phytochemistry, pharmacological activities, analytical characterization, botanical characteristics, ethnomedicinal usesand future research prospects.

2. TAXONOMIC CLASSIFICATION

The taxonomic classification of *Cordia dichotoma* G. Forst is as follows.

Taxonomically, *Cordia dichotoma* is classified under the angiosperms and dicotyledonous plants, exhibiting characteristic morphological features such as simple leaves, cymose inflorescence, and mucilaginous fruits. Its classification aligns with classical botanical systems and modern phylogenetic interpretations.[10-11]

Table 1: Taxonomic Classification of *Cordia dichotoma* G. Forst.

CATEGORY	DETAILS
Scientific Name	*Cordia dichotoma* G. Forst.
Family	Boraginaceae
Order	Boraginales
Kingdom	Plantae
Subkingdom	Tracheobionta (Vascular plants)
Superdivision	Spermatophyta (Seed plants)
Division	Magnoliophyta (Angiosperms)
Class	Magnoliopsida (Dicotyledons)
Subclass	Asteridae
Genus	*Cordia*
Species	*Cordia dichotoma* G. Forst.

3. VERNACULAR NAMES: The plant is widely recognized across different regions and cultures, reflecting its ethnobotanical importance. Common names include Lasora (Hindi), Bhokar (Marathi), Gunda (Gujarati), and Naruvili (South Indian languages). Internationally, it is referred to as Indian cherry, glue berry, or fragrant manjack.

Table 2: Vernacular names of *Cordia Dichotoma* G. Forst.

LANGUAGE/REGION	NAME
Sanskrit	Shlesmataka, Bahuvara
Hindi	Lasora, Gunda
Kannada	Challe, Naruvili
Tamil	Naruvili
Telugu	Nakkera
Malayalam	Virali
Gujarati	Gunda
Bengali	Bahuvara
English	Indian Cherry, Glue Berry
Other Common Names	Bhokar, Gonda

3.1 SYNONYMS: The botanical synonyms of *Cordia dichotoma* include/

Table 3: Synonyms of *Cordia Dichotoma* G. Forst.

SCIENTIFIC SYNONYM	AUTHORITY
***Cordia myxa* L.**	Linnaeus
***Cordia latifolia*Roxb.**	Roxburgh
***Cordia obliqua* Willd.**	Willdenow

These synonyms arise from historical taxonomic classifications and regional botanical descriptions, indicating the plant's widespread distribution and morphological variability.

4. BOTANICAL DESCRIPTION

Figure 1: Whole plant morphology of *Cordia dichotoma* showing natural growth habit and canopy structure (Harapanahalli, Karnataka, India).

Cordia dichotoma G. Forst is a small to medium-sized deciduous tree belonging to the family Boraginaceae, typically attaining a height of approximately 10–15m under favorable ecological conditions. The species exhibits a moderately thick trunk with greyish to brown bark, which becomes rough, fissured, and longitudinally cracked upon maturity, reflecting its adaptation to dry tropical environments.

Figure 2: Representation of *Cordia dichotoma* leaves showing ovate shape, entire margin, and petiole attachment and leaf venation illustrating prominent midrib and reticulate venation pattern.

The leaves are simple, alternate, and broadly ovate to elliptic in morphology, measuring about 8–15 cm in length. They possess an entire margin, acute apex, and a rounded to subcordate base. The lamina is characterized by a slightly rough texture due to the presence of fine pubescence, while the venation pattern is distinctly reticulate with a prominent midrib and lateral veins. These anatomical features contribute to efficient physiological functioning and environmental adaptability.

Figure 3: Clustered leaf arrangement of *Cordia dichotoma* G. Forston young branches.

Young leaves appear bright green and smooth, whereas mature leaves become thicker and slightly leathery. The petiole is short but robust, providing mechanical support to the broad lamina. The venation pattern observed in the present specimen confirms its taxonomic placement within Boraginaceae and aligns with previously reported morphological descriptions. The plant exhibits a spreading branching pattern, forming a moderately dense canopy. Leaves are often observed in clusters along young shoots, enhancing photosynthetic efficiency.

Figure 4: Bark morphology of *Cordia dichotoma* G. Forst showing rough, fissured surface.

The bark is an important diagnostic feature, showing coarse texture and vertical fissures, which can be used for field identification. Overall, the morphological characteristics such as leaf arrangement, venation pattern, and bark texture provide reliable taxonomic markers for the identification of *Cordia dichotoma* and support its classification within the genus *Cordia*.

Figure 5: *Cordia dichotoma* G. Forst Flowers.

