

Medicinal Combretaceae of India

Vol 7



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Volume I



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PREFACE

The Combretaceae family, comprising over 500 species, is a treasure trove of medicinal plants that have been used for centuries in traditional medicine. India, with its rich biodiversity and ancient systems of medicine, is home to a significant number of Combretaceae species that have been used to treat various ailments. This volume aims to bring together the existing knowledge on the medicinal properties, ethnopharmacological values, and pharmacological applications of select Combretaceae species found in India.

The use of plants for medicinal purposes is an ancient practice that has been passed down through generations. In India, the traditional systems of medicine, such as Ayurveda, Siddha, and Unani, have relied heavily on plants for their medicinal properties. The Combretaceae family, in particular, has contributed significantly to the traditional medicine repertoire, with many species being used to treat a range of diseases. This volume seeks to document the medicinal uses of Combretaceae species in India, with the hope of preserving traditional knowledge and promoting further research.

The chapters in this volume have been carefully curated to provide a comprehensive overview of the medicinal properties and applications of select Combretaceae species. Each chapter has been written by experts in the field and provides a detailed review of the existing literature. The volume covers a range of species, from the well-known *Terminalia arjuna* to the lesser-known *Anogeissus acuminata*. We hope that this volume will serve as a

valuable resource for researchers, students, and practitioners of traditional medicine.

We are grateful to the contributors to this volume, who have shared their expertise and knowledge to make this project a success. We also acknowledge the rich traditional knowledge of the indigenous communities in India, who have used these plants for centuries to treat various ailments. We hope that this volume will contribute to the preservation and promotion of traditional knowledge and inspire further research into the medicinal properties of Combretaceae species.

(Editors)



BACKGROUND

The Combretaceae family is a diverse group of flowering plants that comprises over 500 species, many of which have been used for centuries in traditional medicine. In India, where traditional systems of medicine such as Ayurveda, Siddha, and Unani have been practiced for thousands of years, the Combretaceae family has contributed significantly to the country's rich medicinal heritage. This book, "Medicinal Combretaceae of India, Volume 1", aims to document the medicinal properties and applications of select Combretaceae species found in India.

India is home to a vast array of Combretaceae species, many of which have been used in traditional medicine to treat a range of diseases. From the well-known *Terminalia arjuna*, which has been used for centuries to treat cardiovascular diseases, to the lesser-known *Anogeissus acuminata*, which has been used to treat various ailments including fever and rheumatism, the Combretaceae family has contributed significantly to India's traditional medicine repertoire. This book provides a comprehensive overview of the medicinal properties and applications of select Combretaceae species found in India.

The book is divided into seven chapters, each of which focuses on a specific Combretaceae species. The experts from their respective fields have contributed to the existing literature on each species belonging to the Combretaceae family. The book covers a range of species, including *Anogeissus acuminata*, *Combretum roxburghii*, *Anogeissus latifolia*, *Combretum*

albidum, *Terminalia bellirica*, *Terminalia arjuna*, and *Terminalia catappa*. Each chapter provides an in-depth review of the medicinal properties, ethnopharmacological values, and pharmacological applications of each species.

One of the key strengths of this book is its comprehensive coverage of the medicinal properties and applications of Combretaceae species found in India. The book provides a detailed review of each species, including their traditional uses, phytochemical composition, and pharmacological activities. The book also highlights the potential of Combretaceae species as a source of new medicines and treatments and also discusses the challenges and opportunities facing the development of these species for medicinal use.

Overall, "Medicinal Combretaceae of India, Volume 1" is a valuable resource for researchers, students, and practitioners of traditional medicine. The book provides a comprehensive overview of the medicinal properties and applications of some selected Combretaceae species found in India and highlights the potential of these species as a source of new medicines and treatments.



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Chapter I

Comprehensive review on *Anogeissus acuminata* (Roxb. ex DC.) Wall. ex Guill. & Perr.

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ABSTRACT

The family Combretaceae is distributed across tropical and warm temperate regions, encompassing 11 genera and approximately 400 species. Among these, the genus *Anogeissus* is notable for its medicinal significance, with around eight species, including *Anogeissus acuminata*, which is renowned for its extensive medicinal properties. *A. acuminata* has a long history of traditional use for treating ailments like headaches, menstrual pain, rheumatoid arthritis, tuberculosis, and various skin diseases. Additionally, the tree is culturally significant. The species contributes to biodiversity, provides habitat and food for animals, and aids in soil fertility and erosion prevention. This review highlights the morphological characteristics, medicinal uses, bioactive compounds, and pharmacological activities of *A. acuminata*, underscoring its importance in traditional medicine and potential for future drug development.

Keywords: Combretaceae, *Anogeissus*, medicinal uses, pharmacological values

INTRODUCTION

The family Combretaceae comprises trees, shrubs, and lianas that are widely distributed across tropical regions, with a few species found in warm temperate zones. Globally, there are 11 genera and approximately 400 species within this family. *Anogeissus* is one of the important genera

in this family, which consists of about 8 species namely *A. acuminata*, *A. bentii*, *A. dhofarica*, *A. latifolia*, *A. leiocarpus*, *A. pendula*, *A. rivularis* and *A. sericea* (Singh et al. 2016). These species are found in both Asia and Africa. In Asia and Africa, these plants are utilized as ethnomedicine to address a range of health conditions such as diabetes, fever, diarrhoea, dysentery, tuberculosis, wound healing, skin diseases like eczema and psoriasis (Adebayo and Krettli, 2011; Ezurike and Preto 2014). *Anogeissus acuminata*, among them, is renowned globally for its medicinal properties. It is found extensively across South Asia, the Arabian Peninsula, Africa, and India, particularly in the northwest region (Yadav et al. 2019). This plant is rich in bioactive compounds like tannins and flavonoids (Shwetha et al. 2013). *A. acuminata* has a long history of traditional uses in treating a variety of ailments including headaches, menstrual pain, rheumatoid arthritis, tuberculosis, eczema, dermatitis, and skin ulcers (Yadav et al. 2019). It holds great significance among the tree species that are closely linked to the socio-cultural and religious traditions of Odisha. The wood of this tree is specifically used in crafting the wheels of Lord Jagannatha's chariot, which are essential for the renowned Rathayatra festival (Car festival) (Present study). It contributes to the biodiversity of the ecosystems where it is native, providing habitat and food for various animal species and playing a role in improving soil fertility and preventing erosion, which is crucial for maintaining the health of the environment.

MORPHOLOGY

A. acuminata, also known as the axle wood tree, is notable for its distinctive morphological characteristics (Rathore et al. 1993; Saxena and Bramham, 1995; Plates 1-2). It is typically a medium-sized deciduous tree, reaching heights of 15-25 meters. The trunk is straight and cylindrical, often with a diameter of up to 1 meter. The bark is smooth and grey when young, becoming rough and fissured with age.

Leaves: The leaves are simple, alternate, and arranged in a spiral pattern on the branches. They are ovate to elliptic in shape, with a pointed (acuminate) tip, which is a key characteristic of the species. Leaf size generally ranges from 5 to 15 cm in length and 3 to 6 cm in width, has a leathery texture with a smooth surface, and the margins are entire.



Figure 1: Vegetative parts of *A. acuminata*



Figure 2: Plant parts of *A. acuminata*

Flowers: The flowers are small, white to yellowish, and are arranged in dense, spherical heads or clusters.

Fruits: The fruit is a small, woody, and indehiscent capsule, often referred to as a nutlet. The capsules are round to ovoid, about 4-6 mm in diameter, dispersed by wind due to their lightweight and small size.

Bark: The bark is initially smooth but becomes rough and fissured as the tree ages. Grey to brownish-grey in colour.

Wood: The wood of *A. acuminata* is hard, heavy, and durable, making it valuable for timber. It is often used in construction, furniture making, and for other purposes requiring strong wood. The heartwood is dark brown, while the sapwood is lighter in colour.

MEDICINAL USES

A. acuminata has a long history of uses in traditional medicine. Various parts of the tree, including the bark, leaves, and wood, are used for their medicinal properties. The bark and leaves are often used in traditional medicine to promote wound healing. They are applied topically to cuts, wounds, and sores to accelerate healing and prevent infection (Mann et al. 2009; Hemamalini et al. 2011). It has shown promising anti-diabetic effects in diabetes mellitus. A decoction made from the bark is traditionally used to treat respiratory issues such as coughs, colds, and bronchitis. In some cultures, twigs from *A. acuminata* are used as natural toothbrushes (chewing sticks) due to their antimicrobial properties, which help maintain oral hygiene and prevent dental issues. The decoction is believed to soothe the throat and reduce mucus production (Yadav et al. 2019). It has been traditionally used to treat various cardiovascular disorders, such as hyperlipidaemia. Additionally, it is also utilized in ethnic medicine to address skin diseases, gastrointestinal disorders, smooth-muscle-related issues, toothache and mouth lesions, stomach disorders, diarrhoea, dysentery, cough, and burns (Saqib et al. 2020; Mohd et al. 2021). The tree's bark and leaves are used to support digestive health. They are known to alleviate issues such as indigestion, stomach ulcers, and constipation. In Andhra Pradesh, leaves have been utilized in traditional and tribal medicine to address distressing inflammatory ailments (Yadav et al. 2019).

