INTRODUCTION

Tectona grandis Linn. (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, as diuretic, 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 the plant 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.

Taxonomical classification

Kingdom: Plantae - Plants
Subkingdom: Tracheobionta - Vascular Plant
Superdivision: Spermatophyta - Seed Plants
Division: Magnoliophyta - Flowering Plants
Class: Magnoliopsida - Dicotyledons
Subclass: Astrodui
Order: Lamiaceae
Family: Verbenaceae - Verbena family
Genus: Tectona Lf. - Tectona
Species: Tectona grandis Lf. - Teak

Other names

English: Indian Teak, Teak.
Punjabi: Sagwan, Sagun.
Marwadi: Sagwan, Sag.
Tamil: Tekku, Tekkumaram, Tek, Kalindi.
Telugu: Teku, Pedda, Tek, Peddateku, teku-mamu, Adaviteku, Tcekelleka.
Arab: Sah.
Assam: Chingjagug saqun.
Oriya: Saguana, Sagan, Sagun, Singuru.
Persian: Saj, Sal.
Santhali: Saguna.
Sind: Loheru.
Urdu: Sagwan

Plant Botanical Description

It is a large deciduous tree, 10-20 m tall; branchlets are 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, white and bisexual. 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 is 2.5-3 cm long, in fruit enlarged to 2.25 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 as tectoquinone, 5-hydroxylapachol, tectol, betulinic acid, betulinic aldehyde, squalene, lapachol were extracted from the plant [17,18]. Acetovanilone, 6-isofuraldehyde, Evolfin, syringaresinol, medioreisinol, balaphonin, kriiresinol, zhebeiresinol, 1-hydroxypinoresinol together with two new compounds Tectonoelin A and Tectonoelin B were extracted from the leaves of *Tectona grandis* [19].
Lariresinol

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

Pharmacologcal 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 diameter of inhibition zone and compared with standard antibiotic ciprofloxacin. Antifungal 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 (9 mm) at the highest concentration (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 concentrations. The free radical scavenging property of extracts was analysed by 1,2-diphenyl-1-picryl hydrazyl. Antioxidant status of all extracts was checked by DPPH 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 examined. It was effective in inhibiting heat induced albumin denaturation. Maximum inhibition 89.61% was observed from methanol extract followed by ethanol 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-inflammatory drug showed the maximum inhibition 75.89% at the concentration of 200μg/ml[25].

Antihistaminic Activity

Various extracts of Tectona grandis Linn. Barks were screened for antihistamatic 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.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 an anti-histaminic (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 acetate 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 METGF at dose of 100 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 metabolie cages and treated with Hydrochlorothiazide 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 grandisin three doses showed diuresis at different time interval and there was significant increase in urinary Na+, and Cl- excretion[28].

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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) hypoglycaemic activity[29].

Antidiabetic Activity
Antidiabetic activity of methanol extracts of Tectona grandis flowers (METGF) in streptozotocin (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 28th day 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 Wistar Albino 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 10mg/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 ulcer, protein and sialic acid[33].

Antinociceptive Activity
Male Swiss albino mice (25-30 g) were divided into five groups containing six animals each. ATO (100, 200 & 400 mg/kg, p.o.), Indomethacin (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. Indomethacin (100 mg/kg) had 73.60% (P < 0.001) inhibition[36].

Antitumor Activity
Lapachol isolated from Tectona grandis demonstrated highly significant activity against carcinogenic tumors in rats[37]. Its antitumor property along with in combination with radiation was evaluated in female Swiss albino mice, 6-8 weeks old, bearing sarcoma-180 (S-180) ascitic tumor cells. In female mice 2x105, S-180 viable ascitic 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 (CO60 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 ratio 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 naphthaquinone 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 demuced 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, its also the unique source of various 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, antithrombotic, anti-inflammatory, antihyperglycaemic, antidiabetic, antipyretic, wound healing, anti-ulcer, antinoceptive, 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.
REFERENCES