The flowers are small, white, and arranged in cymose inflorescences. Fruits are mucilaginous drupes that become yellowish-brown upon ripening and are widely consumed as edible food. These morphological characteristics serve as important taxonomic markers and facilitate accurate identification of the species.[2-6]

4.1 PLANT PROFILE

Table 4: Botanical Description of *Cordia Dichotoma* G. Forst.

PARAMETER	DESCRIPTION
Plant Type	Deciduous tree
Height	10–15 meters (approx.)
Habitat	Dry deciduous forests, semi-arid regions
Distribution	India, Pakistan, Sri Lanka, Nepal, Southeast Asia
Stem/Bark	Greyish-brown, rough, longitudinally fissured
Leaves	Simple, alternate, ovate, entire margin, reticulate venation
Leaf Texture	Slightly rough due to pubescence
Flowers	Small, white or creamy, bisexual, cymose inflorescence
Fruiting Season	Summer (April–June, varies by region)
Fruit Type	Drupe, mucilaginous, yellowish-brown when ripe
Seeds	Hard, enclosed within mucilaginous pulp
Special Feature	Sticky mucilage in fruits; ethnomedicinal importance

5. ETHNOMEDICINAL USES

Cordia dichotoma G. Forst has been widely utilized in traditional medicine systems for centuries, particularly in rural and indigenous healthcare practices. Different parts of the plant, including the leaves, fruits, bark, and seeds, are traditionally used for the treatment of a wide range of ailments due to their therapeutic and healing properties.[6-7]

The leaves of *Cordia dichotoma* G. Forstare especially valued in ethnomedicine and are commonly used for several therapeutic purposes, including.

- Treatment of fever
- Relief from headache
- Anti-inflammatory remedy
- Treatment of ulcersand gastrointestinal problems
- Management of cough cold, and respiratory disorders
- Healing of wounds and skin infections

Leaf decoctions and infusions arecommonly prepared and administered orallyand frequently prepared in folk medicine to manage respiratory disorders, such as cough, bronchial irritation, and throat inflammation, as well as digestive problems including indigestion and gastric

discomfort. The mucilaginous nature of the plant is believed to provide a soothing effect on irritated tissues, thereby promoting healing and reducing inflammation.

Additionally, other parts of *Cordia dichotoma* G. Forstare also traditionally used. The fruits are often consumed for their nutritive and mild laxative properties, while the bark and seeds have been reported to possess antimicrobial and medicinal value in various folk practices. Poultices prepared from the leaves are sometimes applied externally for wound healing, swelling, and skin infections, reflecting the plant's importance in topical traditional therapies, indicating its importance in traditional dermatological practices.[5-3]

Table 5: Ethnomedicinal Uses of*Cordia Dichotoma* G. Forst.

ASPECT	DESCRIPTION
Ethnomedicinal Importance	Used for fever, inflammation, ulcers, respiratory disorders, and wound healing
Parts Used	Leaves, fruits, bark, seeds
Traditional Systems	Ayurveda, Siddha, Unani
Growth Conditions	Thrives in warm climates and well-drained soils
Ecological Adaptation	Drought-tolerant, suitable for semi-arid regions
Economic Importance	Edible fruits used in pickles; medicinal applications
Morphological Identification	Ovate leaves, rough bark, mucilaginous fruits
Pharmacological Relevance	Antioxidant, anti-inflammatory, antimicrobial, hepatoprotective activities
Conservation Status	Not endangered; widely distributed

PLANT PART	TRADITIONAL USE	METHOD OF PREPARATION	INDICATIONS
Leaves	Anti-inflammatory	Decoction / paste	Swelling, joint pain
Leaves	Antipyretic	Leaf infusion	Fever
Leaves	Wound healing	Leaf paste (topical)	Cuts, wounds, skin infections
Leaves	Respiratory relief	Decoction	Cough, cold, bronchitis
Leaves	Gastroprotective	Infusion	Ulcers, gastric irritation
Fruits	Mild laxative	Consumed raw/pickle	Constipation
Bark	Antimicrobial	Extract/paste	Skin infections
Seeds	Digestive aid	Powder	Indigestion

6. GEOGRAPHICAL DISTRIBUTION AND HABITAT

Figure 6: *Cordia dichotoma* G. Forst in arid landscape.

