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A REVIEW ON PHYTOCHEMICAL AND THERAPEUTIC POTENTIAL OF *TECTONA GRANDIS*

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ABSTRACT

Tectona grandis L.f. (teak) is a widely distributed tropical hardwood species traditionally valued not only for its timber but also for its diverse medicinal properties. Various parts of the plant—including leaves, bark, roots, and seeds—have long been employed in Ayurveda and folk medicine to treat ailments such as skin disorders, wounds, inflammation, diarrhea, diabetes, and microbial infections. Phytochemical investigations reveal that T. grandis is rich in bioactive constituents, including flavonoids, tannins, quinones, phenolic acids, glycosides, and terpenoids, which collectively contribute to its broad spectrum of pharmacological activities. Experimental studies have highlighted its antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, and wound-healing effects, underscoring its therapeutic potential. Despite extensive ethnomedicinal use and promising preclinical findings, challenges remain regarding the standardization of extracts, elucidation of mechanisms of action, and comprehensive toxicological evaluation. This review consolidates current knowledge on the phytochemical composition and therapeutic applications of Tectona grandis, emphasizing its potential role as a source of novel natural agents for drug development. Further in vivo and clinical studies are warranted to validate efficacy, ensure safety, and translate traditional knowledge into evidence-based modern medicine.

KEYWORDS: Phytochemicals, Medicinal properties, Traditional medicine, Pharmacological Activity.

INTRODUCTION

Medicinal plants have been integral to human healthcare for centuries, serving as a primary source of therapeutic agents long before the advent of synthetic drugs. Even today, nearly 80% of the global population relies on traditional herbal remedies for primary health care, highlighting the enduring relevance of phytomedicine. The search for plant-derived compounds has intensified in modern pharmaceutical research, particularly due to their structural diversity, multi-targeted mechanisms of action, and comparatively lower side effect profiles. In this context, Tectona grandis L.f. (commonly known as teak) stands out as a multipurpose plant of both economic and medicinal importance. While its timber is globally renowned, various parts of the plant—including its leaves, bark, roots, and seeds—have a long history of application in traditional medicine across Asia and Africa.

Ethnomedicinal practices describe the use of Tectona grandis preparations for treating a wide range of conditions such as skin infections, wound healing, gastrointestinal disorders, fever, bronchitis, diabetes, and inflammation. These traditional applications have prompted phytochemical and pharmacological investigations, revealing that T. grandis is a rich reservoir of bioactive compounds. Its phytoconstituents include flavonoids, tannins, quinones, glycosides, phenolic acids, sterols, and terpenoids, each associated with distinct biological activities. For example, flavonoids and tannins contribute significantly to antioxidant and anti-inflammatory responses, while quinones exhibit antimicrobial and cytotoxic activities. Such findings highlight the plant's therapeutic potential and justify its exploration as a source of novel drug candidates.

Pharmacological studies conducted over the past decades have substantiated many of the traditional claims surrounding T. grandis. Extracts and isolated compounds from the plant have demonstrated antimicrobial, antioxidant, anti-inflammatory, hepatoprotective, analgesic, wound-healing, and antidiabetic effects in preclinical models. These activities position T. grandis as a promising candidate for the development of therapeutic formulations targeting both infectious and non-communicable diseases. However, while evidence from in vitro and in vivo studies is encouraging, comprehensive clinical validation remains limited. The lack of standardized extraction methods, variable phytochemical profiles influenced by geographical and environmental factors, and insufficient toxicological assessments pose major challenges

to its translational potential.

Given the growing global interest in plant-based therapeutics and the urgent need for safer, affordable, and sustainable healthcare solutions, it is imperative to consolidate existing knowledge on the phytochemistry and therapeutic potential of Tectona grandis. A detailed review not only bridges traditional knowledge with contemporary pharmacological insights but also identifies critical research gaps necessary for the rational development of evidence-based herbal formulations. This paper aims to provide an in-depth overview of the phytochemical composition, pharmacological activities, and therapeutic applications of Tectona grandis, while highlighting future directions for research and development.[1-2]

Figure 1: Leaves of *Tectona grandis.*

PHYTOCHEMICAL POTENTIAL OF TEAK (*Tectona Grandis*)

Three main structural biopolymers—cellulose, hemicellulose, and lignin—as well as a significant amount of extractives and a trace amount of inorganic ash make up teak wood (Tectona grandis). Tensile strength is provided by cellulose, which makes up 40–50% of the oven-dry weight and serves as the structural backbone of the wood. About 20–25% is hemicellulose, which serves as a matrix to support cellulose fibers, and 25–30% is lignin, which provides stiffness and resistance to microbial deterioration. Teak's high level of extractives (5–10%), which include chemicals like tectoquinone, lapachol, deoxylapachol, and different phenolic substances, is one of its most unique features. These compounds help to explain teak's inherent durability and resistance to termites, fungi, and water damage.

