WORLD JOURNAL OF PHARMACY AND PHARMACEUTICAL RESEARCH

Review Article

Coden USA: WJPPCL

2026
Volume: 03
Issue: 07
Page: 88-95

A REVIEW ARTICLE ON ISOLATION, CHARACTERIZATION, PHYTOCHEMICAL PROFILE AND ANTIOXIDANT POTENTIAL OF *TECTONA GRANDIS* SEEDS

Raghav Bhandari*, Dr. N.S. Gill, Aakriti

Department of Pharmaceutical Chemistry, RIP, LTSU.

Received: 20 May 2026 **Revised: 08 June 2026** **Accepted: 28 June 2026**

Corresponding Author: Raghav Bhandari

Address: Department of Pharmaceutical Chemistry, RIP, LTSU.

DOI: https://doi.org/10.5281/zenodo.21106205,

ABSTRACT

Tectona grandis L.f. (teak) is a widely distributed tropical tree species known for its significant medicinal, ecological, and commercial importance. It is classified within the family Lamiaceae (previously categorized under Verbenaceae) and is noted for its valuable phytochemical constituents and biological properties. Besides its excellent timber quality, the plant has gained scientific attention due to the presence of diverse secondary metabolites with significant biological activities. Bioactive molecules derived from natural plant sources have attracted considerable scientific attention owing to their various pharmacological properties, which encompass antioxidant, antimicrobial, anti-inflammatory, and therapeutic effects. Body's antioxidant defenses, resulting leading to the deterioration of critical cellular molecules, including proteins, membrane lipids, and DNA, through oxidative stress. This imbalance is linked to the onset and advancement of several chronic diseases. Bioactive compounds from medicinal plants function as natural antioxidants by neutralizing free radicals and aiding in the maintenance of cellular stability and function.*Tectona grandis* contains various phytoconstituents such as phenolic compounds, flavonoids, tannins, quinones, terpenoids, lignans, saponins, and fatty acids, which contribute to its pharmacological properties. This review summarizes the botanical characteristics, taxonomical classification, geographical distribution, phytochemical profile, and biological importance of *Tectona grandis*. Existing research findings indicate that *Tectona grandis* may

serve as a promising source of natural antioxidant agents, suggesting its potential applications in the development of pharmaceutical and nutraceutical products.

KEYWORDS: *Tectona grandis*, Teak, Antioxidants, Phytochemicals, Flavonoids, Phenolic compounds, Oxidative stress

INTRODUCTION

Medicinal plants are acknowledged in traditional medicine systems and continue to serve as important resources for discovering new therapeutic compounds. The pharmacological characteristics and therapeutic potential of plant-derived chemicals are attributed to a variety of types of secondary metabolites, such as phenolic compounds, flavonoids, alkaloids, terpenoids, tannins, and glycosides. The capacity of naturally occurring antioxidants derived from botanical sources to combat oxidative stress and their potential significance in the production of pharmacological agents and nutraceutical formulations have garnered significant study interest in recent years.

When the body produces more reactive oxygen species (ROS) than its normal antioxidant defense mechanisms, oxidative stress results. The accumulation of free radicals can lead to oxidative damage in critical cellular components, such as proteins, lipids, and genetic material, disrupting normal biological functions. This imbalance has been linked to the onset of various conditions, including cardiovascular diseases, inflammatory illnesses, neurodegenerative diseases, and age-related complications. As a result, research into naturally occurring antioxidant compounds has gained significant attention in contemporary scientific studies.

Tectona grandis L.f., popularly recognized as teak, represents a valuable tropical tree belonging to the Lamiaceae family which was previously classified under Verbenaceae. This species is primarily recognized for its durable and commercially valuable timber; however, Research investigations have focused on multiple plant components, including leaves, bark, flowers, roots, wood, and seeds, to evaluate their pharmacological potential and therapeutic significance. The biological activities attributed to *Tectona grandis* are linked to its varied phytochemical composition, which includes quinone derivatives, phenolics, flavonoids, lignans, terpenoids, and fatty acids.

Among different plant parts, *Tectona grandis* seeds contain valuable chemical constituents, particularly fixed oils and fatty acids, which may contribute to their biological significance. A variety of extraction procedures and advanced analytical techniques have been employed to characterize the phytochemical constituents of *Tectona grandis* and assess the biological activities associated with its derived compounds. Studies have reported antioxidant, antimicrobial, anti-inflammatory, and other pharmacological properties associated with different extracts and isolated compounds of *Tectona grandis*.

The present review aims to summarize the available information regarding the botanical profile, geographical distribution, phytochemical constituents, extraction and isolation approaches, characterization methods, and antioxidant potential *Tectona grandis*, demonstrating its potential role as a valuable botanical source of bioactive constituents for prospective pharmaceutical and therapeutic applications.

