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Review Article

PHYTOCHEMICAL AND PHARMACOLOGICAL EVALUATION OF *TECTONA GRANDIS*.LINN

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ABSTRACT

Tectona grandis Linn. commonly known as Teak or sagwan is one of the most famous timber in the world and is renowned for its dimensional stability. Teak is a major exotic species found in tropical region. It is commonly found in India and other south Asian countries. Teak is also considered as a major constituent in many folklore medicines. Medicinally it has various pharmacological activities like antibacterial, antioxidant, antifungal, anti-inflammatory, anti-pyretic, analgesic, anti-diuretic, and hypoglycemic. Further studies reveal the presence of carbohydrate, tannins, alkaloids, saponins, proteins and flavonoids. Extracts from various parts of teak is used to cure bronchitis, biliousness, dysentery, diabetes, leprosy, hyperacidity. Its medicinal properties are recognized in ayurvedic system of medicine.

Keyword: *Tectona grandis*, Antioxidant, Antifungal, Phenolic compounds, Diabetes.

INTRODUCTION

Tectona grandisLinn. (TG) is commonly known as "teak" belongs to verbanaceae family. It is a large deciduous tree 30-35 metre tall with light brown bark,leaves simple, opposite, broadly elliptical or acute or acuminate, with minute glandular dots, flowers are white in colour, small and have a pleasant smell[1]. The plant *Tectona grandis* is probably the most widely cultivated high value hardwood (HVH) in the world and is native to India and Myanmar and South- East Asian countries[2,3].It is now one of the most important species of tropical plantation forestry. The whole plant is medicinally important and many reports claim to cure several diseases according to Indian traditional system of medicines. The survey reveals that the plant is used in the treatment of urinary discharge, bronchitis, cold and headache, in scabies, used as a laxative and sedative, as duretic, anti-diabetic, analgesic and anti-inflammatory[4-7]. The various phytoconstituents isolated from *Tectona grandis* are Juglone, which has been reported to anti-microbial activity[8], betulin aldehyde shows anti-tumor activity[9], lapachol shows anti-ulcerogenic activity[10].

Taxonomical classification

Kingdom: Plantae - Plants

Subkingdom: Tracheobionta - Vascular Plant

Superdivision: Spermatophyta - Seed Plants

Division: Magnoliophyta - Flowering Plants

Class: Magnoliopsida - Dicotyledons

Subclass: Astridae

Order: Lamiales

Family: Verbenaceae - Verbena family

Genus: Tectona L.f. - Tectona

Species: *Tectona grandis* L.f. –Teak

Other names

English: Indian Teak, Teak.

Hindi: Sagwan, Sagauna, Sagu, Sagun, Sakhu.

Bengali: Segunngachh, Segun.

Gujarati: Sagwan, Sag, Saga, Sagach,

Kannad: Tegu, Sagawani, Thega, Jadi, Tega, Tyagadamara, Tekka-maram

Malyalam: Thekku, Tekka-maram, Tekku, Tekka.

Marwadi: Sagwan, Sag.

Punjabi: Sagwan, Sagun.

Tamil: Tekku, Tekkumaram, Tek, Kalindi.

Telgu: Teku, Pedda, Tek, Peddateku, teku-manu, Adaviteku, Teechekka.

Arab: Saj.

Assam: Chingjagu sagun.

Oriya: Saguana, Sagan, Sagun, Singuru.

Persian: Saj, Sal.

Santhal: Saguna.

Sind: Loheru.

Sanskrit: Anila, Arjunopama, Arna, Atipatraka, Balasara, Balesara, Bhumiruha, Dvarada, Gandhasara, Grihadruma, Halimaka.

