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Review on Tectona Grandis and its Medicinal Aspect

Ms. Sakshi A. Jadhav, Dr. Abhijit V. Shrirao, Dr. A. V. Chandewar
Palatdhamal Wadhwani Collage of Pharmacy, Yavatmal
*Corresponding author: sakshijadhav3652@gmail.com

Abstract: *Tectona grandis L.f, commonly known as teak, is a tree species valued for its timber. Its extensive medicinal applications in various indigenous medicinal systems highlight its significance. Several phytoconstituents, including alkaloids, phenolic glycosides, and steroids, have been identified in the plant. The renewed interest in teak has led to numerous scientific studies aimed at isolating and identifying its active compounds, along with validating its biological effects. Various parts of the teak plant have been rigorously tested for their antioxidant, antipyretic, analgesic, hypoglycemic, wound healing, cytotoxic, and numerous other biological properties. Compiling this scientific information is essential to create a comprehensive reference that covers all aspects of the plant, which could aid future research endeavors. This review consolidates key findings from the research on phytochemistry, methods for identifying and quantifying constituents, evaluation techniques for biological activity, toxicological research, allergy profiles, and relevant patents/patent applications. This information will assist researchers in identifying gaps for further studies*

Keywords: Teak, Tectona grandis Linn., Ethnomedicinal plant, medicinal constituents, pharmacological use

I. INTRODUCTION

Plants serve as vital sources of medicinal compounds. Scientific investigations into natural products often focus on uncovering their therapeutic potential by drawing from both traditional knowledge and existing scientific literature. Phytochemicals derived from plants frequently act as foundational templates for the development and refinement of lead compounds. It has been estimated that approximately 25% of pharmaceuticals in developing countries are derived from plant sources or their derivatives.[1]

Extensive research has been conducted on various plants to evaluate their phytochemical composition and pharmacological properties. One such plant that has garnered significant attention is *Tectona grandis* L.f (commonly known as teak), which belongs to the Verbenaceae family. This large deciduous tree, capable of growing up to 30–40 meters tall, is recognized by its fluted trunk and prominent buttresses at the base in older specimens. The bark has a light grayish-brown hue, and the leaves are large, shiny, opposite, and elliptic, with the underside covered in glandular hairs giving it a grayish appearance. Its flowers are small, white, and bisexual, arranged in large panicles, while the fruit is a green, hairy, woody drupe with an irregular shape.[2]

Teak is native to several South Asian countries, and various parts of the plant—including the roots, bark, flowers, wood, and oil—are known for their medicinal applications. Traditionally and ethnopharmacologically, these parts have been used to treat ailments such as the common cold, headaches, wounds, bronchitis, scabies, and more. Additionally, the plant exhibits properties such as laxative, diuretic, antidiabetic, anti-inflammatory, antioxidant, and lipid-lowering effects, as well as benefits for constipation. Some of these therapeutic effects have been shown to be enhanced when *Tectona grandis* is combined with other herbal extracts, and such combinations have been patented.[3]

This review aims to consolidate information on the phytoconstituents identified in different parts of the plant, the solvents used for extraction, the analytical techniques employed for compound quantification, and the biological activities observed. It also provides an overview of toxicological assessments, potential allergic reactions, and notable patents or patent applications associated with this species.[4]

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Tectona grandis Linn, commonly known as teak and locally referred to as Sagwan, belongs to the Lamiaceae family. Renowned as one of the most valuable hardwoods globally, teak is prized for its attractive grain and natural resistance to termites and fungal decay. This durability is primarily attributed to key bioactive compounds such as tectoquinone, lapachol, and deoxylapachol. Teak is particularly rich in naphthoquinones, anthraquinones, and isoprenoid quinones—metabolites known for their diverse biological activities.[5]

Beyond these, the plant also contains a variety of other phytochemicals, including triterpenoids, steroids, lignans, fatty esters, and phenolic compounds. From a pharmacological perspective, *Tectona grandis* has been extensively studied and shown to exhibit antioxidant, anti-inflammatory, antipyretic, cytotoxic, analgesic, hypoglycemic, wound-healing, and antiplasmodial effects. This review aims to provide a comprehensive overview of the phytochemical profile and pharmacological potential of teak.[6]

Traditional uses

Teak (*Tectona grandis* Linn.) is a highly esteemed tropical hardwood known for its exceptional physical properties, including an average wood density of approximately 650 kg/m³. Due to its remarkable natural durability and dimensional stability, teak has found widespread applications in boat and shipbuilding, construction, decorative veneers, furniture, cabinetry, musical instruments, and artisanal woodcarving.[7]