BIOACTIVE COMPOUNDS

A. acuminata, is an excellent source of active ingredients that add up to its diverse medicinal properties. Tannins, flavonoids, triterpenoids, and polyphenols are the most crucial bioactive components. Tannins in the bark and leaves have been used for the remedy of diarrhoea, and dysentery as well as in the healing of wounds (Singh et al. 2016; Yadav et al. 2019). Flavonoids, which function as free radical scavengers and anti-inflammatory agents, can be used to counteract the adverse effects of oxidative stress and protect the body from inflammation (Hemamalini et al. 2011). The occurrence of triterpenes such as betulinic acid is one of the essential minerals that give antimicrobial and anticancer qualities to *A. acuminata*. Polyphenols are also very important as they are part of the most powerful antioxidants and this is the reason *A. acuminata* has an excellent antioxidant capacity, supports the overall health of the body, and prevents chronic diseases (Navale and Paranjape, 2018; Yadav et al. 2019). Apart from this, these substances also influence the secretion of antimicrobial proteins and are thus the most natural weapon to be used against even the hardest bacterial and fungal infestations (Jagetia, 2019). The collective effects of these bioactive compounds form the basis for the traditional medicinal uses of *A. acuminata* as a curative agent for respiratory conditions, digestive tract disorders, and skin and dental health problems (Mishra and Padhy, 2018).

PHARMACOLOGICAL ACTIVITIES

Throughout the history of traditional medicine, *A. acuminata*, is a tree that has made a lot of impacts, and demonstrates different pharmacological activities attributed to a variety of its bioactive compounds (Rimando et al. 1994; Singh et al. 2016; Navale and Paranjape, 2018; Saqib et al. 2020).

Antimicrobial activity: When extracts from the bark and leaves of the tree are used, they can display remarkable antimicrobial properties. These are efficacious against a variety of bacterial and fungal pathogens, as a result, they are effective in preventing infections and thus promoting health generally.

Antioxidant activity: The polyphenols and flavonoids in the tree provide powerful antioxidant activity. The agents bind to free radicals to free them

to the atmosphere and prevent cells from reacting to them or they initiate the chemical process in which a cell transforms.

Anti-inflammatory activity: The isolates of the tree have exhibited their capability to reduce inflammation, which is useful in the case of a number of disorders that occur through inflammation including arthritis, inflammatory bowel disease, etc.

Astringent properties: Tannins in the bark and leaves make them astringent, which is why astringents are useful in the treatment of diarrhoea or dysentery.

Wound healing: The root and leaf of the tree are customarily used for faster healing of wounds. Its antimicrobial and astringent properties act by sanitizing wounds, diminishing the risk of infection, and accelerating the healing process.

Antidiabetic activity: Some studies proposed that it has the properties of lowering the levels of sugar in the blood, which could be very beneficial to the diabetes patient to manage diabetes and thereby take pieces of control away from the diabetes that has been controlling them.

Anticancer potential: Some chemical compounds found in the tree, such as triterpenoids, have been observed to have cytotoxic activities, i.e., the compounds seem to kill only cancer cells in early studies, thus, the compounds have potential for the development of anticancer drugs.

Skin health: The tree's antimicrobial side and its anti-inflammatory side, however, which are manifested in the extracts make the feature, possible in the treatment of ailments such as skin diseases, e.g., they can be useful in combating eczema, psoriasis, and fungal infections.

CONCLUSION

A. acuminata, is a prominent species within the Combretaceae family, and holds substantial medicinal and ecological values. Its rich array of bioactive compounds, including tannins, flavonoids, triterpenoids, and polyphenols, underpins its diverse therapeutic applications in traditional medicine across Asia and Africa. The tree's efficacy in treating a wide range of conditions -from respiratory and digestive disorders to skin diseases and diabetes- demonstrates its pharmacological versatility.

Furthermore, its cultural significance and ecological contributions highlight its multifaceted roles in both human and environmental health. Future research should focus on isolating and characterizing the bioactive compounds of *A. acuminata* to develop novel pharmacological agents, thus bridging traditional knowledge and modern medicines. The continued exploration and conservation of this species are essential for sustaining its benefits for future generations.

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Chapter II

Review on a medicinal liana of India (*Combretum roxburghii* Spreng.)

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ABSTRACT

Combretum, encompassing approximately 200-250 species, thrives across the tropics and subtropics. *Combretum roxburghii*, a prominent species in this genus, is highly adaptable to various habitat. Medicinally, *C. roxburghii* is valued for its antibacterial, antifungal, anti-inflammatory, and antioxidant properties. Traditional uses range from treating infections and wounds to managing diabetes, malaria, and respiratory conditions. Its bioactive compounds, including flavonoids, tannins, saponins, alkaloids, and glycosides, underpin these pharmacological activities. Morphologically, *C. roxburghii* is a woody climber or large shrub with distinctive four-winged samaras aiding in wind dispersal. This review highlights the morphological characteristics, medicinal uses, bioactive compounds, and pharmacological activities of *C. roxburghii*, highlighting its importance in traditional medicine and potential for future drug development. Continued research into its phytochemistry and therapeutic potential could yield new medicinal applications.

Keywords: *Combretum*, bioactive compounds, traditional knowledge, pharmacological activities

INTRODUCTION

Combretum consists of approximately 200-250 species that are found across the tropics and subtropics, including Africa, India, and China, but they are notably absent from Australia and the Pacific Islands. The species

within the *Combretum* genus range from trees to shrubs and woody climbers, with rare sub-herbaceous forms (Roy et al. 2014; Sharma et al. 2021). *Combretum roxburghii*, among them, is also known for its adaptability and is found in tropical and subtropical regions of Southeast Asia. The distribution is spread along several countries, where it can grow in different ecosystems (Saxena and Brahmam, 1995). The species is not only found in the deciduous forest but also in the bank of the river as well as in the scrubland (Begum et al. 2016). The vitality of this plant is that is tolerant to different types of soils as well as climates. It provides habitat and shelter for different wildlife. The dense canopy helps birds, bugs, and small animals, contributing to local biodiversity. The plant's flowers produce nectar, attracting pollinators such as bees, butterflies, and other insects. These pollinators play a crucial role in the ecosystem by facilitating the reproduction of many other plant species. Additionally, the seeds and fruits are consumed by various animals, contributing to their diet and aiding in seed dispersal (Present study). It is used in traditional medicine for its antibacterial and antifungal properties to treat infections (Begum et al. 2016; Sharma et al. 2021). It has anti-inflammatory effects, alleviating pain and swelling from conditions like arthritis. The plant's antioxidant compounds help neutralize harmful free radicals, and its leaves and bark are applied to wounds to promote healing (Rout and Bhatnagar, 2023). Additionally, it is used to manage digestive issues and respiratory ailments (Kadavul and Dixit, 2009). Expanding the scientific understanding of this plant can offer valuable insights into various aspects of plant biology, and ecology, and the possibility of uncovering new compounds that can be advantageous for human health.

MORPHOLOGY

It is a woody climber or large shrub or a liana. It can grow up to 5-10 meters in height when it climbs or spreads as a shrub. The stems are woody and can become quite thick with age. The bark is generally rough and can have a greyish to brown colouration. Leaves are arranged oppositely or sub-oppositely on the stem. They are broadly ovate to elliptic in shape. Leaf length typically ranges from 5 to 15 cm and width from 3 to 8 cm. The upper surface of the leaves is smooth and glossy, while the lower surface is slightly hairy. The leaf margins are entire. Flowers are borne in dense, axillary, or terminal racemes or spikes. Each flower has a tubular calyx

with four spreading lobes. Flowers are small, typically less than 1 cm in diameter. They are usually white or yellowish-white. The fruit is a four-winged samara, characteristic of the Combretaceae family. Each samara is about 2.5 to 4 cm long, initially green, turning brown as they mature. The wings of the samara are papery and aid in wind dispersal (Plate 1; Figure 1; Saxena and Brahmam, 1995; Roy et al. 2014; Kumar et al. 2022).



Plate 1: Vegetative parts of *C. roxburghii* A) Whole plant, B) Fruits, C) Flowers



Figure 1: Habitat of *C. roxburghii*

MEDICINAL USES

C. roxburghii is extensively used in traditional medicine against inflammation, infection, diabetes, malaria, bleeding, diarrhoea, cancer, and other disorders. The leaves are used as an antiseptic to clean wounds and prevent infections (Agra et al. 2007). The young white leaves are crushed & made into juice. The juice is taken to reduce the problems of diarrhoea. Leaf extracts are used to reduce fever. The leaves are applied topically to reduce inflammation and swelling (Rout et al. 2023). The mature leaf paste is used against skin infections. Bark decoctions are consumed to treat diarrhoea, and dysentery (Begum et al. 2016; Nayak and Kumar, 2023). The bark has astringent properties and is used to treat various skin conditions. Bark paste is applied to wounds to promote healing. Bark paste is applied externally to reduce inflammation. The bark paste is mixed with turmeric & applied to reduce muscle inflammation. Fruit paste is applied to reduce inflammation caused by accidents. Root extracts are used to treat digestive problems such as stomach pain and indigestion (Kadavul and Dixit, 2009). Root decoctions are also used to reduce fever. Various parts of the plant are used for their analgesic properties to relieve pain. The plant treats respiratory conditions such as coughs and asthma (Nayak and

Kumar, 2023). Some traditional medicine practices use extracts of *C. roxburghii* to help manage blood sugar levels. Grinding the plant parts and mixing with water to form a paste for topical application (Roy et al. 2014; Rout et al. 2023). These traditional uses highlight the importance of *C. roxburghii* in various cultural medicinal practices, emphasizing its role in treating a range of ailments.