Urdu: Sagwan

Plant Botanical Description

It is a large deciduous tree, 10-20 m tall; branchletsare 4-angled, densely clothed with yellowish grey tomentum. Leaves are opposite, ovate-elliptic toovate, 30-50 x 15-20 cm, cuneate at base. Flowers are small, whitish andbisexual. They appear in large panicles containing upto a few thousand flower buds,which open only few at a time during flowering period of 2-4 weeks. Calyx in flower is2.5-3 cm long, in fruit enlarged to 2-2.5 cm or more, bladdery, enclosing the fruit. Fruit is a drupe with 4 chambers; round, hard and woody, enclosed in an inflated, bladder-like covering; pale green at first, then brown at maturity. Each fruit contains 0 to 4 seeds. Seeds are oblong, brown, enclosed in bony endocarp.

Traditional Uses

Bark: is used as astringent, constipation, anthelmintic and depurative. It is used in bronchitis, hyperacidity, dysentery, verminosis, burning sensation, diabetes, difficult labour, leprosy and skin diseases.

Leaves: are cooling, haemostatic, depurative, anti-inflammatory and vulnerary. They are useful in inflammations, leprosy, skin diseases, pruritus, stomatitis, indolent ulcers, haemorrhages and haemoptysis.

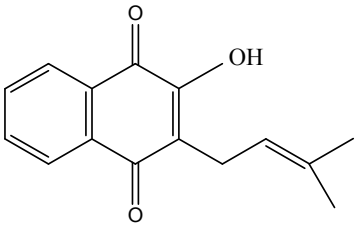
Wood: Acrid, cooling, laxative, sedative to gravid uterus, useful in treatment of piles, leucoderma and dysentery. Oil extracted from the wood is best for headache, biliousness, burning pains particularly over a region of liver.

Roots: are useful in anuria and retention of urine[11,12].

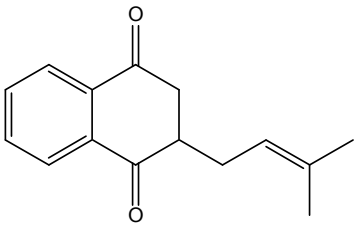
Flowers: are acrid, bitter dry and cures bronchitis, biliousness, urinary discharge[13]. According to unani system of medicine, oil extracted from the flowers is useful in scabies, and promotes the hair growth[14-16].

Phytochemical Constituents

Several classes of phytochemicals like alkaloids, glycosides, saponins, steroids, flavonoids, proteins and carbohydrates have been reported in *Tectona grandis*[13]. Secondary metabolites such astectoquinone, 5-hydroxylapachol, tectol, betulinic acid, betulinic aldehyde, squalene, lapachol were extracted from the plant[17,18]. Acetovanillone, E-isofuraldehyde, Evofolin, syringaresinol, medioresinol, balaphonin, laricresinol, zhebeiresinol, 1-hydroxypinoresinol together with two new compounds Tectonoelin A and Tectonoelin B were extracted from the leaves of *Tectona grandis* [19].



Lapachol



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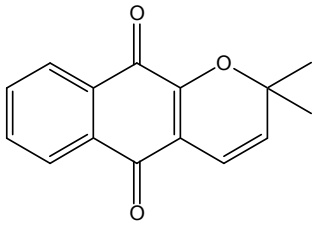
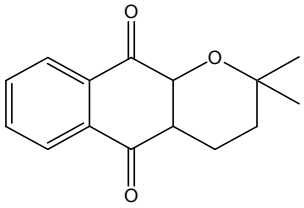
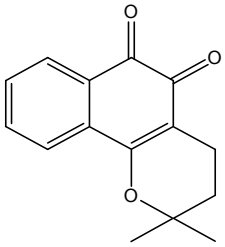