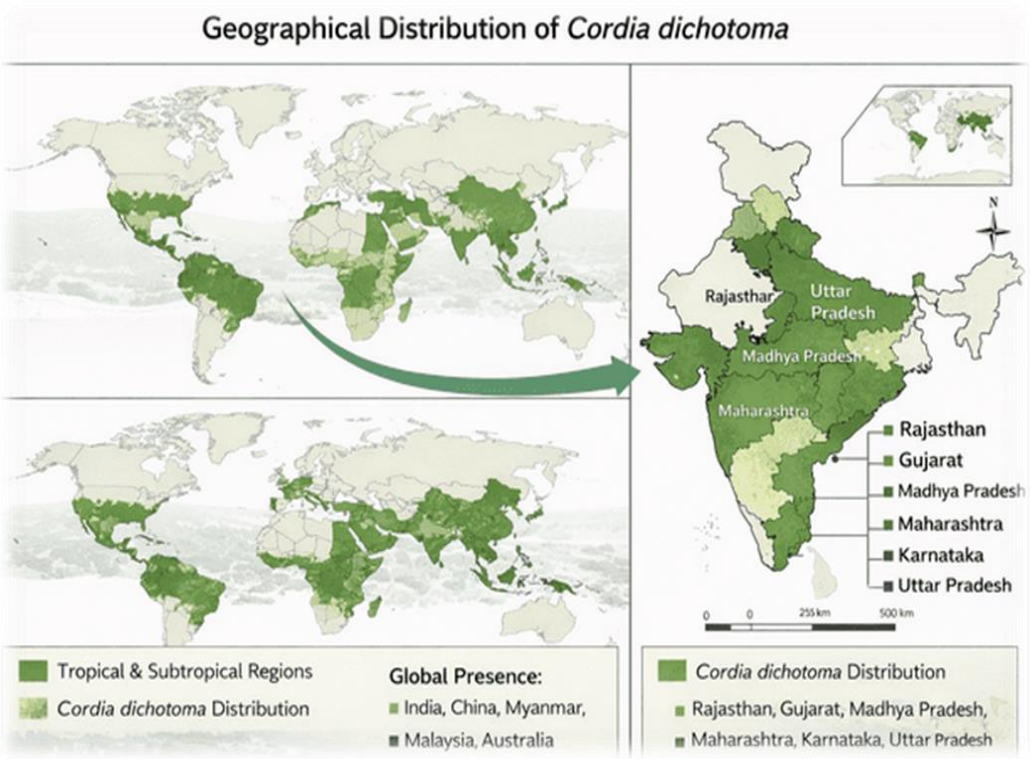

Figure 7: Geographical distribution of *Cordia dichotoma* G. Forst.

Cordia dichotoma is widely distributed in tropical and subtropical regions like India and other parts of Asia, including China, Myanmar, Malaysia, and Australia. It grows naturally in

dry deciduous forests, open grasslands, and semi-arid regions. The plant is well adapted to warm climates and thrives in well-drained soils. In India, it is commonly found in states such as Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Karnataka, and Uttar Pradesh. Its adaptability to diverse environmental conditions contributes to its widespread availability and ethnomedicinal use. It is commonly found up to an altitude of approximately 1500 meters.[2-5]

7. PHYTOCHEMICAL CONSTITUENTS

The therapeutic potential of *Cordia dichotoma* is primarily attributed to the presence of a diverse array of bioactive phytochemical constituents distributed across various parts of the plant, particularly the leaves, fruits, bark, and seeds. Extensive phytochemical investigations have demonstrated that the plant is rich in multiple classes of secondary metabolites, which play a crucial role in its pharmacological and medicinal properties.[12-3]

Preliminary phytochemical screening of *Cordia dichotoma* leaves has revealed the presence of several major bioactive constituents, including alkaloids, flavonoids, tannins, saponins, phenolic compounds, glycosides, terpenoids, steroids. These compounds are known to contribute significantly to the plant's broad spectrum of biological activities.

Among these, flavonoids and phenolic compounds are of particular importance due to their potent antioxidant properties. These molecules effectively scavenge free radicals, thereby protecting cellular components from oxidative damage and reducing the risk of oxidative stress–related disorders. Tannins exhibit notable astringent and antimicrobial properties, while saponins are recognized for their anti-inflammatory and immunomodulatory effects.[13-16]

The presence of such a wide range of phytoconstituents has attracted considerable scientific interest, leading to numerous studies aimed at evaluating the pharmacological potential of *Cordia dichotoma* leaves. These investigations have reported significant antioxidant, anti-inflammatory, antimicrobial, and hepatoprotective activities. Collectively, these findings provide strong scientific validation for the traditional medicinal uses of the plant and highlight its potential as a valuable source of natural therapeutic agents.[14]