Beyond its industrial value, teak holds significant importance in traditional medicine. Various extracts obtained from different parts of the plant have demonstrated expectorant, anti-inflammatory, and anthelmintic activities. Traditionally, teak has been utilized in the management of bronchitis, bilious disorders, hyperacidity, diabetes, leprosy, and helminth infections. A paste made from teak wood powder is commonly applied to alleviate bilious headaches and localized swellings.[8]

According to Ayurvedic practices, teak wood is considered acrid, cooling, and laxative, and is believed to have a sedative effect on the gravid uterus. It is traditionally used in the treatment of conditions such as piles, leukoderma, dysentery, and excessive thirst, and is valued for its anthelmintic and expectorant effects. Additionally, leaf extracts of *Tectona grandis* are widely used in folk medicine, particularly for the treatment of various wounds, with a notable emphasis on burn injuries.[9]

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Distribution and description

The natural range of *Tectona grandis* Linn. (teak) extends across the Indian subcontinent, Myanmar, and Thailand. It predominantly thrives in deciduous forests with well-drained alluvial soils. India accounts for nearly one-third of teak's natural distribution, where it is sporadically found throughout Peninsular India below the 24°N latitude, particularly in the states of Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka, and Kerala. In Myanmar, teak is widely distributed across the country up to 25°N latitude, while in Thailand, it naturally occurs up to 17.5°N and between 97° and 101°E, particularly in the watersheds of the Mae Khong, Salween, and Chao Phraya rivers.

Teak has also been successfully introduced as a plantation species in around 36 tropical countries across Asia, Africa, as well as Central and South America.[10] In favorable environments, *T. grandis* can grow into a large deciduous tree exceeding 30 meters in height. The crown is open with numerous slender branches, and the trunk is often buttressed and may be fluted, with clear stem growth up to 15 meters before the first branches emerge. The stem is generally cylindrical but becomes fluted and slightly buttressed at maturity. The bark is light brown to gray, distinctly fibrous, and marked with shallow longitudinal fissures.[11]

The root system is primarily superficial, typically extending no deeper than 50 cm, although lateral roots can spread up to 15 meters from the trunk. Teak sheds its notably large, four-sided leaves for a period of 3 to 4 months during the latter half of the dry season, leaving the smaller branches bare. The mature leaves are about 30 x 20 cm in size—shiny on the upper surface and hairy beneath—with a clearly visible vein network. They are broadly ovate to oval in shape, tapering at the base with blunt or shortly pointed tips; young leaves can grow up to 1 meter in length.[12]

The flowers are small (approximately 8 mm across), mauve to white in color, and borne in large inflorescences about 45 cm long, located at the topmost branches exposed to full sunlight. The fruit is a drupe with four chambers, hard and woody in texture, enclosed in an inflated, bladder-like covering. Initially pale green, the fruit turns brown upon maturity. Each fruit may contain between 0 to 4 seeds, and approximately 1,000 to 3,500 fruits are found per kilogram.[13]

Chemical constituents

Tectona grandis, more widely known as teak, is a tropical hardwood species that holds value not only for its highly durable wood but also for its diverse range of naturally occurring chemical compounds. These compounds are present in different parts of the tree, such as the leaves, bark, heartwood, roots, and seeds, and are responsible for a variety of biological activities. Teak has long been used in traditional medicine due to its therapeutic properties, many of which are linked to the presence of these phytochemicals. Additionally, these constituents play a major role in the plant's resistance to pests and decay, which adds to the durability of its wood.[14]

One of the most significant compounds identified in teak is tectoquinone, a type of naphthoquinone found predominantly in the heartwood. This compound contributes to teak's natural defense against termites, fungi, and microbial degradation, which helps explain why teak is so valued for outdoor applications. Other related naphthoquinones, such as lapachol and deoxylapachol, are also found in the wood and foliage and have been studied for their potential medicinal benefits. Lapachol, in particular, has shown promise in laboratory studies due to its antimicrobial and anticancer properties.[15]

The leaves of Tectona grandis are known to contain flavonoids, such as luteolin and apigenin, which are known for their antioxidant capabilities. These compounds help protect the body's cells from damage caused by free radicals and may also offer anti-inflammatory benefits. In addition to flavonoids, teak leaves include tannins, which are known for their astringent and antimicrobial effects and are traditionally used to treat wounds, skin conditions, and gastrointestinal problems.[15]

Further compounds, such as phenolic acids and triterpenoids, are found in the tree's bark and root systems. One notable triterpenoid, betulinic acid, has shown a wide range of biological effects, including anti-inflammatory, antiviral, and even anti-tumor activities in some experimental models. This compound is being explored for its potential in therapeutic development. Moreover, alkaloids and steroidal compounds found throughout the plant contribute additional health-promoting effects, including pain relief and immune support.[15]

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Teak seeds are another source of beneficial chemicals, particularly essential fatty acids like oleic, palmitic, and linoleic acid. These fats support skin and cellular health and may also reduce inflammation in the body.