The oily texture and golden-brown color of teak are mostly caused by these extractives, which are particularly concentrated in the heartwood. Calcium, potassium, phosphorus, magnesium, and trace levels of iron and silicon are among the minerals found in teak ash (0.5–2%), which is left over after burning and represents the inorganic makeup of the wood. Because of its distinct chemical composition, teak is one of the most valuable hardwoods in the world, particularly for use in high-end furniture, outdoor settings, and marine environments.

Tectona grandis is endowed with a broad spectrum of phytoconstituents that underlie its diverse pharmacological properties. The distribution of secondary metabolites varies across different plant parts, each contributing distinct therapeutic roles.[3]

- **Leaves**

The leaves are rich in flavonoids (luteolin, apigenin, quercetin, rutin), phenolic acids (gallic acid, syringic acid, ferulic acid), and saponins, which impart potent antioxidant, anti-inflammatory, and antimicrobial activities. Leaf extracts also exhibit strong free radical scavenging and wound-healing potential.

- **Bark**

Bark contains high levels of tannins, lignans, and stilbenes (tectograndins A–C), which show antioxidant, anti-inflammatory, and anticancer effects. The presence of lapachol and its derivatives enhances antifungal and cytotoxic activities, making the bark an important source of therapeutic compounds.

- **Wood and Heartwood**

The heartwood is characterized by naphthoquinones (lapachol, deoxylapachol, tectoquinone) and anthraquinones, which display antifungal, antibacterial, and antitumor potential. These constituents not only contribute to teak's natural durability but also to its pharmacological relevance.

- **Roots**

Roots contain steroids, terpenoids, and coumarins such as scopoletin, associated with anti-inflammatory, hepatoprotective, and immunomodulatory effects.

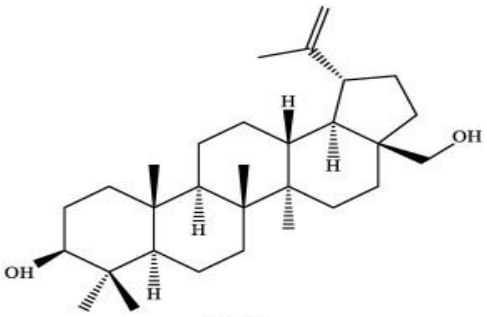
- **Seeds**

Seeds are a source of fixed oils rich in linoleic and oleic acids, in addition to steroids and triterpenoids (β-sitosterol, stigmasterol, ursolic acid, lupeol). These compounds demonstrate

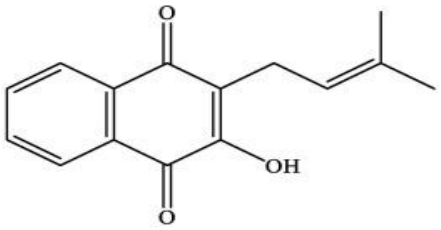
hepatoprotective, hypolipidemic, and anticancer properties.

Table 1: Phytochemical Constituents of *Tectona grandis.*

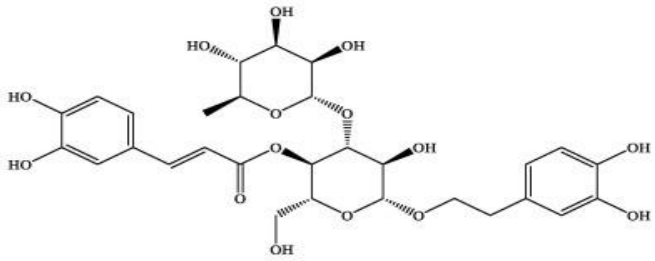
CLASS	REPRESENTATIVE COMPOUNDS	PLANT PART
Napthoquinone	Tectoquinone, Lapachol	Heartwood
Anthraquinones	Deoxylapachol	Root
Flavonoids	Luteolin,Rutin	Leaves
Phenolic acid	Gallic, Caffieic	Leaves
Terpenoids	Betulinic acid,Lupeol	Bark
Sterols	β-Sitosterol	Seed, Root
Lignans	Tectograndinol	Root