Taxonomical Classification of *Tectona grandis*

Taxonomic Rank	**Classification**
Kingdom	Plantae
Division	Angiosperms
Class	Eudicots
Order	Lamiales
Family	Lamiaceae (formerly Verbenaceae)
Genus	*Tectona*
Species	*Tectona grandis* Linn.
Wood knots	Forsythoside B, Isoacteoside

Plant Profile of *Tectona grandis*

Botanical Description

One well-known deciduous tree found in tropical forest habitats is *Tectona grandis* tree that demonstrates robust growth and can reach a height of approximately 30 to 40 meters when cultivated in optimal ecological and climatic conditions. The plant possesses a strong woody trunk covered with greyish-brown bark. The bark is fibrous and provides natural resistance against environmental damage.

The tree develops a broad crown with large leaves and produces small white flowers arranged in terminal inflorescences. The fruit is a hard, rounded drupe containing seeds protected by a thick outer covering.

Morphological Characteristics

Stem

The stem is tall, cylindrical, and woody with a strong structure. The bark contains various chemical constituents that contribute to the durability and biological protection of the plant.

Leaves

The leaves are large, opposite, elliptical, and rough in texture. Young leaves may show reddish coloration, while mature leaves are green with a prominent vein network.

Flowers

The flowers of *Tectona grandis* are relatively small, varying in color from white to light shades, and are produced in highly branched inflorescences. They are bisexual and occur as terminal panicles.

Fruits

The fruit develops as a solid, rounded drupe encased in a hard, woody exterior that surrounds the seeds. Seeds are enclosed within the fruit and contribute to plant propagation.

Geographical Distribution

Tectona grandis is naturally distributed in tropical regions of Asia, particularly India, Myanmar, Thailand, Laos, and Indonesia. It grows mainly in deciduous forests and adapts to different climatic conditions ranging from moist to relatively dry environments.

Teak cultivation is widely practiced in India due to its substantial economic importance, and the species is acknowledged as one of the most commercially valuable hardwood trees.

Phytochemical Profile of *Tectona grandis*

Phytochemical studies on *Tectona grandis* L.f. have identified a variety of bioactive compounds present in different parts of the plant. The seeds primarily consist of fixed oils and fatty acids, while the leaves and flowers are notable for their higher concentrations of phenolic acids and flavonoids. The heartwood is rich in quinone derivatives, including tectoquinone and naphthoquinones, while the bark and roots contain triterpenoids. These plant-derived phytoconstituents are responsible for the plant's reported antioxidant, anti-inflammatory, antimicrobial, and other pharmacological properties.

S. No.	Plant Part	Phytochemical constituents
1	**Seeds**	Linoleic acid, Oleic acid, Palmitic acid, Octadecenoic acid methyl ester
2	**Leaves**	Linoleic acid, Oleic acid, Palmitic acid, Octadecenoic acid methyl ester, Luteolin
3	**Flowers**	Quercetin, Kaempferol, Rutin, Gallic acid, Ferulic acid, Ellagic acid
4	**Stem bark**	Betulin
5	**Heartwood**	Lapachol, Tectoquinone, 1,4-Naphthoquinone, 2-Methylanthraquinone
6	**Wood/Sawdust**	Tectol, Hemitectol, Deoxylapachol, Tectoquinone
7	**Different plant parts**	Alkaloids, Steroids, Terpenoids, Glycosides, Tannins, Saponins

Extraction and Isolation of *Tectona grandis* L.f. Seeds

Extraction is an important step in phytochemical investigation as it facilitates the purification of bioactive constituents from Botanical source materials. The yield and efficiency of the extraction process are affected by various parameters, including the characteristics of the plant sample, the choice of solvent and its polarity, the extraction method employed, and the chemical properties of the bioactive compounds being targeted.

Seeds of *Tectona grandis* contain valuable phytoconstituents, particularly fixed oils, fatty acids, and other secondary metabolites. Different solvent systems have been reported for the extraction of seed constituents based on their chemical properties. Non-polar solvents are generally used for the recovery of lipid components and fatty acids, whereas polar solvents may assist in extracting phenolic compounds and other polar phytochemicals.

Traditional extraction methods, such as Soxhlet extraction, maceration, and various solvent-based techniques, are commonly employed for the separation and evaluation of pharmacologically important compounds present in plant-derived materials. These approaches allow the recovery of phytoconstituents that can be further analyzed for their biological activities. Following extraction, separation and purification of individual compounds may be carried out using chromatographic techniques such as thin-layer chromatography (TLC), column chromatography, and high-performance liquid chromatography (HPLC).