BIOACTIVE COMPOUNDS

C. roxburghii is known for its many bioactive substances, that are responsible for the plant-based drug and has been extensively studied for their pharmacological activities. Key bioactive constituents found in *C. roxburghii* are flavonoids, tannins, saponins, alkaloids, and glycosides. Flavonoids like quercetin and kaempferol have strong antioxidant and anti-inflammatory effects (Bhatnagar et al. 2012). The plant's astringent and antimicrobial properties are partly due to tannins, which are polyphenolic compounds. *C. roxburghii* has Saponins that can affect immune system responses while having properties against fungi as well as inflammation. Although in small amounts, alkaloids have been shown to work against pain and malaria hence not neglecting an important part of the plant's clinical properties (Rout and Bhatnagar, 2023). Glycosides including cardiac glycosides are good for heart conditions by regulating heart rate and cardiac output. Research also shows the antibacterial properties of the plant against many bacteria. The presence of phenolic acids like gallic acid and ellagic acid adds to its antioxidant properties. All these bioactive compounds put together to make the plant good for treating inflammation, infections, and cardiovascular diseases. It has been traditionally used in folk medicine for wound healing, which can be attributed to its bioactive components that promote cell regeneration and reduce microbial contamination (Toklo et al. 2021; Rout and Bhatnagar, 2023). The plant's extracts have been utilized in various formulations, including teas, ointments, and tinctures, reflecting its versatility in medicinal applications. *C. roxburghii* is a valuable medicinal plant with a rich composition of bioactive compounds that confer numerous health benefits. Continued research into its phytochemical properties and mechanisms of action may lead to the development of new therapeutic agents derived from this plant.

PHARMACOLOGICAL ACTIVITIES

C. roxburghii is renowned for its diverse pharmacological activities, making it a significant plant in traditional and modern medicine. The primary pharmacological properties of this plant include:

Antioxidant activity: Flavonoids and phenolic acids like quercetin, kaempferol, gallic acid, and ellagic acid in *C. roxburghii* exhibit strong antioxidant properties. They remove free radicals and save the cell from stress and damage (Rout and Bhatnagar 2023; Das et al. 2020).

Anti-inflammatory activity: Flavonoids and saponins have shown significant anti-inflammatory effects. They are active and reduce inflammation by cox-2 and pro-inflammatory cytokines (Roy et al. 2014).

Antimicrobial activity: Tannins, alkaloids, and phenolic compounds in *C. roxburghii* are antibacterial and antifungal. It is useful against many bacteria and fungi for infection (Sharma et al. 2021).

Anticancer activity: Some studies show that *C. roxburghii* extract is cytotoxic to cancer cell lines. Tannins and flavonoids are there so it is anticancer through apoptosis and cell cycle arrest (Bhatnagar et al. 2012).

Antidiabetic activity: Extracts are good for diabetes by inhibiting carbohydrate metabolism enzymes and reducing blood sugar. Flavonoids and tannins play a crucial role in this activity (Begum et al. 2016).

Cardioprotective activity: Cardiac glycosides in *C. roxburghii* are good for the heart. It regulates heart rate and cardiac output and is good for some cardiovascular diseases (Sharma et al. 2021).

Hepatoprotective activity: Antioxidants of bioactive compounds protect the liver from toxins and stress (Sharma et al. 2021).

Analgesic activity: Alkaloids and other bioactive compounds in *C. roxburghii* exhibits pain-relieving properties. It is pain relief by pain signal inhibition and inflammation reduction (Rout and Bhatnagar 2023).

Wound healing activity: Traditional uses of *C. roxburghii* for wound healing are there because of its antimicrobial and anti-inflammatory properties. (Roy et al. 2014; Sharma et al. 2021).

Antimalarial activity: Some alkaloids and other bioactive compounds in *C. roxburghii* have shown antimalarial properties. So, it is good for the treatment and prevention of malaria (Roy et al. 2014).

C. roxburghii possesses a wide range of pharmacological activities that contribute to its therapeutic potential. Its bioactive compounds offer multiple health benefits, making it a valuable plant in both traditional and contemporary medicine.

CONCLUSION

Combretum roxburghii, a versatile and resilient species, plays a significant role in both ecological and medicinal contexts. Its ability to thrive in diverse ecosystems contributes to local biodiversity, offering habitat and sustenance to various wildlife and pollinators. Medicinally, *C. roxburghii* is a powerhouse of bioactive compounds, providing a wide range of pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, anticancer, antidiabetic, cardioprotective, and hepatoprotective. There is a potential for discovering new therapeutic agents and exploring their value in both traditional and modern medicine.

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Chapter III

A review on ethnopharmacological values of *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guill. & Perr.

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ABSTRACT

Anogeissus latifolia is a medium-sized deciduous tree belonging to the family Combretaceae. This important medicinal plant is primarily utilized for its timber, fodder, gum, tannin, and pulp. Found in tropical and sub-tropical regions, across the sub-Himalayan tract, the Indian Peninsula, Myanmar, and Sri Lanka and growing in association with various forest types. The tree is valued not only for its timber but also for its medicinal properties, particularly its bark and leaves, which are rich in bioactive compounds such as tannins, flavonoids, terpenes, and saponins. These compounds confer a range of pharmacological activities, including antimicrobial, antioxidant, anti-inflammatory, hepatoprotective, antidiabetic, anti-ulcer, anticancer, and wound healing properties. The plant is also a significant source of commercial Indian gum and is used in Ayurvedic formulations such as Ayaskrti. Its extensive medicinal uses span the treatment of urinary tract infections, liver disorders, fever, epilepsy, cardiac issues, vomiting, diarrhoea, dysentery, snake and scorpion bites, diabetes, piles, stomach aches, anaemia, and respiratory problems. The review focuses on the morphological features, medicinal properties, bioactive compounds, and pharmacological effects of *A. latifolia*, emphasizing its significance in traditional medicine and potential for upcoming drug discovery.

Keywords: *Anogeissus*, medicinal uses, bioactive compounds, pharmacological values

INTRODUCTION

Anogeissus latifolia, a medium sized deciduous tree belonging to the family Combretaceae one of the important medicinal plants in Ayurveda. It is locally known as Dhaura, Dhau, Vekkali, or Dhawa and commonly known as Gahtti (Kumar et al. 2010; Radha et al. 2023). Mainly used for timber, fodder, gum, tannin, pulp, etc (Kumar et al. 2010). It is a tree of the tropical and sub-tropical climatic regions; it grows throughout the sub-Himalayan tract from the Ravi to Nepal, Bihar, Chota Nagpur and ascends to south India and a large part of the Indian Peninsula hills, Myanmar, and in Sri Lanka. It grows in association with moist Siwalik Sal forests, dry Siwalik Sal forests, southern dry mixed deciduous forests, dry peninsular Sal forests, and northern dry mixed deciduous forests (Dubey et al. 2012). It is an important timber and the leaves and bark are used for tanning. *A. latifolia* is useful in UTI infections, liver complaints, fever, epileptic fits, cardiac disorder, vomiting, cold, diarrhoea, dysentery, snake and scorpion bite, diabetes, piles, stomach ache, anaemia, and urinary discharge, etc. due to high content of tannins, appreciable quantities of flavonoids, terpenes and saponins (Hassan et al. 2023). So, most of the pharmaceutical industries depend on these plants for the secondary metabolites for the development of health care products and drugs (Vennila et al. 2023). The plant is rich in pharmacologically active phenolic phytoconstituent-ellagic acid and possesses microbicidal activities, antiulcer potential, hypolipidemic activities, and hepatoprotective potential (Patil and Gaikwad 2011). This tree is considered one of the most useful trees in India as the main source of commercial Indian gum (Hassan et al. 2023). The stem bark of *A. latifolia* is used as an important ingredient in the Ayurvedic formulation Ayaskrti. The important analgesic prototypes (Salicylic acid and morphine) were originally derived from plant sources and traditionally used as painkillers (Vennila et al. 2023).

MORPHOLOGY

A. latifolia typically grows to a height of 20-25 meters. The trunk is straight and cylindrical with a girth that can reach up to 2 meters in mature trees (Saxena and Bramham 1995; Byraiah 2018; Deepika et al. 2024)

Bark: The bark is smooth and greyish-white when young, becoming rough, fissured, and darker with age.

Leaves: Leaves are simple, alternate, and arranged spirally, broadly ovate to elliptic, with a rounded or slightly heart-shaped base and a pointed apex, leathery, with a smooth surface and prominent veins, dark green on the upper surface and lighter green on the underside. They are typically 5-12 cm long and 2-7 cm wide (Plate 2).

Flowers: Flowers are small, inconspicuous, and arranged in globose heads, yellowish-green in color. Flowering usually occurs between April and June. The flowers have a mild, pleasant fragrance.

Fruit: The fruit is a small, woody, one-seeded capsule, obovoid to ellipsoid. Each capsule is about 6-8 mm in length. When mature, the capsules are brownish (Plate 1).

Seeds: Each fruit contains a single seed. The seeds are small and ellipsoid, primarily dispersed by wind.

Wood: The wood of *A. latifolia* is hard, heavy, and durable, with a fine texture. The heartwood is light brown to reddish-brown, and the sapwood is pale yellow. The wood is commonly used in construction, making agricultural implements, furniture, and tool handles due to its strength and durability.