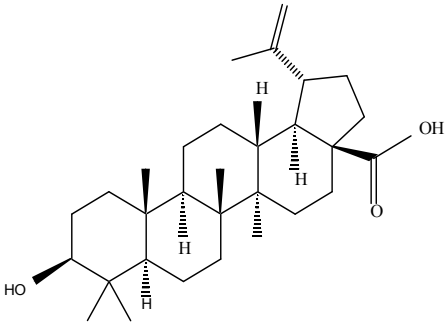
dehydroxy-alpha-lapachone



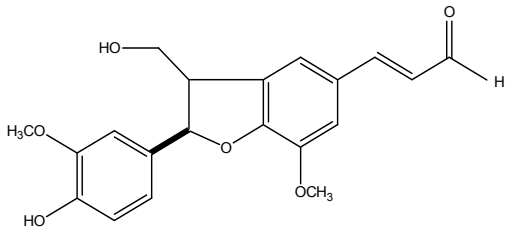
alpha-lapachone



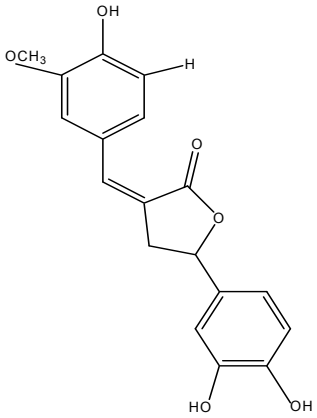
beta-lapachone



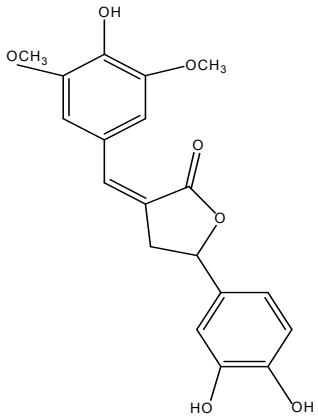
Betunilic acid



Balaphonin



Tectonoelin A



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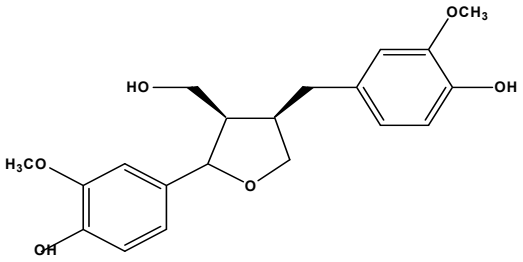
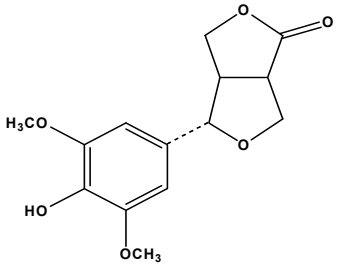


lariciresinol



zhebeiresinol

9,10 dimethoxy-2 methyl-anthra-1,4-quinone ,5-Hydroxylapachol along with tecomaquinone,methylquinizarin, lapachol, dehydroxy-α-lapachone were isolated from the heartwood of *Tectona grandis*[20,21].Teak wood contains naphthoquinone (lapachol, deoxylapachol, 5-hydroxylapachol), naphthoquinone derivatives (α-dehydrolapachone, β-dehydrolapachone, tectol, dehydrotectol), anthraquinones (tectoquinone,1-hydroxy-2-methylanthraquinone, 2-methyl quinizarin, pachybasin), and also obtusifolin, betulinic acid, trichione, β-sitosterol and sqaulene.Roots are rich in lapachol,tectol, tectoquinone, β-sitosterol, and diterpenes, tectograndinol[22].

Pharmacological Study

Antibacterial activity

Antibacterial activity of all extracts from *Tectona grandis* were checked against staphylococcus aureus, klebsiella pneumonia, salmonella paratyphi and proteus mirabilis by disc diffusion assay. Samples were tested at 25,50, 100, 250, and 500 µg concentration per disc of 5 mm diameter. Carrier soaked disc were also kept as negative control. Result expressed as diameterof inhibition zone and compared with standard antibiotic ciprofloxacin. Antibacterial activity of crude extract from the leaf, bark and wood showed chloroform extract of leaf to be outstanding. Out of the four cultures tested, it showed good activity against S. aureus (14 mm) and K. pneumonia (8 mm) at the highest concentration checked (500 µg). Methanol extract of leaf and ethyl acetate extract of wood was also able to show fairly good activity against gram positive and gram negative species[23].