In summary, Tectona grandis offers much more than just premium hardwood. Its wide array of bioactive compounds, including naphthoquinones, flavonoids, tannins, triterpenoids, and fatty acids, make it a valuable plant in both traditional and modern medicinal contexts.[16] These natural constituents give teak its renowned resilience and also show potential for use in pharmaceuticals, antimicrobial products, and anti-inflammatory treatments. Ongoing research continues to uncover new ways in which this versatile tree may contribute to health and medicine.[17]

Toxicological studies

Acute toxicity studies are essential for determining the dose at which a substance may cause death or severe toxicological effects following a single dose or several administrations over a short period. These studies are crucial for assessing the safety margin of a drug. Various toxicological screenings have been conducted on different parts of *Tectona grandis* (TG). The findings suggest that doses ranging from 1,000 mg/kg to 5,000 mg/kg of body weight were used to evaluate the toxicity of the plant. The extracts were prepared using solvents such as water, methanol, and ethanol.[18]

In these studies, the plant extract showed no significant signs of toxicity, even at a dose as high as 5,000 mg/kg. However, the majority of studies typically limited the maximum dose to 2,000 mg/kg. Below is a table summarizing some of the toxicological studies conducted on various parts of the plant, including the solvent used, the part of the plant tested, and the animal species involved in the study.[19]

Pharmacological activities

In recent years, the global use of herbal products has been on the rise. Plants have long served as a significant source of medicinal compounds. However, understanding the complex molecular interactions and bioactive mechanisms of these plant extracts and their active constituents remains a challenge for scientists. *Tectona grandis* Linn. (teak) is known for its broad spectrum of pharmacological activities, and a concise overview of its pharmacological properties is provided below.[20]

Cytotoxic activity

The methanol extract of teak wood and the hexane extract of its leaves were evaluated using the MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide] assay. Additionally, the chloroform extract of teak bark demonstrated significant cytotoxic activity against chick embryo fibroblast (CEF) and human embryonic kidney (HEK 293) cells, with 87% and 95.3% inhibition, respectively. Column chromatography of the concentrated petrol extract from the root heartwood revealed the presence of hydroxynaphthoquinone.[21]

The petrol extract of teak root heartwood exhibited notable cytotoxicity against brine shrimp, prompting further investigation to identify the active compounds. This led to the isolation of a new compound, 5-hydroxylapachol, alongside previously identified compounds including lapachol, dehydro-α-lapachone, methylquinizarin, and squalene. Both 5-hydroxylapachol and lapachol were found to exhibit cytotoxic activity. The activity of 5-hydroxylapachol is particularly noteworthy, as it is comparable to lapachol, but with an additional hydroxyl group that may enhance its solubility. The study also indicates that 5-hydroxylapachol has a more favorable toxicity profile compared to lapachol, making it a promising candidate for further exploration as a potent cytotoxic agent.[21]

Antibacterial activity

A research study investigated the inhibitory mechanisms of *Tectona grandis* Linn. bark and assessed its effectiveness against *Listeria monocytogenes* and methicillin-resistant *Staphylococcus aureus* (MRSA) using the disc diffusion method. The study also identified the antibacterial compound 5-hydroxy-1,4-naphthalenedione (Juglone) through gas chromatography-mass spectrometry, along with 1H and 13C NMR analyses.[22]

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In a subsequent study, it was found that Juglone exhibited inhibitory effects against several oral pathogens, including *Streptococcus mutans*, *Streptococcus sanguis*, *Porphyromonas gingivalis*, and *Prevotella intermedia*. This finding may explain the traditional use of twigs and sticks for oral hygiene in regions of Africa and the Middle East.[22]

Antioxidant activity

The antioxidant activity of hexane, chloroform, ethyl acetate, and methanol extracts from the leaf, bark, and wood of *Tectona grandis* Linn. was evaluated using 1,2-diphenyl-1-picrylhydrazyl (DPPH) and ABTS+ free radical assays. Among these, the ethyl acetate extract of the wood demonstrated the highest antioxidant activity, with 98.6% inhibition against both DPPH and ABTS+ free radicals. The antioxidant potential of *T. grandis* Linn. was further confirmed through its crude ethanol extracts, which exhibited significant H_2O_2 scavenging activity, along with positive results in both the DPPH and FRAP assays.[23]