MEDICINAL USES

A. latifolia, known as Dhava or Dhaura in Ayurveda, has been used for centuries in traditional Ayurvedic medicine. The bark of *A. latifolia* is used externally to treat wounds, cuts, and ulcers. Its astringent properties help in the quick healing of wounds and prevention of infections (Patil and Gaikwad 2011; Singh et al. 2023). The bark decoction is used in treating diarrhoea and dysentery. It helps in reducing the frequency of stools and provides relief from gastrointestinal discomfort. The plant is used in managing fevers. The bark and leaves are used to prepare a decoction that is consumed to reduce fever (Singh et al. 2010). *A. latifolia* bark is used in oral care. Chewing on the bark or using a decoction as a mouthwash helps in maintaining gum health, treating bleeding gums, and preventing dental caries (Deepika et al. 2024). The plant is used in the treatment of various skin disorders. It is applied topically to manage conditions like eczema, rashes, and boils. The bark helps in managing hemorrhoids by reducing bleeding and inflammation. The plant treats respiratory ailments such as

cough, bronchitis, and asthma (Kumar et al. 2022; Nayak and Kumar 2023). The decoction of the leaves and bark is taken to provide relief from these conditions. The bark is used to expel parasitic worms and other internal parasites from the body, helping in maintaining digestive health. In some traditional practices, the plant is used to manage diabetes by regulating blood sugar levels. The plant is utilized in treating liver disorders and promoting liver health (Deepika et al. 2024).

BIOACTIVE COMPOUNDS

A. latifolia has been under extensive research because of its wide bioactive compounds. Some of the primary bioactive constituents of *A. latifolia* are tannins, flavonoids, glycosides, steroid, triterpenoid and saponins (Rahman et al. 2007). The bark is plenty rich in tannins, which define the core of its strong antioxidant and antimicrobial properties (Deshpandey et al. 1977). Several tannins have been isolated from the plant as 3,4,3'-tri-O-methylellagic acid, 3,4,3' -tri-O-methyl flavellagic acid, 3,3'-di-Omethylellagic acid 4'- β -D-xyloside, 3,3'-di-O- methyl ellagic acid 4'- β -D-glucoside, chebulic acid, corilagin and trigallic acid (Hassan et al. 2023). These molecules are responsible for the traditional uses in wound and dysenteric patients. Flavonoids from *A. latifolia* were screened for anti-inflammatory and anticancer activities. Natural antioxidants scavenge free radicals, protect cells from oxidative stress, and reduce the chances of chronic diseases in the body (Dubey et al. 2012; Hassan et al. 2023). The medicinal properties of the plant are also influenced by the presence of glycosides and saponins. Glycosides are known to play a role in cardio protection and antimicrobial activity, while saponins exhibit several activities that include expectorant, anti-inflammatory, and immunomodulatory activity (Reddy et al. 1965; Patil and Gaikwad 2011). It has been found that extracts from *A. latifolia* demonstrated profound antimicrobial activities against a wide spectrum of bacterial and fungal pathogens (Rahman et al. 2007; Chandraiah 2021). This identifies the plant as one that will have great potential in the development of new antimicrobial compounds, especially in the face of growing antibiotic resistance.



Plate 1: Fruits and leaves of *A. latifolia* in wild



Plate 2: Leaves and bark of *A. latifolia* in wild

The extracts showed hepatoprotective and nephroprotective effects, thus implying their potential for supporting the health of both the liver and kidney (Dubey et al. 2012). It is, therefore, a very valuable medicinal plant with so many bioactive compounds. The validation through scientific studies on the pharmacological potential of the plant for treating several diseases and in the discovery of drugs.

PHARMACOLOGICAL POTENTIALS

A. latifolia is a native Indian and South-East Asian tree that has been used, for a very long period, in indigenous medicine for varied purposes. Some pharmacological activities associated with *A. latifolia* are:

Antimicrobial Activity: Extractions from the bark and leaves showed high antimicrobial activity against different bacterial and fungal micro-organisms. Therefore, this plant will be quite effective in treating infections and curing wounds (Govindarajan et al. 2006; Singh et al. 2010).

Antioxidant Activity: It has been claimed to contain compounds with strong antioxidant activity (Deepika et al. 2024)

Anti-inflammatory Activity: *A. latifolia* extracts have been reported to have anti-inflammatory activity, which is helpful in reducing inflammation in various diseases (Parvathi et al. 2009).

Hepatoprotective Activity: This tree has been reported to protect the liver against damage caused by toxins and hence is beneficial for the treatment of hepatic disorders (Dubey et al. 2012; Deepika et al. 2024).

Antidiabetic Activity: Some studies indicate that the extracts of the plant could lower blood glucose and, therefore, are likely to be useful in the management of diabetes (Rajani et al. 2014).

Anti-ulcer Activity: The extracts of *A. latifolia* have been reported to show gastroprotective effects through the prevention of gastric ulcers likely via their antioxidant and anti-inflammatory properties (Govindarajan et al. 2004; Singh et al. 2010).

Anticancer Activity: Preliminary studies have shown that some compounds from *A. latifolia* have anticancer properties with cancer cell proliferation inhibiting activity (Diab et al. 2015).

Wound Healing: Traditional uses of the plant include application in wound healing. These uses are supported by scientific studies that have so far revealed that the plant enhances faster wound repair (Singh et al. 2010).

CONCLUSION

Anogeissus latifolia stands out as a highly valuable medicinal plant with diverse applications in traditional and modern medicine. Its rich content of bioactive compounds, particularly tannins, flavonoids, terpenes, and saponins, underpins its wide-ranging pharmacological activities, making it a key resource for developing health care products and drugs. The tree's significant role in traditional Ayurvedic medicine is complemented by scientific validation of its therapeutic potential. With demonstrated antimicrobial, antioxidant, anti-inflammatory, hepatoprotective, antidiabetic, anti-ulcer, anticancer, and wound healing properties, *A. latifolia* contributes substantially to contemporary medicine, particularly in the face of increasing antibiotic resistance and the ongoing search for natural therapeutic agents.

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Chapter IV

***Combretum albidum* G. Don: a medicinal liana of India**

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ABSTRACT

Combretum albidum is a significant medicinal climber belonging to the family Combretaceae, widely recognized for its therapeutic properties in traditional medicine. Phytochemical studies of *C. albidum* have revealed the presence of various bioactive compounds, including flavonoids, tannins, saponins, and alkaloids, which are associated with its medicinal properties. Traditionally, different parts of the plant, such as leaves, roots, and bark, are used in the treatment of ailments like fever, diarrhoea, wounds, and skin infections. It also exhibits potential antibacterial, antifungal, and antioxidant activities, making it a promising agent for the development of novel therapeutics. Keeping this in mind, an attempt has been made to present its botany, ecology and associated plants to bring attention towards its conservation in natural habitat. The photographs are provided for the easy identification in the field.

Keywords: *Combretum*, medicinal climber, traditional medicine, phytochemicals, pharmacological uses

INTRODUCTION

The family Combretaceae is also known as ‘The Indian almond family’. The species of this family are evergreen trees, shrubs, or lianas that are found mainly in tropical and subtropical Africa, Asia, and America (Bokhad and Rothe 2013; Sharma et al. 2021). Generally, leaves are simple and arranged alternately while flowers tend to be small and white or yellowish. Some of the notable genera include: *Combretum*, *Terminalia*, *Conocarpus*, etc. The family is ecologically and economically significant, providing timber, fuelwood, and medicinal products (Zalke et al. 2018).

For their antimicrobial and anti-inflammatory properties, most of the species have been used in traditional medicine. Additionally, fruits from this family such as Indian almond (*Terminalia catappa*) can also be eaten and contain a wide range of nutrients. The family has great significance in different ecosystems as well as human societies by providing a diverse range of benefits and usage (Ejidike et al. 2023). Among them, *Combretum albidum* commonly known as “Buffalo Calf” in English. It is extensive a woody twine that occupies the upper canopy of the host tree. Its distribution is limited to semi-evergreen and dry deciduous forests, particularly along riverbanks (Zalke et al. 2018). It is a valuable plant known for its numerous medicinal applications. It has been utilized for medicinal purposes by tribal communities for an extended period in India. Various parts of the plant contain significant chemical constituents that contribute to its therapeutic properties (Bokhad and Rothe, 2013). The plant has a history of usage as old as records exist in African and Asian traditional medicine. It is known popular as Ayurvedic medicine and is used for fever, diarrhoea, skin infections, and many other diseases. Pharmacological studies on *C. albidum* have proven its activity as an antimicrobial, antioxidant, anti-inflammatory, and anticancer agent.

The plant contains several active compounds like flavonoids, phenolic acids, and terpenoids which exert medicinal properties (Sharma et al. 2021). The heart wood of the plant also yields beta sitosterol, gallic acid, ellagic acid, oleanolic acid, betulinic acid, arjunolic acid, botulin, ursolic acid, beta sitosterol and gallic acid (Kumar et al. 2015). The present study deals with the exploration of this medicinal plant, its morphology, and medicinal and pharmacological uses.

MORPHOLOGY

C. albidum is a deciduous climber native to tropical and subtropical regions of Africa. The morphology of *C. albidum* is below (Saxena and Brahmam, 1995; Sharma et al. 2021; Plate 1):

Leaves: The leaves are simple, alternate, and arranged spirally along the stem. They are ovate or elliptical in shape, with a slightly acute or obtuse apex. The base of the leaf is rounded. The upper surface is dark green, while the undersides are paler. Leaf venation is pinnate.

Flowers: The flowers are small and arranged in spikes at the end of branches. These spikes form short, oblong, or almost globe-like clusters. The flower color is typically yellowish-white. Each flower has five petals and numerous stamens.

Inflorescence: The inflorescence consists of terminal spikes. These spikes are composed of densely packed flowers.

Sepals and Petals: Sepals are triangular-ovate and curve outward. There is a hairy ring below the insertion of the stamens. Petals are small and inconspicuous.

Fruits: The fruit is a globose capsule. When young, it is green, but it turns red as it matures. The capsule has four wings. Each fruit contains a solitary seed.