Antioxidant activity

Leaf, bark and wood extracts of *Tectona grandis* were taken and subjected to antioxidant screening by chemical methods at different concentration. The free radical scavenging property of extracts were analysed by 1,2-diphenyl 1-picryl hydrazil. Antioxidant status of all extracts was checked by DPP and $ABTS^{+}$free radical. Its ability to scavenge those free radicals at different concentrations was analysed. Ethyl acetate extract of wood showed maximum activity against DPPH and $ABTS^{+}$ and it was higher than quercetin and trolox, which were the respective standards[23].

Antifungal Activity

The antifungal activity of teak leaf extract was tested against A. phaeospermum, the cause of wood decay. The air-dried leaves of teak, *Tectona grandis* were extracted with methanol and evaporated in a rotary evaporator. Antifungal activity of the leaf extract was tested based on well diffusion method on potato dextrose agar (PDA). Leaf extracts, 0.5%, 1%, 2% and 4% (w/v) were tested in this study. Sterile distilled water containing 0.2% Tween-80 was used as solvent and control. The result at a concentration as low as 0.5% (w/v) suppressed significantly the growth of A.phaeospermum by 81.4%, with minimum inhibitory concentration (MIC) of 0.4% (w/v). The leaf extract inhibited significantly the fungal radial growth, total biomass and sporulation [24].

Anti-inflammatory Activity

Denaturation of proteins is a well-documented cause of inflammation. As part of the investigation on the mechanism of the anti-inflammation activity, ability of different solvent plant extract protein denaturation was studied. It was effective in inhibiting heat induced albumin denaturation. Maximum inhibition 89.61% was observed from methanol extract followed byethanol 86.81% and water 51.14%. All the solvent extracts inhibited the albumin denaturation, the methanol extract stood first compared to ethanol and water extracts. Aspirin, a standard anti-inflammation drug showed the maximum inhibition 75.89% at the concentration of 200µg/ml[25].

Antiasthmatic Activity

Various extracts of *Tectona grandis*Linn. Barks were screened for antiasthmatic activity by using different *in-vivo* animal models like clonidine induced catalepsy in mice, haloperidol induced catalepsy in mice, milk induced leucocytosis and eosinophilia. The observation of this study indicated that the *Tectona grandis*bark having antihistaminic activity inhibited clonidine-induced catalepsy in mice and not inhibited haloperidol-induced catalepsy in mice. The results of these studies indicated that ethyl acetate extract of *Tectona grandis*Linn. Bark showed significant ($p< 0.001$) anti-asthmatic activity at the dose of 100 mg/kg. The anti-asthmatic activity of ethyl acetate extract can be attributed to antihistaminic (H1-antagonist), anti-muscarinic, anti-allergic, anti-inflammatory and adaptogenic activity suggestive of its potential in management of asthma[26].

Analgesic Activity

The preliminary phytochemical analysis of methanol extract of *Tectona grandis* flower (METGF) showed presence of tannins and phenolic compounds which prompted to evaluate its pharmacological activity. Therefore, present study was aimed to investigate analgesic efficacy of methanol extract of *Tectona grandis* flowers in carrageenan induced rat paw edema and thermally induced analgesia animal model. Analgesia was induced by intraperitoneal injection of 0.6% v/v acetic acid in mice to assess peripheral analgesic action of METGF. Also hot plate was used to induce pain in mice to evaluate central analgesic action of METGF. As a result of administration of METGFat dose of100 and 200 mg/kg significantly increased reaction time compared to control animals[27].

Diuretic Activity

Aqueous extract of *Tectona grandis*was selected for scientific base of its diuretic evaluation. LD50 value of aqueous extract of *Tectona grandis*was above 2000 mg/kg body weight. Adult male wistar rats 150-200 g was used for diuretic studies using aqueous extract of *Tectona grandis*administered orally. A five groups consisted of 6 rats were placed in a metabolic cages and treated with Hydrochlorothiazde as a standard and three different doses (100, 200 & 400 mg/kg) of aqueous extract of *Tectona grandis* .The urine excreted over a period was measured at every 2, 4, 6, 8 and 24 hrs. for single rat was collected and measured. Urinary Na+, K+and Cl- contents for each group after 24 hours were analyzed by Auto analyser. The present study has indicated that the aqueous extract of *Tectona grandis*in three doses showed diuresis at different time interval and there was significant increase in urinary Na+, and Cl- excretion[28].