Numerous analytical techniques, such as gas chromatography–mass spectrometry (GC–MS), liquid chromatography–mass spectrometry (LC–MS), and spectroscopic methods like infrared (IR) and nuclear magnetic resonance (NMR) analysis, can be used to characterize the isolated compounds and purified fractions obtained from *Tectona grandis* seed extracts. These methods are effective for identifying chemical components, assessing molecular

properties, and elucidating the structural characteristics of bioactive compounds found in teak seed extracts.

Although extensive phytochemical studies have been conducted on various components of *Tectona grandis*, seed-based investigations remain comparatively limited. Further research focusing on optimized extraction methods, compound isolation, and detailed characterization of seed constituents may help explore their antioxidant and pharmaceutical potential.

Pharmacological Activities of *Tectona grandis*

Tectona grandis L.f. has been the subject of significant scientific research due to its diverse biological properties linked to its rich phytochemical composition. Various extracts and isolated compounds from teak, have been demonstrated to have a variety of pharmacological properties, including cytotoxic, anti-inflammatory, antioxidant, antibacterial, and analgesic actions. These advantageous characteristics are mainly linked to a variety of secondary metabolites, including as terpenoids, quinones, flavonoids, and phenolics and other biologically active phytoconstituents, which enhance the therapeutic potential of the plant.

Cytotoxic activity

Bioactive compounds isolated from *Tectona grandis*, particularly quinone derivatives, have been investigated for cytotoxic potential. Compounds such as lapachol and related naphthoquinones have shown biological activity in preliminary studies. These observations suggest that bioactive constituents derived from teak could serve as valuable candidates for future pharmacological research and therapeutic development.

Antibacterial Activity

Four bacterial strains were used to evaluate the antibacterial qualities of *Tectona grandis* extracts: Staphylococcus aureus, Salmonella paratyphi, Proteus mirabilis, and Klebsiella pneumoniae. The evaluation of antimicrobial activity was conducted using the disc diffusion method, with solvent-treated discs serving as negative controls and ciprofloxacin used as the reference standard. The assessment of the inhibitory effect involved measuring the zone of inhibition, which represents the area where bacterial growth was inhibited around the disc; a larger zone indicates increased antibacterial activity. The chloroform fraction obtained from teak leaves exhibited notable antibacterial potential, showing inhibitory effects against Klebsiella pneumoniae (8 mm) and Staphylococcus aureus (14 mm) at a dose of 500 µg. Additionally, extracts prepared using methanol from leaves and ethyl acetate from wood

samples also displayed antibacterial activity, demonstrating effectiveness against both Gram-positive (S. aureus) and Gram-negative (K. pneumoniae) bacterial strains.

Antioxidant Activity

The antioxidant capacity of *Tectona grandis* has been examined using various in vitro evaluation methods, including DPPH and ABTS radical scavenging assays, reducing power tests, and other models for free radical inhibition. This activity is primarily linked to the existence of flavonoid and phenolic chemicals, which may aid in scavenging reactive oxygen species and reducing damage related to oxidative stress. Compounds found in teak seeds, particularly fatty acids and other phytoconstituents, may enhance their biological potential; To clarify the precise processes behind their antioxidant activities, more investigation is necessary.

Diuretic Activity

Urinary volume and electrolyte excretion patterns were monitored in Wistar rats to assess the diuretic efficacy of the aqueous leaf extract of *Tectona grandis* L.f. When compared to common diuretics like furosemide and hydrochlorothiazide, the extract showed a notable and dose-related improvement in urine output and electrolyte removal. The findings suggest that *Tectona grandis* leaf extract may have significant diuretic effects.

Anti-inflammatory Activity

Experimental studies have indicated that various extracts derived from *Tectona grandis* demonstrate potential anti-inflammatory and analgesic properties, implying their possible role in alleviating inflammatory responses and pain-related effects. These effects may be associated with phytoconstituents capable of reducing inflammatory responses and modulating pain-related pathways. Phenolic compounds and other secondary metabolites are considered important contributors to these activities.

Antimicrobial Activity

Extracts obtained from different parts of *Tectona grandis* have shown antimicrobial effects against several bacterial strains. The biological effect is thought to be linked to the presence of various phytoconstituents, including quinone compounds, phenolic constituents, and terpenoid derivatives. Studies have reported inhibitory effects of teak extracts against both Gram-positive and Gram-negative microorganisms. However, seed-specific antimicrobial investigations are comparatively limited and require further exploration

Future Perspectives

Further investigations on *Tectona grandis* L.f. are necessary to support the isolation, characterization, and identification of bioactive constituents, with a particular focus on compounds obtained from its seeds. The application of advanced analytical techniques, conducting standardization studies, evaluating toxicity, and performing clinical investigations may facilitate the development of it s potential pharmaceutical applications**.**

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