MEDICINAL USES

C. albidum is used as a folk remedy to treat various ailments. The plant is used as an effective remedy for jaundice, diarrhoea, dysentery, and skin problems by Muthuvans, Chinnar tribe of Idukki District, Kerala, and

Paliyan tribes in Sirumalai Hills of Eastern Ghats (Sreedhar et al. 2013). Leaves of *C. albidum* are used for treating jaundice. They have been traditionally employed to address liver-related problems (Kumar et al. 2015). Leaves are reported to cure wounds and cuts. The bark of this plant is utilized for managing various skin infections to help soothe skin ailments and promote healing. A decoction made from the fruits of *C. albidum* is used to treat dysentery and diarrhoea (Zalke et al. 2013). The fruit extracts may have antimicrobial and anti-inflammatory effects. The stem, seed oil, and roots of this plant are reported to address eye-related issues. The oil or extracts may help alleviate eczema symptoms. Seed oil and root are reported to cure eye problems, malarial fever, and eczema (Bokhad and Rothe, 2013). In summary, *C. albidum* holds promise as an unexplored medicinal plant with potential therapeutic applications. Further research into its chemical constituents and pharmacological activities could enhance its role in healthcare.

BIOACTIVE COMPOUNDS

C. albidum, is known for its rich content of bioactive compounds with significant medicinal properties. Among these, glycoside, carbohydrate, flavonoid, phytosterols, phenolic compounds, and saponin are the most prominent. These compounds exhibit strong antioxidant, antimicrobial, and anti-inflammatory activities, making the plant valuable in traditional medicine (Rajalingam et al. 2016; Kumar et al. 2017). Tannins contribute to their astringent properties, while flavonoids are known for their ability to scavenge free radicals, thus protecting cells from oxidative damage (Chandari and Ramasamy, 2016).

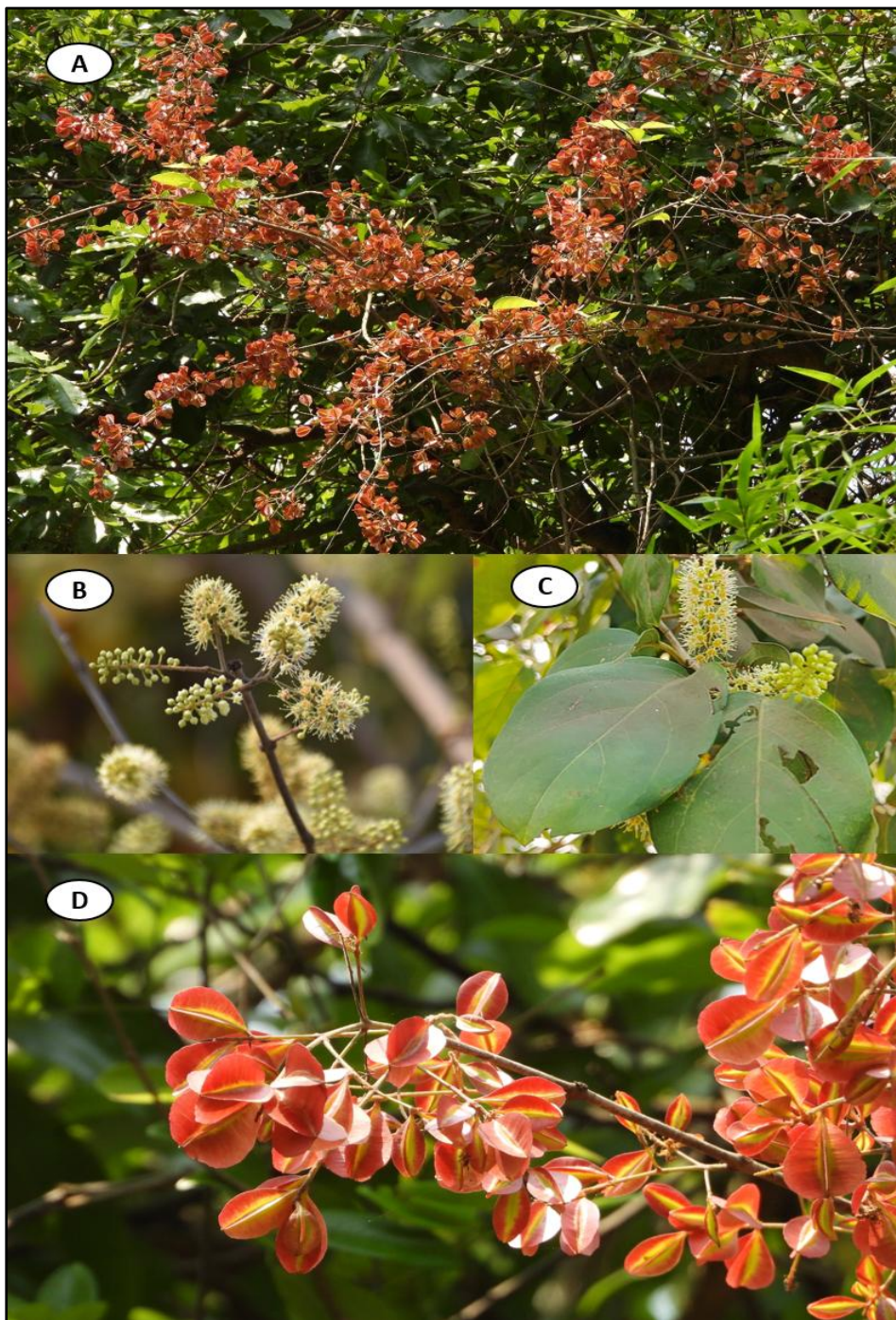


Plate 1: A) Habitat of *C. albidum*, B) Flower, C) Leaf, D) Fruits of *C. albidum*

The presence of a phenolic group of compounds further enhances the plant's therapeutic potential, as they are involved in the prevention of various diseases, including cardiovascular disorders. Additionally, alkaloids and saponins found in *C. albidum* play significant roles in anti-cancer and anti-diabetic effects (Bokhad and Rothe, 2013; Sharma et al. 2021).

PHARMACOLOGICAL USES

Some pharmacological activities associated with *C. albidum* are antioxidant activity, antimicrobial activity, anti-inflammatory activity, antidiabetic activity, anticancer activity, analgesic activity, and wound healing activities (Sreedhar et al. 2012; Kumar et al. 2017). It contains high levels of phenolic compounds and flavonoids, which have strong antioxidant properties. Extracts from *C. albidum* have been shown to possess antimicrobial properties, effective against a range of bacteria, fungi, and viruses. This could suggest potential applications in treating infections (Chandari and Ramasamy, 2016; Sharma et al. 2021). It is also a potential species for managing inflammatory conditions. It has been used traditionally to manage diabetes. It may have anticancer properties, possibly through mechanisms like apoptosis induction in cancer cells. It is often used for pain relief. This suggests that *C. albidum* may also have analgesic properties (Rajalingam et al. 2016). It has also been traditionally used in wound healing due to its antimicrobial and anti-inflammatory properties, which could accelerate the healing process (Kumar et al. 2017).

CONCLUSION

The medicinal and pharmacological activities of *C. albidum* shows potential value as a key therapeutic agent. It is abundant in bioactive

compounds, in which there are tannins, flavonoids, phenolic acids, alkaloids, and saponins. It has also a vast array of pharmacological values, like antioxidant, anti-inflammatory, antimicrobial, anti-cancer, and anti-diabetic activities. These activities not only validate its traditional use in herbal medicine. It is essential to utilize analytical methods to thoroughly identify and quantify the bioactive compounds present. Comprehensive pharmacological investigations, including clinical trials, are necessary to validate its effectiveness and safety for applications in human health.

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Chapter V

***Terminalia bellirica* (Gaertn.) Roxb. (Combretaceae): a medicinal tree of India**

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ABSTRACT

Terminalia bellirica, commonly known as Belleric Myrobalan, is a significant medicinal tree native to India and other parts of Southeast Asia. Esteemed in traditional medicine systems such as Ayurveda and Unani, *T. bellirica* is renowned for its diverse therapeutic properties. The tree is rich in bioactive compounds, including tannins, flavonoids, phenolic acids, saponins, and triterpenoids. These compounds impart a wide range of pharmacological activities, including potent antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, and hypolipidemic values. The present study highlights the importance of *T. bellirica* in traditional medicine and modern therapeutic applications.

Keywords: *Terminalia*, therapeutic potential, pharmacological uses, bioactive compounds

INTRODUCTION

Terminalia bellirica is recognized as one of the ancient medicinal plants (Nayak and Kumar, 2023) found in India, Pakistan, Nepal, Bangladesh, Sri Lanka, and Southeast Asia. Its therapeutic applications have been documented across various traditional medicinal practices, including Ayurveda, Unani, Siddha, and Traditional Chinese Medicine (Gupta et al.

2022). *T. bellirica* is found in deciduous forests across a greater portion of India, excluding arid areas. Its presence is noted in the upper Gangetic plains, Chota Nagpur, Bihar, Odisha, West Bengal, Konkan, Deccan, and the majority of South India (Kumar and Khurana, 2018). It is a large deciduous tree characterized by its broadly elliptical leaves. It possesses antibacterial, antioxidant, and anthelmintic properties. It is an Ayurvedic herb employed for both preventive and therapeutic applications. An important Ayurvedic formulation, Triphala consists of Bahada, Amla, and Harada (Gilani et al. 2008). Herbal medicines are derived from various plant components, including leaves, stems, roots, and bark. These preparations predominantly consist of biologically active compounds and are primarily utilized for the treatment of mild to chronic health conditions. In India, Ayurvedic remedies are widely practiced, with several Ayurvedic formulations used to cure colds, coughs, dysentery, and poor appetite (Yadav et al. 2012; Sharma et al. 2021). It is utilized in traditional medicine due to the extensive range of pharmacological effects linked to the biologically active secondary metabolites found in this plant. A diverse array of phytochemicals has been extracted from different parts of the plant, including alkaloids, coumarins, flavonoids, steroids, lignans, tannins, glycosides, terpenoids, and saponins which are responsible for various pharmacological activities like anti-diabetic, anti-microbial, anti-salmonella, anti-biofilm, anticancer, hepatoprotective, antipyretic and anti-diarrheal (Kumari et al. 2017; Rashed, 2021). This study focuses on the investigation of this medicinal tree, examining its morphology as well as its medicinal and pharmacological potentials.