Hypoglycaemic Activity

The hypoglycaemic activity of methanolic extract of *Tectona grandis* root in alloxan induced diabetic rats. A comparison was made between the action of *Tectona grandis* methanolic extract and a known antidiabetic drug glibenclamide (0.5 mg/kg p.o). The methanolic extract of *Tectona grandis* linn. root was administered orally at different doses to normal rats. The methanolic extract at 500 mg/kg dose level exhibited significant ($p<0.05$) hypoglycemic activity[29].

Antidiabetic Activity

Antidiabetic activity of methanol extracts of *Tectona grandis* flowers (METGF) in streptozoticin (STZ) induced diabetic rats was carried out to support its traditional use. Acute toxicity study of (METGF) was carried out in rat to determine its dose for antidiabetic study. Oral glucose tolerance test (OGTT) was performed to evaluate METGF effect on elevated blood glucose level. Diabetes was induced in rat by administration of STZ (60 mg/kg, ip) and was confirmed 72h after induction. METGF was orally given to the diabetic rat upto 28 days and blood glucose level was estimated each week. On 28thday of the experiment, diabetic rats were sacrificed after blood collection for the biochemical parameter analysis. The results reveal that in acute toxicity, METGF did not show toxicity and death upto the dose of 2000 mg/kg in rats. Administration of METGF 100 and 200 mg/kg significantly ($p<0.001$) reduced blood glucose levels in OGTT and STZ induced diabetic rats[30].

Antipyretic Activity

The methanolic extract of root of *Tectona grandis* was tested on yeast-induced pyrexia in WistarAlbino rats. The root extract at oral doses of 250mg/kg and 500mg/kg has been used to investigate the Antipyretic potential of root extract. Both doses showed significant reduction in body temperature on yeast induced pyrexia when compared to standard (paracetamol 100mg/kg)[31].

Wound Healing Activity

The frontal leaves of *Tectona grandis* are widely used in the treatment of wounds, especially burn wound. The present study was carried out to evaluate the effect of hydrochloric extract of *Tectona grandis* on experimentally induced wounds in rats. The models selected were excision wound, incision wound, burn wound and dead space wound. A suitable gel formulation was selected for the application using cellophane membrane penetration. In the excision wound and burn wound models, animals treated with *Tectona grandis* leaf extract showed significant reduction in period of epithelisation and wound contraction 50%. In the incision wound model, a significant increase in the breaking strength was observed. *Tectona grandis* leaf extract treatment orally produced a significant increase in the breaking strength, dry weight and hydroxyproline content of the granulation tissue in dead space wound. It was concluded that *Tectona grandis* leaf extract applied topically (5% and 10% gel formulation) or administered orally (250 mg and 500 mg/kg body weight) possesses wound healing activity[32].

Anti-ulcer Activity

Lapachol, a naphthaquinone isolated from the roots of *Tectona grandis* given at a dose of 5 mg/ kg twice daily for 3 days was found to have an anti-ulcerogenic effect on subsequently induced experimental gastric and duodenal ulcers in rats and guinea-pigs. Its action appears to be associated with an effect on the protein content of gastric juice, and it reversed aspirin-induced changes in peptic activity, protein and sialic acid[33].