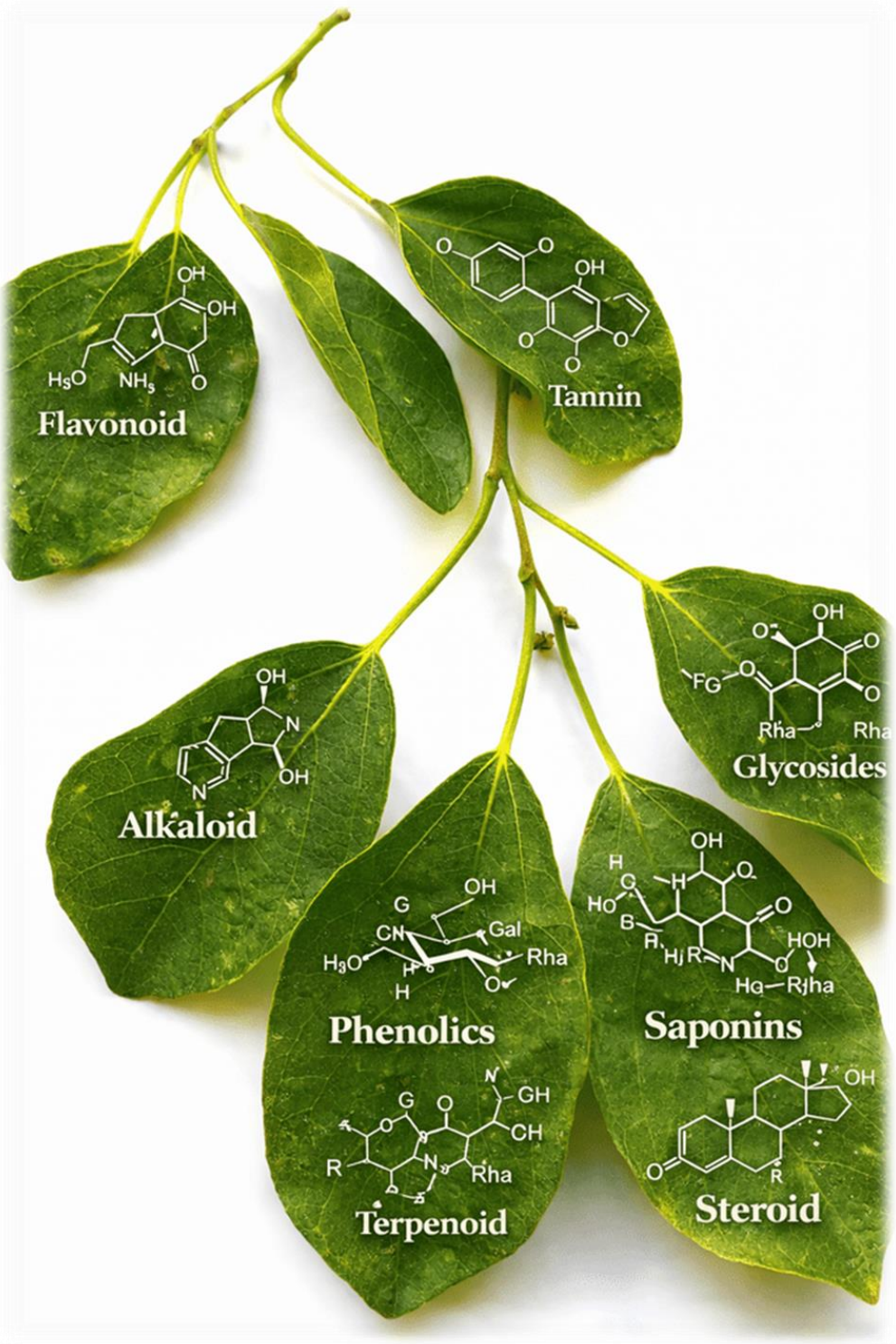

Figure 8: Major phytochemical constituents of *Cordia dichotoma* G.Forst.

Table 6: Major phytochemical constituents of *Cordia dichotoma* G. Forstand their pharmacological significance.[7]

Phytochemical Class	Representative Compounds / Examples	Plant Part	Pharmacological Activities	Mechanism Of Action	Therapeutic Significance
Alkaloids	Pyrrolizidine alkaloids	Leaves, seeds	Antimicrobial, analgesic	Interference with microbial metabolism and neurotransmission	Infection control, pain relief
Flavonoids	Quercetin, Kaempferol, Apigenin	Leaves, fruits	Antioxidant, anti-inflammatory, cardioprotective	Free radical scavenging, inhibition of COX & LOX pathways	Oxidative stress disorders, inflammation
Tannins	Hydrolysable and condensed tannins	Bark, leaves	Astringent, antimicrobial, anti-diarrheal	Protein precipitation, microbial enzyme inhibition	Wound healing, gastrointestinal disorders
Saponins	Triterpenoid saponins	Leaves, seeds	Anti-inflammatory, immunomodulatory, expectorant	Membrane permeability alteration, immune stimulation	Respiratory disorders, inflammation
Phenolic Compounds	Caffeic acid, Chlorogenic acid	Leaves, fruits	Antioxidant, hepatoprotective	Scavenging ROS, inhibition of lipid peroxidation	Liver protection, anti-aging
Glycosides	Cardiac and phenolic glycosides	Leaves	Cardioprotective, antimicrobial	Enzyme modulation, cellular signaling	Heart health, infections
Terpenoids	α-amyrin, betulin	Seeds, bark	Anti-inflammatory, anticancer	Modulation of inflammatory pathways	Chronic inflammation, cancer prevention
Steroids	β-sitosterol	Leaves, twigs	Anti-inflammatory, cholesterol-lowering	Membrane stabilization, lipid metabolism regulation	Cardiovascular diseases
Carbohydrates	Mucilage polysaccharides	Fruits	Gastroprotective, demulcent	Protective coating on mucosa	Ulcers, gastric irritation
Proteins & Amino acids	Structural proteins	Leaves	Nutritional, metabolic support	Enzyme synthesis and repair	General health support