Plate 1: Vegetative parts of *T. bellirica* (Photo credit: Sweta Mishra)

MORPHOLOGY

T. bellirica, typically grows to a height of 20 to 35 meters, with a straight trunk that can measure up to 2 meters in diameter. The leaves of *T. bellirica* are simple, alternate, and broadly ovate, measuring about 10 to 15 cm in length and 7 to 10 cm in width. They have a glossy surface with a rounded or heart-shaped base, and the leaf margin is smooth. The leaves are arranged in a spiral pattern towards the ends of branches, creating a dense canopy. Flowers of *T. bellirica* are small, yellowish-white, and arranged in spikes that are about 10 to 15 cm long. These flowers are bisexual, meaning they contain both male and female reproductive organs. The flowering season generally occurs from April to June. The fruit is a distinctive feature of *T. bellirica*. It is a drupe, oval, or ellipsoid in shape, and measures about 2 to 4 cm in length. The fruit is green when unripe and turns a yellowish-brown or greyish color upon maturity. The surface of the fruit is covered with fine, velvety hairs. Inside the fruit is a single, large seed that is hard and dark brown (Saxena and Brahmam, 1995; Gupta et al. 2020; Kumar et al. 2022; Plate 1).

MEDICINAL USES

Various parts of the *T. bellirica* plant are used for their therapeutic properties (Chanda et al. 2013; Gupta et al. 2020; Rashed, 2021; Sharma et al. 2021):

Fruits: The fruits are used to treat respiratory conditions such as asthma and bronchitis, helping to clear the airways and reduce inflammation. They may have hepatoprotective properties, aiding in liver function and helping to manage hepatitis. The fruit is known for its astringent properties, which help to treat diarrhoea by reducing intestinal motility. It can help to

alleviate symptoms of piles (hemorrhoids) by reducing inflammation and pain. It aids in digestion and can relieve symptoms of indigestion. They are also used to treat various eye conditions due to their anti-inflammatory and antioxidant properties. It can soothe the throat and restore normal voice in cases of hoarseness. Traditional use includes applying the fruit to neutralize venom and reduce pain from scorpion stings. The fruit is believed to promote hair growth and improve hair health. It helps in regulating menstrual cycles and alleviating related symptoms. Green fruit decoction is specifically used to treat coughs. The pulp is used to treat diarrhoea and leprosy due to its antimicrobial and astringent properties. It can be applied to reduce the symptoms of piles. The ripened fruit acts as a strong laxative, helping in clearing the bowels. It may have sedative properties, providing relief from pain and inducing sleep.

Bark: The gum and kernel oil are used as a laxative. These are applied to alleviate symptoms of rheumatism, such as joint pain and stiffness.

Leaves: The leaves can help improve appetite. They are used to treat hemorrhoids by reducing inflammation and discomfort. The leaves have properties that help in lowering cholesterol levels and blood pressure, contributing to overall heart health. They help to strengthen the immune system. The leaves have antioxidant properties, which help in slowing down the aging process.

This plant is highly valued in traditional medicine for its wide range of therapeutic uses, particularly for digestive, respiratory, and immune system health.

BIOACTIVE COMPOUNDS

T. bellirica is renowned for its medicinal properties in traditional medicine, particularly in Ayurveda. This tree's therapeutic potential is largely attributed to its diverse range of bioactive compounds, including tannins, flavonoids, phenolic acids, saponins, and triterpenoids (Kumar et al. 2023). Among the tannins, ellagitannins, and gallotannins are especially significant, known for their potent antioxidant, anti-carcinogenic, and anti-inflammatory properties. Flavonoids, particularly quercetin and rutin, further enhance their medicinal value (Kumar et al. 2010; Sharma et al. 2010). The phenolic acids, mainly gallic and ellagic acids (Figure 1), are known for antioxidant and anti-inflammatory capabilities, contributing to their role in traditional remedies for various ailments.

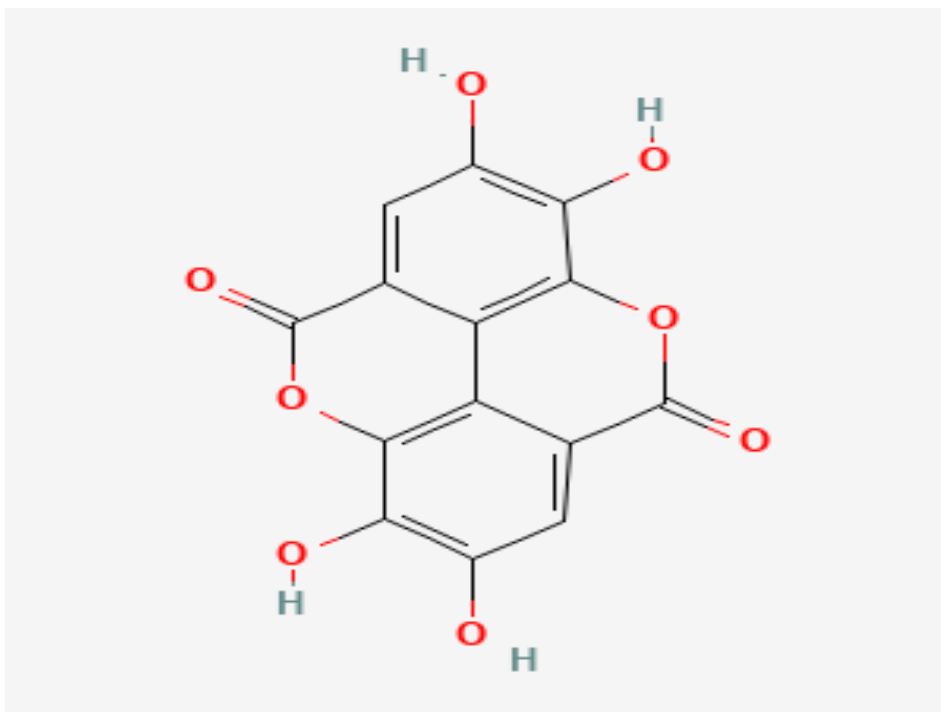


Figure 1: Structure of ellagic acids (Source: PubChem)

Saponins, exhibit antimicrobial and immunomodulatory properties, making them effective against a wide range of pathogens, including bacteria, fungi, and viruses (Kumari et al. 2017). Triterpenoids, including belleric acid and beta-sitosterol, also play a vital role in the plant's therapeutic efficacy. *T. bellirica* stands as a remarkable example of nature's pharmacy, offering a wealth of bioactive compounds with significant health benefits that continue to be harnessed both in traditional practices and modern pharmacology (Gupta et al. 2020).

PHARMACOLOGICAL ACTIVITIES

T. bellirica exhibits a wide range of pharmacological activities. The fruits are rich in bioactive compounds such as tannins, flavonoids, phenolic acids, and triterpenoids, which contribute to their diverse therapeutic properties (Saraswathi et al. 2012). One of the most prominent pharmacological activities of *T. bellirica* is its antioxidant capacity, primarily due to the presence of compounds like ellagic acid and gallic acid (Khan and Gilani, 2010; Sharma et al. 2021). These antioxidants help neutralize free radicals, thereby reducing oxidative stress and preventing cellular damage, which is crucial in managing chronic diseases like cancer, diabetes, and cardiovascular disorders (Kumar et al. 2010). Additionally, *T. bellirica* possesses significant anti-inflammatory activity, which is beneficial in treating conditions associated with inflammation, such as arthritis, asthma, and gastrointestinal disorders. The anti-inflammatory effect is largely attributed to its ability to inhibit pro-inflammatory mediators and enzymes (Nag and De, 2011; Saraswathi et al. 2012). Moreover, *T. bellirica* has demonstrated potent antimicrobial properties, effective against a wide range of pathogens, including bacteria, fungi, and

viruses, making it useful in treating infections and promoting wound healing. The fruit also exhibits hepatoprotective activity, protecting the liver from damage caused by toxins and diseases, which is supported by its traditional use in managing liver disorders (Chanda et al. 2013; Hanem et al. 2015). Furthermore, *T. bellirica* shows hypolipidemic activity, aiding in the reduction of cholesterol levels and thus playing a role in cardiovascular health. Its immunomodulatory effects, which enhance the body's immune response, further contribute to its therapeutic potential (Sabnis, 2014). Overall, the pharmacological activities of *T. bellirica* make it a valuable medicinal resource in preventing and treating various health conditions (Madani and Jain, 2008).

CONCLUSION

T. bellirica is a prominent medicinal tree with a rich heritage in traditional Indian medicine. Its therapeutic efficacy is largely attributed to its complex array of bioactive compounds. Despite its established traditional uses, continued scientific research is essential to fully elucidate and validate these medicinal properties, potentially leading to the development of new therapeutic agents. The integration of *T. bellirica* into modern pharmacological practices could offer valuable insights into natural remedies and promote its use in contemporary healthcare systems.