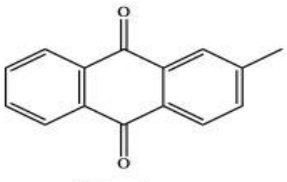
Betulin
(Triterpene)



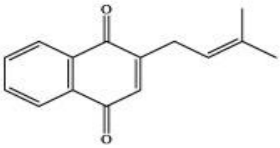
Lapachol
(Naphthaquinone)



Verbascoside
(Caffeoyl ethanoid)



Tectoquinone
(Anthraquinone)



Deoxylapachol
(Naphthaquinone)

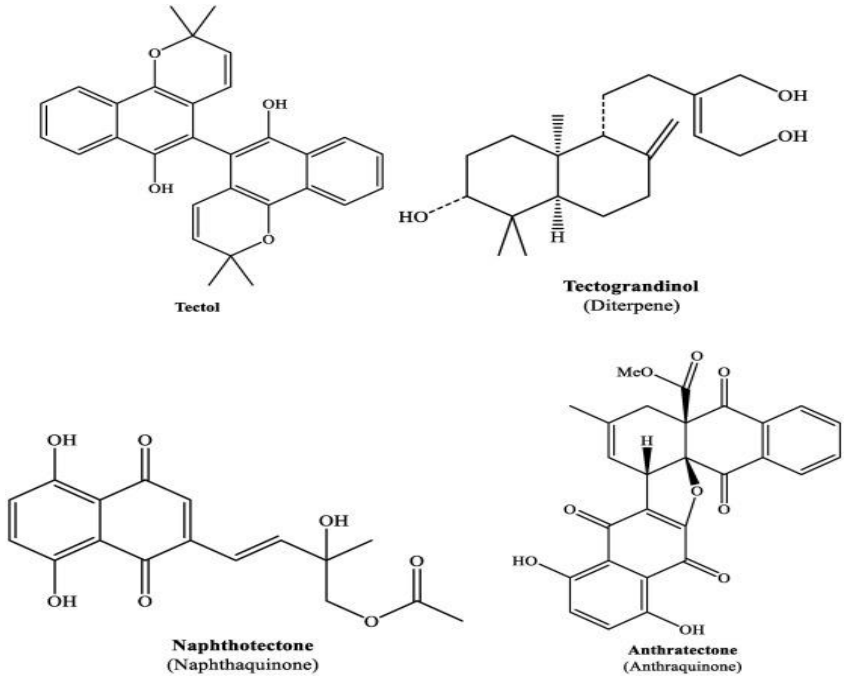


Figure 1: Phytochemical constituents of *Tectona grandis.*

- **Flavonoids**

Quercetin, kaempferol, and their derivatives have been identified in teak extracts, contributing to its antioxidant and anti-inflammatory properties.

- **Tannins**

Teak contains various tannins, including gallic acid and ellagic acid, which are known for their astringent, antimicrobial, and antioxidant activities.

- **Phenolic Acids**

Teak extracts have been found to contain phenolic acids such as caffeic acid, ferulic acid, and sinapic acid, which possess antioxidant and anti-inflammatory properties.

- **Terpenoids**

Teak contains terpenoids like β-sitosterol and stigmasterol, which have been reported to exhibit anti-inflammatory and antimicrobial activities.

- **Anthraquinones**

Some studies have identified anthraquinones in teak extracts, which are known for their laxative, antimicrobial, and anti-inflammatory properties.

➢ **Saponins**

Teak extracts have been found to contain saponins, which are known for their surfactant and foaming properties.

➢ **Glycosides**

Some studies have reported the presence of glycosides in teak extracts, which may contribute to its therapeutic potential.

MEDICINAL PROPERTIES OF TEAK

Tectona grandis, commonly known as teak, is a valuable tree species renowned for its timber and medicinal properties. The phytochemical composition of teak has been extensively studied, revealing a diverse range of bioactive compounds with therapeutic potential. This review aims to provide an in-depth analysis of the medicinal properties of teak, highlighting its potential applications in medicine.

❖ **Antibacterial activity**

The term "antibacterial activity" describes a substance's capacity to stop or eradicate bacterial growth. Antibiotics, synthetic drugs, and natural items (such as plant extracts, essential oils, and phenolic compounds) can all display this activity. The disk diffusion method (also known as the Kirby-Bauer test), minimum inhibitory concentration (MIC), or broth dilution procedures are commonly used to determine antibiotic activity.