8. PHARMACOLOGICAL ACTIVITIES

Extensive pharmacological investigations have been carried out on *Cordia dichotoma* to evaluate its therapeutic potential. The biological activities of this plant are mainly attributed to the presence of various bioactive phytochemicals such as flavonoids, phenolic compounds, tannins, saponins, glycosides, and terpenoids. Different extracts obtained from the leaves, fruits, bark, and seeds have demonstrated a wide range of pharmacological effects, supporting its traditional medicinal applications.

8.1 Anti-inflammatory Activity: Extracts of *Cordia dichotoma* leaves have been reported to exhibit significant anti-inflammatory effects in experimental models. These effects are primarily associated with the presence of flavonoids and phenolic compounds, which helps inhibit the production of inflammatory mediators such as prostaglandins and cytokines. As a

result, the plant has been traditionally used to reduce swelling, pain, and inflammatory conditions.[19-20]

8.2 Antioxidant Activity: The plant demonstrates strong antioxidant properties, which play a crucial role in protecting biological systems from oxidative damage caused by free radicals. Extracts of *Cordia dichotoma* have shown significant free-radical scavenging activity in various *invitro* studies. The presence of polyphenols, flavonoids, and tannins contributes to its ability to neutralize reactive oxygen species and prevent cellular damage.[17-18]

8.3 Antimicrobial Activity: Various solvent extracts of *Cordia dichotoma* leaves have demonstrated antimicrobial activity against several pathogenic microorganisms, including bacteria and fungi. These antimicrobial properties are believed to be associated with the presence of tannins, alkaloids, and phenolic compounds, which interfere with microbial cell membranes and metabolic processes. This activity supports the traditional use of the plant in treating skin infections, wounds, and gastrointestinal disorders.[21-22]

8.4 Antidiabetic Activity: Studies have indicated that extracts of *Cordia dichotoma* leaves may possess antidiabetic potential. Experimental research suggests that the plant can help regulate blood glucose levels and improve glucose metabolism. The antidiabetic activity is thought to be related to the presence of flavonoids and other bioactive compounds that may enhance insulin secretion or improve peripheral glucose utilization.[22-24]

8.5 Hepatoprotective Activity: Research has also reported hepatoprotective effects of *Cordia dichotoma* leaves extracts. These extracts have been shown to protect liver cells against chemically induced liver damage in experimental studies. The hepatoprotective activity is mainly attributed to the plant's antioxidant compounds, which help reduce oxidative stress and prevent cellular damage in liver tissues.[3]

8.6 Wound Healing Activity: Traditional medicine has long used *Cordia dichotoma* leaves for wound healing and treatment of skin disorders. Scientific studies have demonstrated that extracts of the leaves promote tissue regeneration, collagen formation, and faster wound contraction. The presence of antimicrobial compounds and mucilage helps prevent infection and maintains a moist environment that supports tissue repair.[5]

8.7 Gastroprotective and Anti-ulcer Activity: Some studies suggest that extracts of *Cordia dichotoma* leaves exhibit gastro protective and anti-ulcer activities. The mucilaginous

components of the plant help form a protective layer on the gastric mucosa, thereby reducing irritation and promoting healing of ulcers. These properties support its traditional use in managing gastric discomfort and digestive disorders.[3]

8.8 Analgesic Activity: Certain experimental studies have indicated that extracts of *Cordia dichotoma* leaves may possess analgesic (pain-relieving) properties. These effects are believed to result from the inhibition of pain mediators and inflammatory pathways, which helps reduce pain perception.

8.9 Antipyretic Activity: The plant has also shown antipyretic activity, meaning it may help reduce fever. Extracts of *Cordia dichotoma* leaves have demonstrated the ability to lower elevated body temperature in experimental models, supporting its traditional use in the treatment of fever.