Antinociceptive Activity

Male Swiss albino mice (25-30 g) were divided into five groups containing six animals each. ATG (100, 200 & 400 mg/kg, p.o.), Indomethacine (10 mg/kg, p.o.) [34]. All the drug treatments were given 1 hour before i.p. injection of 0.6 % (v/v) acetic acid, at a dose of 10 ml/kg [35]. Writhing is a syndrome characterized by a wave of contraction of the abdominal musculature followed by a wave of contraction of hind limbs. The hind limbs contractions that occurred over a period of 10 min were counted. A reduction in time of writhing initiation & number of writhing as compared to the vehicle treated group was considered as evidence for the analgesia.*Tectona grandis* significantly reduced writhings and stretchings induced by 0.6% acetic acid at a dose of 10 ml/kg. The significant protective effect was dose dependent with 39.08% ($P<0.001$), 54.31% ($P<0.001$) and 67.51 ($P<0.001$) reduction observed for 100, 200 and 400 mg/kg respectively.Indomethacine (100 mg/kg) had 73.60% ($P < 0.001$) inhibition[36].

Antitumor Activity

Lapachol isolated from *Tectona grandis* demonstrated highly significant activity against cancerous tumors in rats[37].Its anti-tumor property alone and in combination with radiation was evaluated in female Swiss albino mice, 6-8 weeks old, bearing sarcoma-180 (S-180) ascetic tumor cells. In female mice $2x10^5$, S-180 viable ascetic cells were injected intraperitoneally. These ascetic bearing mice were treated with different concentrations of lapachol (50, 100 mg/kg body weight) at various days alone and with radiation (CO^{60} gamma radiation 3, 6 Gy). In another group of ascetic bearing animals, the animals were irradiated with 3, 6 Gy of gamma radiation in combination with 50, 100 mg/kg body weight of lapachol. Therapeutic cure ratio (T/C) and percentage change in body weight were taken as parameters for the assessment of antitumor activity. There was increase in the T/C ratio in the animals treated with lapachol or irradiated with gamma radiation. However, there was highly significant increase in the T/C ratio in the group of animals treated with lapachol in combination with radiation. The change in the T/C ration was concentration and dose dependent. There was significant change in the percentage of body weight [38].

Anti-metastatic activity

Metastasis is the major process responsible for the death in cancer patients[39]. The literature survey has revealed that the lapachol a napthaquinone isolated from *Tectona grandis* effects on a human cancer cell line and evaluated the potential of this substance as an anti-metastatic drug using an in vivo assay. The results of this study indicated that lapachol, in the maximal non-toxic concentration for HeLa cells of 400 µg/ml (corresponding to 1012 molecules of the drug/cell), induce alterations in the protein profile and inhibit cellular invasiveness, thus representing an important anti-metastatic activity[40].

Hair growth activity

The seeds of *Tectona grandis* Linn. are traditionally acclaimed as hair tonic in the Indian system of medicine. Studies were therefore undertaken in order to evaluate petroleum ether extract of *T. grandis* seeds for its effect on hair growth in albino mice. The 5% and 10% extracts incorporated into simple ointment base were applied topically on shaved denuded skin of albino mice. The time required for initiation of hair growth as well as completion of hair growth cycle was recorded. Minoxidil 2% solution was applied topically and served as positive control. The result of treatment with minoxidil 2% is 49% hair in anagenic phase. Hair growth initiation time was significantly reduced to half on treatment with the extracts compared to control animals. The treatment was successful in bringing a greater number of hair follicles (64% and 51%) in anagenic phase than standard minoxidil (49%). The results of treatment with 5% and 10% petroleum ether extracts were comparable to the positive control minoxidil[41].

CONCLUSION

Tectona grandis, is a medicinal plant with versatile nature, apart from possessing high value of hardwood, itis also the unique source ofvarious types of compounds having diverse chemical structure.The extract of the different parts of the plant shows various activities like antibacterial, antioxidant, antifungal, anti-inflammatory, antiasthmatic, analgesic, diuretic, hypoglycaemic, antidiabetic, antipyretic, wound healing, anti-ulcer, antinociceptive, anti-tumor, anti-metastatic and hair growth activity. This review further highlighted the discovered pharmacological effects and phytochemical details of*Tectona grandis*which provide way to further studies and research.

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