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Chapter VI

The Ancient Healer: Exploring the Medicinal Properties of *Terminalia arjuna*(Roxb. ex DC.) Wight & Arn.

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ABSTRACT

Terminalia arjuna, commonly known as Arjuna, is a deciduous tree of the family Combretaceae, widely distributed across the Indian subcontinent. Renowned in traditional medicine, especially Ayurveda, it has been utilized for its cardioprotective, hepatoprotective, and antioxidant properties. The bark, rich in bioactive compounds such as flavonoids, tannins, glycosides, and triterpenoids, is a key therapeutic part of the plant. It is traditionally used to treat cardiovascular disorders, diabetes, ulcers, and respiratory ailments. Modern pharmacological studies corroborate its efficacy in improving cardiac function, reducing hypertension, and enhancing lipid metabolism. This study highlights the importance of *T. arjuna* in traditional medicine and modern pharmacology and advocates for its sustainable utilization and further research to unlock its full potential.

Keywords: *Terminalia*, therapeutic potential, pharmacological uses, bioactive compounds

INTRODUCTION

Terminalia arjuna, commonly known as Arjuna, is a deciduous tree belonging to the Combretaceae family, predominantly found across the Indian subcontinent. This plant has been integral to traditional Ayurvedic medicine for centuries, primarily recognized for its cardioprotective properties. The bark of *T. arjuna* has been extensively utilized in treating various cardiovascular ailments, including ischemic heart disease, hypertension, and heart failure. The historical significance of this plant in Ayurvedic practices dates back to at least 500 BC, when it was esteemed for its ability to enhance cardiac function and overall health (Harshita and Sharma 2021; Kaur et al. 2014). The therapeutic efficacy of *T. arjuna* is attributed to its rich phytochemical profile, which includes flavonoids, tannins, glycosides, and triterpenoids such as arjunic acid and arjungenin (Thakur et al. 2021). These compounds exhibit a range of biological activities, including antioxidant, anti-inflammatory, and hypolipidemic effects. Extracts from *T. arjuna* can significantly lower total cholesterol, triglycerides, and low-density lipoprotein (LDL) levels in hyperlipidemic models (Barman and Das 2012; Borde et al. 2018). Additionally, the antioxidant properties of the plant's constituents help mitigate oxidative stress, which is a contributing factor in cardiovascular diseases (Gauthaman et al. 2005; Hebbani et al. 2021). Furthermore, the plant has the ability to manage diabetes and improve insulin sensitivity (Barman and Das 2012; Borde et al. 2018; Dwivedi and Chopra 2014). In addition to its cardiovascular and antidiabetic effects, *T. arjuna* has been explored for its anticancer properties (Kuo et al. 2005). *T. arjuna* is a significant medicinal plant with a long history of use in traditional medicine. Its diverse pharmacological properties, particularly in cardiovascular health and

metabolic regulation, make it a valuable subject for further research and clinical application.

MORPHOLOGY

It is a large evergreen deciduous tree that can grow to a height of 20-25 m with a wide spreading canopy. The bark is smooth, grayish-white or slightly pinkish, silvery-grey in color, shedding in thin strips. This is one of the main parts used medicinally because of the high content of phytochemicals. The leaves are simple, opposite, and sub-opposite in arrangement. The leaves are elongated or elliptic, with rounded or slightly notched apex and glabrous leathery texture. Leaves are about 10-20 cm long, 4-7 cm wide, shiny dark green above and with pale underside. Flowers are small, inconspicuous, and yellowish to whitish, borne in clusters (spikes) in leaf axils. They bloom usually between March and June. The flowers are mildly aromatic and are bisexual- both male and female parts are found. The fruit is a woody, fibrous drupe shaped like an elongated 2.5-5 cm long and has five to seven hard-winged ridges [Plate 1]. Fruits mature in the fall from September to December (Kumar et al. 2022; Saxena and Brahmam 1995).

MEDICINAL USES

Ayurvedic medicine has a high esteem for Arjuna, due to its apparent health benefits with a focus on conditions affecting the heart. Ancient texts describe it as a “heart tonic,” and it has been widely used to treat cardiovascular conditions (Verma et al. 2023). The bark, rich in tannins, saponins, and glycosides, is often prepared as a decoction or powder to strengthen the heart muscles, regulate blood pressure, and alleviate symptoms of heart diseases (Maulik and Talwar 2012). Traditional healers

used Arjuna to manage heart palpitations and reduce cholesterol levels, making it a staple in Ayurvedic heart care. The therapeutic applications of *T. arjuna* extend beyond cardiovascular health; it has been traditionally used to treat conditions such as ulcers, diabetes, and dysentery (Kaur et al., 2014; Tahsin et al. 2021). *T. arjuna* can also be used for the treatment of respiratory disorders in addition to heart problems. Its use in alleviating asthma, bronchitis, and coughs has been attributed to its anti-inflammatory and soothing qualities. The bark has a cooling and astringent property and has therefore been used traditionally for the treatment of wounds, skin ulcers, and burns, and, in some cases, has been applied as a paste to relieve burnt skin or mixed into other ingredients for treating digestive complaints such as diarrhoea and dysentery. *T. arjuna* has a long history of being used in traditional medicine as a panacea for any and every ailment affecting the heart, lungs, and skin (Kaur et al. 2014; Verma et al. 2023).

BIOACTIVE COMPOUNDS

T. arjuna is recognized for its diverse bioactive compounds that contribute to its therapeutic efficacy. The bark of *T. arjuna* is particularly rich in phytochemicals, including tannins, flavonoids, glycosides, and triterpenoids, which are responsible for its various pharmacological activities (Abo-Elghiet et al. 2022; Kaur et al. 2014; Stepnik 2023). Among these compounds, triterpenoid saponins such as arjunic acid and arjunolic acid have been highlighted for their cardioprotective properties, while flavonoids like quercetin exhibit significant antioxidant effects (Amalraj and Gopi 2017; Tahsin et al. 2021). Phytochemical screening has revealed that *T. arjuna* contains a variety of bioactive constituents, including phytosterols, lactones, and phenolic compounds, which contribute to its

anti-inflammatory and antioxidant properties (Mandal et al. 2013). The presence of these compounds allows *T. arjuna* to scavenge reactive oxygen species (ROS), thereby mitigating oxidative stress, which is implicated in numerous chronic diseases (Chatha et al. 2014; Tahsin et al. 2021). *T. arjuna* is a valuable source of bioactive compounds that confer a wide range of health benefits. Its rich phytochemical profile, characterized by triterpenoids, flavonoids, and tannins, supports its use in traditional medicine for the treatment of various ailments, particularly those related to cardiovascular health and oxidative stress. Different triterpenoids, such as arjunolic acid, arjunic acid, arjungenin, arjunetin, arjunoglycoside, arjunoglucoside, arjunoside, arjunoside, arjunoside, terminic acid, arjunolitin, terminolitin, arjunoside, methyl oleanate, arjunetoside, lupeol, oleanolic acid, arjunoglucoside, β -sitosterol-d-glucoside, arjunin, casuarinin, ellagic acid, and gallic acid, as well as flavonoids like leucocyanidin, cerasidin, quercetin-7-o-rhamnoside, and luteolin, were isolated from different parts of the plant (Jain et al. 2009).

PHARMACOLOGICAL USES

T. arjuna is a significant medicinal plant in traditional Ayurvedic medicine, primarily recognized for its cardioprotective properties. The pharmacological uses of *T. arjuna* are extensive, with a focus on cardiovascular health, metabolic disorders, and various other therapeutic applications. The bark of *T. arjuna* is particularly noted for its ability to manage coronary artery diseases, heart failure, and hypercholesterolemia, primarily due to its antioxidant properties that help in scavenging free radicals (Subramaniam et al. 2011). The active constituents of *T. arjuna*, including tannins, flavonoids, and triterpenoid saponins, contribute to its



Plate 1: Vegetative parts of *T. arjuna* a) Leaf and flower, b) bark, c) Inflorescence, d) flowers, e) fruits

cardiotonic effects, which have been validated through various studies (Kaur et al. 2014; Ramesh and Palaniappan 2023). It exhibits significant hypolipidemic effects, leading to reductions in total cholesterol (TC), triglycerides (TG), very low-density lipoprotein (VLDL), and low-density lipoprotein (LDL) levels in hyperlipidemic models (Tahsin et al. 2021). These effects are attributed to the plant's ability to modulate lipid metabolism and enhance antioxidant defences, which collectively mitigate oxidative stress associated with cardiovascular diseases (Gauthaman et al. 2005). Furthermore, *T. arjuna* has been shown to improve endothelial function and reduce the risk of ischemic heart disease, making it a valuable therapeutic agent in the management of cardiovascular conditions (Ramesh and Palaniappan 2023). In addition to its cardiovascular benefits, *T. arjuna* has demonstrated anti-diabetic properties. Extracts from the bark can enhance insulin sensitivity and improve glycemic control in diabetic models (Dwivedi and Chopra 2014). Its anti-inflammatory properties, mediated by the inhibition of prostaglandin production, further support its use in treating conditions characterized by inflammation (Tahsin et al. 2021). The plant's ability to enhance baroreflex sensitivity and myocardial function further underscores its role in managing heart-related ailments (Parveen et al. 2012). Furthermore, studies have indicated that *T. arjuna* possesses hepatoprotective effects, particularly against cadmium-induced toxicity, highlighting its potential for detoxification and liver health (Haidry and Malik 2014). The antimicrobial activity of *T. arjuna* is another significant aspect of its pharmacological profile. The plant has shown efficacy against various pathogens, including bacteria and fungi, which can be attributed to its rich phytochemical composition (Abo-Elghiet et al. 2022; Akter et al. 2019; Gupta and Kumar 2017). This antimicrobial

property is particularly relevant in the context of treating infections and enhancing overall health, further establishing *T. arjuna* as a versatile medicinal plant. It has been explored for its anti-urolithic effects, with studies indicating its ability to inhibit calcium oxalate crystal formation, thereby preventing kidney stones (Mittal et al. 2015). The extract's protective effects against oxidative damage, particularly in erythrocyte membranes, also underscore its potential in mitigating oxidative stress-related disorders (Hebbani et al. 2021).