Another study investigated the antioxidant activity of *T. grandis* Linn. leaf extracts using four in vitro assay systems: total phenolic content, reducing power, superoxide radical scavenging activity, and inhibition of H_2O_2-induced erythrocyte hemolysis. This research aimed to explore the plant's potential both as a foodstuff and in medicinal applications. Additionally, the plant extracts of 17 commonly used Indian medicinal plants were evaluated for their ability to regulate nitric oxide (NO) levels, using sodium nitroprusside as an NO donor in vitro. *T. grandis* Linn. showed notable scavenging activity, ranking among the most effective extracts.[24]

Hair growth activity

In traditional Indian medicine, the seeds of *Tectona grandis* Linn. are well-regarded as a hair tonic. A study evaluated the effect of petroleum ether extract of teak seeds on hair growth in albino mice. The extracts, at concentrations of 5.00% and 10.00%, were incorporated into a simple ointment base and applied topically to the shaved, denuded skin of the mice. The time required for the initiation and completion of the hair growth cycle was recorded, with a 2.00% minoxidil solution used as a positive control. Treatment with the extracts significantly reduced the time required to initiate hair growth, cutting it by half compared to the control group. Moreover, the extracts were more effective than minoxidil in promoting a greater number of hair follicles in the anagen phase.[25]

Hypoglycemic activity

The study suggests that *Tectona grandis* Linn. may be beneficial in managing insulin resistance, due to its antioxidant properties and its ability to enhance glucose uptake. Dexamethasone administration led to a significant increase in blood glucose and triglyceride (TG) levels. However, treatment with *T. grandis* Linn. resulted in a dose-dependent reduction in both plasma glucose and TG levels elevated by dexamethasone. Beta-lapachone, a chemical constituent of *T. grandis* Linn., has been reported to possess glucocorticoid antagonistic activity.[26] It is hypothesized that the observed effects on plasma glucose and TG levels may be due to this glucocorticoid antagonism, as well as the presence of other compounds such as terpenoids and tannins, which are known to have antihyperglycemic effects. Furthermore, the treatment significantly increased insulin-assisted glucose uptake, suggesting improved insulin sensitivity.[27]

In a separate study, the hypoglycemic activity of the methanol extract of *T. grandis* Linn. root was investigated in alloxan-induced diabetic albino rats. The study found that the extract exhibited significant hypoglycemic activity when compared to the standard antidiabetic drug, glibenclamide. Another study evaluated the anti-hyperglycemic effect of the bark extract of *T. grandis* Linn. in both control and alloxan-diabetic rats. Oral administration of the bark suspension led to a significant reduction in blood glucose levels.[28]

Anthelmintic activity

The ethanolic extract of *Tectona grandis* Linn. fruits was evaluated for its anthelmintic activity using the Indian earthworm *Pheretima posthuma* as the test organism. The study involved determining the time of paralysis and the time of death of the worms, with piperazine citrate used as the standard reference drug. The crude ethanolic extract of the fruits showed significant anthelmintic activity at a concentration of 50 mg/ml, comparable to the activity of piperazine citrate.[29]

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Diuretic activity

The study investigated the acute diuretic activity of an aqueous extract of *Tectona grandis* Linn. leaves in Wistar rats by assessing urine volume and electrolyte levels. The results showed a significant, dose-dependent increase in both urine volume and electrolyte excretion, in comparison to the standard diuretics furosemide and hydrochlorothiazide.[30]

Anti-inflammatory Activity:

The anti-inflammatory effects of the methanol extract of *T. grandis* Linn. flowers (METGF) were evaluated using the carrageenan-induced inflammation model. The extract exhibited significant activity, particularly during the second phase of inflammation. The study suggests that the anti-inflammatory effect may be due to the inhibition of inflammatory mediators' release by the methanol extract of *T. grandis* Linn. flowers.[30]

Analgesic activity

The analgesic effect of the methanol extract of *Tectona grandis* Linn. flowers (METGF) was investigated using two different animal models: acetic acid-induced writhing and Eddy's hot-plate tests. The study aimed to explore the potential peripheral and central analgesic actions of METGF. The results indicated that METGF administration may mediate its analgesic effect via opioid receptors. In both models, METGF demonstrated dose-dependent inhibition of pain, suggesting both peripheral and central analgesic activity. The analgesic effect is likely attributed to the presence of phenolic compounds and tannins in the METGF.[31]

II. CONCLUSION

Herbs have long been used for the treatment of various ailments. This review emphasizes the significance of the phytochemistry, biological activities, and patents associated with *Tectona grandis*. Phytochemical studies have revealed that the plant contains compounds with diverse chemical structures. The various parts of *T. grandis* exhibit a range of biological activities, including antioxidant, wound-healing, analgesic, anti-inflammatory, and antipyretic effects. However, it has been observed that there are relatively few patents related to this plant, highlighting the potential for further research and future patent applications.

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