Flavonoids, alkaloids, tannins, and phenolics, which are derived from plants, have demonstrated promising antibacterial properties against a variety of Gram-positive and Gram-negative microorganisms.[4-7]

Mechanism of Action: Teak extracts may disrupt microbial cell membranes, inhibit enzyme activity, and interfere with DNA replication.

Potential Applications: Prevention and treatment of infections, promotion of wound healing, and management of antimicrobial resistance.

❖ **Cytotoxic activity**

The term "cytotoxic activity" describes a substance's capacity to either kill or stop the proliferation of living cells, particularly cancer cells. This characteristic is essential for the creation of anticancer medications. Cytotoxic substances can cause cell cycle arrest, induce apoptosis (programmed cell death), or interfere with vital cellular functions such as protein

synthesis, DNA replication, or mitochondrial activity. Flavonoids, alkaloids, terpenoids, quinones, and phenolic chemicals are examples of plant secondary metabolites that have demonstrated notable cytotoxic effects on a range of human cancer cell lines.[8-11]

Mechanism of Action: Teak extracts may inhibit cell proliferation, induce apoptosis, and modulate signaling pathways involved in cancer development.

Potential Applications: Prevention and treatment of cancer, particularly in combination with conventional therapies.

❖ **Antianaemic effect**

The ability of a drug (natural or synthetic) to prevent or treat anemia, a disorder marked by a lack of red blood cells (RBCs) or hemoglobin, which results in decreased oxygen delivery in the body, is known as the antianaemic effect. Iron deficiency, vitamin B12 or folic acid insufficiency, chronic illnesses, and hereditary conditions such as sickle cell anemia are common causes of anemia. Vitamins, minerals (particularly iron), plant extracts, and bioactive substances can all have antianemic effects by, Increasing the formation of red blood cells, or erythropoiesis, Enhancing the metabolism and absorption of iron, Increasing the production of hemoglobin, supplying vital hematopoietic micronutrients, such as trace minerals, vitamin B12, and folic acid.[12-14]

❖ **Wound healing activity**

The ability of specific chemicals to support the regeneration and repair of damaged skin and tissues through a multifaceted process that includes hemostasis, inflammation, proliferation, and remodeling phases is known as wound healing activity. Due to their abundance of bioactive substances, including flavonoids, tannins, saponins, alkaloids, and phenolic acids, which support their anti-inflammatory, antibacterial, antioxidant, and collagen-promoting qualities, many medicinal plants have the ability to heal wounds. Together, these actions promote epithelialization, stop infections, and quicken tissue restoration. Research has indicated that plant extracts such as Centella asiatica, Carica papaya, and Aloe vera greatly enhance tissue regeneration and wound closure.

In a mouse burn model, for instance, Gurung and Skalko-Basnet (2009) documented the effectiveness of Carica papaya latex in wound healing, emphasizing its proteolytic enzymes that support tissue remodeling and debridement. Similar to this, Kumar et al. (2007)

highlighted the value of traditional Indian medicinal herbs in wound care and showed how they may be used as alternative therapies in contemporary wound care. These natural compounds' capacity to influence inflammatory cytokines and promote fibroblast proliferation lends more credence to their potential for wound healing by improving wound contraction and speeding up the healing process.[15-17]

Mechanism of Action: Teak extracts may stimulate fibroblast proliferation, increase collagen deposition, and enhance wound contraction.

Potential Applications: Treatment of wounds, cuts, and burns, and management of skin disorders.

❖ **Antioxidant activity**

The ability of a material to neutralize free radicals, also known as reactive oxygen species (ROS), which are very reactive chemicals that can oxidatively damage biological components like proteins, DNA, and lipids, is known as antioxidant activity. Age, cancer, heart disease, neurological disorders, and inflammatory ailments are all linked to excessive oxidative stress. Phenolic compounds, flavonoids, tannins, alkaloids, carotenoids, and vitamins (such as C and E) are examples of natural antioxidants, particularly those found in medicinal plants. These substances can donate electrons to free radicals, stabilizing them and reducing cellular damage. To assess antioxidant capability, a variety of in vitro tests are frequently employed, including the Ferric Reducing Antioxidant Power (FRAP) assay, ABTS assay, and DPPH (2,2-diphenyl-1- picrylhydrazyl) radical scavenging assay**.** Due to their high polyphenolic content, studies have demonstrated the strong antioxidant benefits of plant extracts from species like Emblica officinalis (amla), Curcuma longa (turmeric), and Camellia sinensis (green tea). The use of medicinal plants as natural therapeutic agents against disorders linked to oxidative stress is supported by the substantial association found between their antioxidant properties and total phenolic content (Cai et al., 2004).[18-19]

Mechanism of Action: Teak extracts may scavenge free radicals, reduce lipid peroxidation, and enhance antioxidant enzyme activity.