Overall, the diverse pharmacological activities exhibited by *Cordia dichotoma* leaves provide strong scientific evidence supporting its traditional medicinal uses. These findings highlight the plant as a valuable natural resource for the development of novel therapeutic agents, encouraging further research on its pharmacological mechanisms and clinical applications.

Figure 9: *Cordia dichotoma* G. Forstextract for health benefits.

Table 7: Pharmacological activities of *Cordia dichotoma*G.Forst leaves and their therapeutic relevance.

ACTIVITY	OBSERVED EFFECT	PROPOSED MECHANISM	THERAPEUTIC RELEVANCE
Antioxidant	Free radical scavenging	Neutralization of ROS	Prevents oxidative stress disorders
Anti-inflammatory	Reduced inflammation	Inhibition of prostaglandins & cytokines	Arthritis, inflammation
Antimicrobial	Inhibits microbes	Cell membrane disruption	Infections, wounds
Antidiabetic	Lowers blood glucose	Enhances insulin sensitivity	Diabetes management
Hepatoprotective	Protects liver cells	Reduces oxidative damage	Liver disorders
Wound healing	Accelerates repair	Collagen synthesis stimulation	Tissue regeneration
Anti-ulcer	Protects gastric mucosa	Mucilage barrier formation	Ulcers, gastritis
Analgesic	Pain relief	Inhibition of pain mediators	Pain management
Antipyretic	Reduces fever	Central thermoregulation	Fever control

9. MECHANISM OF ACTION[25-26]

The pharmacological activities exhibited by *Cordia dichotoma* leaves are believed to result from the synergistic action of multiple bioactive phytochemicals, particularly flavonoids, phenolic compounds, tannins, and saponins. These compounds influence various biological pathways and molecular targets, thereby contributing to the plant's therapeutic effects. The major mechanisms of action underlying the pharmacological activities of *Cordia dichotoma* leaves are discussed below.

9.1 INHIBITION OF INFLAMMATORY MEDIATORS: One of the key mechanisms associated with the medicinal activity of *Cordia dichotoma* leaves is the inhibition of inflammatory mediators. Bioactive compounds such as flavonoids and phenolic acids may suppress the synthesis and release of pro-inflammatory mediators, including prostaglandins, leukotrienes, and cytokines. These compounds can interfere with inflammatory signaling pathways and reduce the activity of enzymes involved in inflammation, such as cyclooxygenase and lipoxygenase. As a result, the leaves exhibit anti-inflammatory and analgesic effects, helping to alleviate swelling, pain, and tissue irritation.

9.2 SCAVENGING OF FREE RADICALS: The antioxidant activity of *Cordia dichotoma* leaves is primarily attributed to its ability to scavenge reactive oxygen species (ROS) and free radicals. Flavonoids and phenolic compounds act as natural antioxidants by donating

hydrogen atoms or electrons to unstable free radicals, thereby neutralizing them and preventing oxidative damage to cellular components such as lipids, proteins, and DNA. This mechanism contributes to the leaf's protective effects against oxidative stress–related disorders.

9.3 MODULATION OF ENZYME ACTIVITY: Extracts of *Cordia dichotoma* leaves may influence the activity of several enzymes involved in physiological and pathological processes. Certain phytochemicals present in the plant can inhibit or regulate enzyme systems related to inflammation, oxidative stress, and metabolic disorders. For instance, modulation of enzymes associated with antioxidant defense systems may enhance the body's ability to combat oxidative damage. This enzymatic regulation contributes to the leaf's hepatoprotective, anti-inflammatory, and antioxidant activities.

9.4ANTIMICROBIAL MEMBRANE DISRUPTION: The antimicrobial properties of *Cordia dichotoma* leaves are believed to involve disruption of microbial cell membranes and interference with microbial metabolism. Phytochemicals such as tannins and phenolic compounds may alter the permeability of microbial membranes, leading to leakage of essential cellular components. Additionally, these compounds may inhibit microbial enzymes and metabolic pathways, thereby suppressing the growth of pathogenic bacteria and fungi.

9.5 REGULATION OF GLUCOSE METABOLISM: Another important mechanism associated with the pharmacological activity of *Cordia dichotoma* leaves is the regulation of glucose metabolism. Certain phytochemicals may enhance insulin sensitivity, stimulate insulin secretion, or inhibit carbohydrate-digesting enzymes, thereby helping to maintain normal blood glucose levels. This mechanism supports the potential antidiabetic effects of the leaves observed in experimental studies.