CONCLUSION

T. arjuna is a revered medicinal tree in India, deeply rooted in traditional Ayurvedic practices and known for its significant health benefits, particularly for cardiovascular health. The tree's bark, enriched with bioactive compounds such as tannins, flavonoids, triterpenoids, glycosides, and saponins, has made it a cornerstone in treating heart ailments, regulating blood pressure, and reducing cholesterol levels. Beyond heart health, *T. arjuna* offers anti-inflammatory, antioxidant, hepatoprotective, and antimicrobial properties, supporting diverse treatments for respiratory, digestive, and skin-related conditions. As research continues to validate its traditional uses, *T. arjuna* stands out as a natural, multifaceted remedy with therapeutic potential that extends beyond traditional medicine into modern healthcare.

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Chapter VII

Botany, chemistry, and pharmacological applications of *Terminalia catappa* L.

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ABSTRACT

Terminalia catappa, a tropical tree species, has been extensively used in traditional medicine for its diverse range of medicinal properties. This review aims to summarize the current knowledge on the medicinal, pharmacological, and bioactive properties of *T. catappa*. The tree's various parts, including the bark, leaves, fruits, and stem bark, have been found to exhibit antifungal, antimicrobial, antioxidant, anti-inflammatory, antidiabetic, hepatoprotective, and anticancer activities. Phytochemical analysis has revealed the presence of bioactive compounds, including alkaloids, tannins, steroids, cardiac glycosides, flavonoids, phenols, saponins, coumarins, phenols, flavonoids, and carotenoids. The tree's potential in managing various health conditions, including dysentery, gastritis, diabetes, hypertension, and cancer, is highlighted. This review underscores the importance of *T. catappa* as a valuable resource for developing new medicines and treatments and emphasizes the need for further research to fully exploit its medicinal and pharmacological potential.

Keywords: *Terminalia*, medicinal uses, bioactive compounds

INTRODUCTION

Terminalia catappa, commonly referred to as the Indian Almond, Tropical Almond, Sea Almond, or Malabar Almond, is a tropical tree species native to South Asia, Southeast Asia, and the Pacific regions (Thomson and Evans 2006). Due to its ornamental value, adaptability, and ecological benefits, it has been extensively cultivated and naturalized in tropical and subtropical regions worldwide (Thomson and Evans 2006; Present study). This highly adaptable species thrives in diverse environments, from coastal areas to inland regions, and prefers well-drained soils. Its ability to tolerate high salt levels and withstand strong winds makes it an ideal tree for coastal afforestation and erosion control. The tree's symmetrical growth habit, vibrant foliage, and dense canopy also make it a popular choice for landscaping and urban greening projects. The fruit kernel is edible, rich in oil, and has a distinct nutty flavour, while the leaves are sometimes used in traditional cooking (Tercas et al. 2017). The tree has been extensively used in traditional medicine, with its leaves, bark, and fruit exhibiting anti-inflammatory, antioxidant, and antimicrobial properties. Decoctions made from the leaves are used to treat various ailments, including diarrhoea, dysentery, and liver disorders (Anand et al. 2015). In addition to its medicinal properties, *T. catappa* provides numerous ecological benefits, including shade, soil erosion prevention, and microclimate improvement (Present study). The tree also absorbs carbon dioxide, contributing to climate change mitigation. Furthermore, its leaves are used in aquariums and fish farms to maintain water quality and promote the health of aquatic organisms (Nurhidayata et al. 2024). Despite its hardiness, *T. catappa* faces threats such as habitat destruction and overexploitation for its durable and termite-resistant wood. Conservation efforts are essential to maintain the

ecological and economic value of this versatile tree. With its adaptability, multiple uses, and significant ecological, economic, and cultural importance, *T. catappa* is a vital species for biodiversity conservation and sustainable development initiatives. Keeping the importance of this tree species, an attempt has been made to gather information on its botany and significance through literature and field surveys during 2022-2024 and presented the results in the communication.



Figure 1: Leaves of *Terminalia catappa*

MORPHOLOGY

T. catappa is a striking, medium to large deciduous tree, capable of reaching heights of up to 35 meters. Its distinctive pagoda-like form is characterized by a symmetrical crown and horizontally arranged, tiered branches. As the tree matures, its crown flattens and expands into a vase-

like shape, adding to its aesthetic appeal. The tree's large, obovate leaves are leathery to the touch and display vibrant hues of red, yellow, and orange before falling, making *T. catappa* a highly ornamental species (Figure 1). Small, greenish-white flowers are borne in terminal spikes, with male and female flowers occurring on the same tree, a characteristic known as monoecy. The fruit of *T. catappa* is a drupe, featuring a fibrous outer layer that encloses a hard seed (Saxena and Brahmam 1995; Figure 2).



Figure 2: Fruits of *Terminalia catappa*

MEDICINAL AND PHARMACOLOGICAL VALUES

T. catappa has been found to possess various medicinal properties. The bark of the tree has been used to treat dysentery, as reported by Tercas et al. (2017). The leaves of the tree have been found to exhibit antifungal properties, also reported by Tercas et al. (2017), and antimicrobial and antioxidant properties, as reported by Mwangi et al. (2024). The fruits of

T. catappa have been found to possess anti-inflammatory, antidiabetic, antioxidant, hepatoprotective, and anticancer activities, as reported by Anand et al. (2015). The leaves of the tree have also been used to treat gastritis, as reported by Pinheiro et al. (2015), and diabetes, as reported by Iheagwam et al. (2022) and Divya et al. (2019). Additionally, the stem bark of *T. catappa* has been found to have the potential to treat hypertension, as reported by Dada et al. (2021). The leaves of the tree have also been found to possess anticancer properties, as reported by Zarredar et al. (2021), antimicrobial properties, as reported by Allyn et al. (2018), and anti-inflammatory activity, as reported by Fan et al. (2004). Furthermore, the leaves have been found to have hypoglycemic and hematological potentials, as reported by Ben et al. (2024). Details are in Table 1.

Table 1: Medicinal uses of *Terminalia catappa*

Parts used	Medicinal & Pharmacological uses	Source(s)
Bark	Dysentery	Tercas et al. (2017)
Leaves	Antifungal	Tercas et al. (2017)
Leaves	Antimicrobial and antioxidant	Mwangi et al. (2024)
Fruits	Anti-inflammatory, antidiabetic, antioxidant, hepatoprotective, and anticancer activities.	Anand et al. (2015)
Leaves	Gastritis	Pinheiro et al. (2015)
Leaves	Diabetes	Iheagwam et al. (2022); Divya et al. (2019)

Stem bark	Hypertension	Dada et al. (2021)
Leaves	Anticancer	Zarredar et al. (2021)
Leaves	Antimicrobial	Allyn et al. (2018)
Leaves	Anti-inflammatory activity	Fan et al. (2004)
Leaves	Hypoglycemic and Haematological Potentials	Ben et al. (2024)

BIOACTIVE COMPOUNDS

T. catappa has been found to contain a diverse range of bioactive compounds. According to Mwangi et al. (2024), the tree contains alkaloids, tannins, steroids, cardiac glycosides, flavonoids, phenols, saponins, and coumarins (Table 2).

Table 2: Bioactive compounds detected in *T. catappa*

Bioactive compounds	Source(s)
Alkaloids, tannins, steroids, cardiac glycosides, flavonoids, phenols, saponins, and coumarins.	Mwangi et al. (2024)
Phenol, flavonoid, and carotenoid.	Anand et al. (2015)
Phenolic compounds and flavonoids	Allyn et al. (2018)

These compounds have been associated with various biological activities, including antioxidant, anti-inflammatory, and antimicrobial effects. Further analysis by Anand et al. (2015) revealed the presence of phenols, flavonoids, and carotenoids in *T. catappa*. These compounds are known for their antioxidant properties and have been linked to various health

benefits, including the prevention of chronic diseases such as cancer, cardiovascular disease, and neurodegenerative disorders.

CONCLUSION

T. catappa is a versatile tree species with a wide range of medicinal, pharmacological, and bioactive properties. The various parts of the tree, including the bark, leaves, fruits, and stem bark, have been found to exhibit antifungal, antimicrobial, antioxidant, anti-inflammatory, antidiabetic, hepatoprotective, and anticancer activities. The presence of bioactive compounds, including alkaloids, tannins, steroids, cardiac glycosides, flavonoids, phenols, saponins, coumarins, phenols, flavonoids, and carotenoids, further highlights the tree's potential as a valuable resource for developing new medicines and treatments. Future studies on *T. catappa* should focus on isolating and characterizing the bioactive compounds responsible for its medicinal properties. Additionally, *in-vivo* and *in-vitro* studies are needed to fully understand the tree's pharmacological activities and potential interactions with other medications. The development of standardized extracts and formulations from *T. catappa* could also facilitate its use in clinical settings. Furthermore, investigations into the tree's potential applications in agriculture, cosmetics, and food industries could uncover new uses and economic benefits. Overall, further research on *T. catappa* is warranted to fully exploit its medicinal and pharmacological potential.

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