Potential Applications: Prevention and management of chronic diseases, such as cancer, cardiovascular disease, and neurodegenerative disorders.

❖ **Nitric oxide scavenging activity**

The ability of a material to neutralize nitric oxide free radicals, which are reactive nitrogen species (RNS) generated in biological systems, is known as nitric oxide (NO) scavenging activity. Although nitric oxide is necessary for many physiological functions, including immunological responses, neurotransmission, and vasodilation, excessive nitric oxide production causes oxidative stress, which damages cells and is linked to cancer, neurodegenerative illnesses, and inflammatory disorders. A popular in vitro technique for assessing a plant extract's or pure compound's capacity to block nitric oxide radicals produced by sodium nitroprusside under physiological conditions is the NO scavenging assay. Because of their ability to donate electrons, compounds such as flavonoids, phenolics, alkaloids, and tannins are known to have strong NO scavenging capabilities, stabilizing reactive nitrogen species. According to studies, medicinal herbs like Phyllanthus emblica, Azadirachta indica, and Ocimum sanctum have a substantial nitric oxide scavenging action, which is consistent with their traditional use in disorders related to oxidative stress and inflammation. Polyphenolic components from medicinal plants have been shown by Sreejayan and Rao (1997) to efficiently scavenge nitric oxide, reducing the generation of nitrite.[20-21]

❖ **Gastroprotective Activity**

Tectona grandis exhibits significant gastroprotective activity, primarily attributed to its antioxidant and anti-inflammatory properties. The plant's extracts have been shown to reduce gastric mucosal lesions and ulcer index in experimental models, likely due to free radical scavenging, increased mucin secretion, and antioxidant activity. Key phytochemicals such as flavonoids (quercetin and rutin), phenolic compounds (gallic acid and ellagic acid), and anthraquinones (lapachol and tectoquinone) may contribute to its gastroprotective effects. These properties make Tectona grandis a potential candidate for treating gastric ulcers and promoting gastrointestinal health. Further research is needed to fully explore its therapeutic potential and identify the specific compounds responsible for its activity.

Mechanism of Action: Teak extracts may reduce gastric acid secretion, enhance mucosal defense, and protect against oxidative damage.

Potential Applications: Prevention and treatment of gastrointestinal disorders, such as ulcers and gastritis.

❖ **Anti-Diabetic Activity**

Teak leaves exhibits significant anti-diabetic activity, primarily attributed to its ability to inhibit α-glucosidase, delay glucose absorption, and enhance postprandial glucose uptake in muscles. Studies have shown that the ethyl acetate fraction of T. grandis crude extract reduces high blood glucose levels in diabetic rats by improving pancreatic β-cell function, insulin sensitivity, and liver glycogen content. The plant's phytochemical constituents, including flavonoids and polyphenols, are thought to contribute to its antidiabetic effects. Specifically, compounds 4, 5, and 7 isolated from T. grandis have demonstrated significant inhibitory activities against α-glucosidase, while compounds 21 and 23 promote glucose uptake in 3T3-L1 adipocytes. Overall, T. grandis may be a valuable natural resource for developing new antidiabetic therapies.

❖ **Cardioprotective Activity**

The plant's extracts have been shown to reduce oxidative stress, inflammation, and lipid peroxidation, which can contribute to cardiovascular disease. T. grandis may also help to improve lipid profiles, reduce blood pressure, and protect against cardiac damage. The cardioprotective effects of T. grandis are thought to be mediated by its phytochemical constituents, including flavonoids, phenolic acids, and terpenoids, which have been reported to possess antioxidant and anti-inflammatory activities. Overall, T. grandis may be a valuable natural resource for preventing or managing cardiovascular disease.

Mechanism of Action: Teak extracts may reduce blood pressure, improve lipid profiles, and protect against cardiac damage.

Potential Applications: Prevention and management of cardiovascular diseases, such as hypertension and atherosclerosis.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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