Overall, the pharmacological effects of *Cordia dichotoma* leaves are the result of complex interactions between multiple phytochemicals and biological pathways. Among these compounds, flavonoids and phenolic constituents play a particularly important role due to their antioxidant, anti-inflammatory, and enzyme-modulating properties. Further molecular and pharmacological studies are necessary to better understand these mechanisms and to identify the specific compounds responsible for each biological activity.

Table 8: Proposed mechanisms underlying the pharmacological effects of *Cordia dichotoma* G. Forst leaves.

MECHANISM	DESCRIPTION	BIOLOGICAL EFFECT
Free radical scavenging	Neutralizes ROS	Prevents cellular damage
Inhibition of inflammatory mediators	Blocks cytokines, prostaglandins	Reduces inflammation
Enzyme modulation	Regulates metabolic enzymes	Improves metabolic balance
Antimicrobial action	Disrupts microbial membranes	Prevents infections
Glucose metabolism regulation	Enhances insulin activity	Controls blood sugar

10. TOXICITY AND SAFETY PROFILE[27-28]

The evaluation of toxicity and safety is an essential aspect in determining the therapeutic applicability of medicinal plants. Several experimental and traditional studies suggest that *Cordia dichotoma* leaves are generally considered safe when used in moderate amounts, particularly in traditional medicinal preparations and dietary applications. However, scientific evaluation of its toxicity profile is important to ensure its safe use in pharmacological and therapeutic contexts.

10.1 ACUTE TOXICITY STUDIES: Acute toxicity studies conducted on extracts of *Cordia dichotoma* leaves have indicated low levels of toxicity in experimental animal models. In many studies, administration of leaf or fruit extracts at moderate doses did not produce significant mortality or severe behavioral changes, suggesting that the plant possesses a relatively high safety margin. These findings support its long-standing use in traditional medicine.

10.2 SUB-ACUTE AND CHRONIC TOXICITY: Limited studies evaluating sub-acute and chronic toxicity of Cordia *dichotoma* leaves extracts have generally reported no major toxic effects on vital organs, including the liver, kidneys, and heart, when administered at therapeutic doses. Biochemical and hematological parameters in experimental animals typically remain within normal ranges, indicating minimal systemic toxicity.

10.3 CYTOTOXICITY AND CELLULAR SAFETY: Preliminary *in-vitro* studies assessing the cytotoxic effects of extracts from *Cordia dichotoma* leaves have shown low cytotoxicity at pharmacologically relevant concentrations. This suggests that the plant extracts may be relatively safe for therapeutic use while still demonstrating biological

activity. However, more detailed studies are required to fully understand the cellular safety and mechanisms of action.

10.4 TRADITIONAL SAFETY AND DIETARY USE: In many regions, the fruits of *Cordia dichotoma* are consumed as food, particularly in the form of pickles and traditional culinary preparations. The long history of dietary consumption without significant adverse effects further supports the general safety of the plant, especially when used in traditional quantities.

10.5 POSSIBLE ADVERSE EFFECTS AND PRECAUTIONS: Although the leaves are generally considered safe, excessive consumption or inappropriate use of concentrated extracts may potentially lead to mild gastrointestinal discomfort or allergic reactions in sensitive individuals. Therefore, proper dosage, preparation methods, and medical supervision are recommended when the plant is used for therapeutic purposes.

10.6 NEED FOR FURTHER TOXICOLOGICAL STUDIES: Despite promising safety indications, comprehensive toxicological investigations, including long-term toxicity, genotoxicity, reproductive toxicity, and clinical safety studies, are still limited. Future research is necessary to establish standardized dosage ranges and safety guidelines for the medicinal use of *Cordia dichotoma* leaves.

Overall, available evidence suggests that *Cordia dichotoma* leaves have a favorable safety profile, particularly when used within traditional therapeutic limits. Nevertheless, further scientific studies are required to confirm its long-term safety and clinical applicability.

Table 9: Toxicity and safety evaluation of *Cordia dichotoma* G.Forst leaves.

STUDY TYPE	OBSERVATION	CONCLUSION
Acute toxicity	No mortality at moderate dose	Safe at therapeutic levels
Sub-acute toxicity	No major organ damage	Low toxicity
Traditional usage	Long-term safe use	Supports safety profile
Adverse effects	Mild GI discomfort (rare)	Dose-dependent caution

11. FUTURE RESEARCH PERSPECTIVES:[24-30]Although considerable progress has been made in understanding the pharmacological and ethnomedicinal importance of *Cordia dichotoma* leaves, several scientific aspects remain insufficiently explored. Further research is necessary to fully elucidate the therapeutic potential of this plant and to facilitate its

integration into modern healthcare systems. Future investigations should therefore focus on the following areas.

11.1 ISOLATION AND CHARACTERIZATION OF BIOACTIVE COMPOUNDS: One of the major priorities in future research is the isolation, purification, and structural characterization of bioactive phytochemicals present in *Cordia dichotoma* leaves. Although preliminary phytochemical screening has identified the presence of compounds such as flavonoids, tannins, alkaloids, and phenolics, the specific active constituents responsible for various pharmacological activities have not been fully characterized. Advanced analytical techniques such as high-performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC–MS), nuclear magnetic resonance (NMR), and liquid chromatography–mass spectrometry (LC–MS) can be employed to identify and characterize these compounds more precisely.

11.2 MOLECULAR MECHANISM STUDIES: While several pharmacological activities of *Cordia dichotoma* leaves have been reported, the underlying molecular mechanisms responsible for these biological effects are still not completely understood. Future studies should focus on elucidating the cellular and molecular pathways involved in its anti-inflammatory, antioxidant, antimicrobial, and antidiabetic activities. Techniques such as gene expression analysis, enzyme inhibition studies, and molecular docking approaches could provide deeper insight into the mechanisms through which the leaves exert its therapeutic effects.

11.3 CLINICAL TRIALS AND HUMAN STUDIES: Most of the currently available pharmacological data on *Cordia dichotoma* leaves are derived from in-vitro and animal studies. Therefore, well-designed clinical trials involving human subjects are essential to validate the safety, efficacy, and therapeutic potential of the plant. Clinical research would help establish evidence-based dosage guidelines, treatment protocols, and possible side effects, thereby facilitating its acceptance in modern medical practice.

11.4 STANDARDIZATION OF HERBAL FORMULATIONS: Another important area of research is the standardization of herbal formulations prepared from *Cordia dichotoma* leaves. Variations in leaf source, harvesting time, extraction methods, and processing techniques can significantly influence the quality and efficacy of herbal preparations.

Establishing standardized protocols for extraction, quality control, and dosage will ensure the production of consistent and reliable herbal products.

11.5 DEVELOPMENT OF NOVEL PHYTOPHARMACEUTICAL PRODUCTS: With increasing interest in plant-based medicines, *Cordia dichotoma* leaves offer promising opportunities for the development of novel phytopharmaceuticals and nutraceutical products. Future research may focus on designing modern dosage forms such as tablets, capsules, gels, ointments, and topical formulations derived from its bioactive compounds. In addition, the leaves may serve as valuable source for the development of natural antioxidants, anti-inflammatory agents, and antimicrobial products for pharmaceutical and healthcare applications.

Table 10: Future research directions for *Cordia dichotoma* G. Forst.

AREA	FOCUS	EXPECTED OUTCOME
Clinical studies	Human trials	Efficacy validation
Standardization	Dosage, extraction	Consistency
Molecular studies	Pathways, targets	Mechanistic insight
Formulation	Dosage forms	Product development
Drug discovery	Lead compounds	Novel therapeutics

12. CONCLUSION

Cordia dichotoma G. Forst. is a pharmacologically significant medicinal plant with well-established ethnomedicinal relevance and notable therapeutic potential. Evidence indicates that its leaves are a rich source of diverse bioactive phytoconstituents, including flavonoids, phenolic compounds, tannins, saponins, and terpenoids, which contribute to a wide range of biological activities.

Experimental studies have demonstrated that *C. dichotoma* exhibits significant antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, wound healing, and gastroprotective effects. These activities are mediated through mechanisms such as free radical scavenging, inhibition of inflammatory mediators, modulation of enzymatic pathways, and disruption of microbial cell membranes, thereby supporting its traditional medicinal use. However, current research is largely limited to in vitro and preclinical studies. Well-designed clinical trials, detailed toxicological evaluations, and standardization of extracts are essential to establish its safety, efficacy, and appropriate dosage in humans.

Advances in phytochemical isolation, molecular pharmacology, and drug delivery systems may further support the development of novel phytopharmaceuticals from *Cordia dichotoma*. Overall, it represents a promising natural source for safe, effective, and affordable therapeutic agents, contributing to the progress of modern phytotherapy and drug discovery.

ACKNOWLEDGEMENT

The authors express their deep sense of gratitude to His Holiness Sha‖ Bhra‖ Shri Varasadyojatha Shivacharya Swamiji, President TMAE society, Harapanahalli and Dr. T.M. Chandrashekharaiah, Secretary T.M.A.E society Harapanahalli, Mr. Pratheek T M Administer officer, Gnanagangothri campus, Harapanahalli and Principal S.C.S. College of Pharmacy, Harapanahalli for their constant encouragement.

CONFLICT OF INTEREST: The authors declare there is no conflict of interest.

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