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THEPESIA POPULNEA FOR THE MANAGEMENT OF DIVERSE DISEASES: AN OVERVIEW

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Keywords:

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ABSTRACT: *Thespesia populnea Linn*., a member of the Malvaceae family also known as Portia tree, a plant commonly found in coastal and tropical regions of India. Its therapeutic properties have been recognized in ayurvedic medicine, which has been validated by modern scientific research. This paper highlights the chemical constituents and pharmacological profile of *Thespesia populnea*. The plant has shown remarkable potential as an anti-inflammatory, antidiabetic, antimicrobial, antipsoriatic, antidiarrheal, anti-implantation, anticancer, and alzheimer's disease management agent *etc*. Its extracts also exhibit a synergistic activity with oxytetracycline, a commonly used antibiotic. Additionally, the plant is used as a natural dye for various fabrics, a source of biodiesel and an anti-corrosive agent. Phytochemical analysis has exposed the presence of alkaloids, sesquiterpenoids, fatty acids, polysterol, glycosides and alkane in various extracts of the plant. These bioactive compounds are responsible for the diverse pharmacological activities exhibited by *Thespesia populnea*. The review provides advanced evidence to support the traditional knowledge of *Thespesia populnea* and highlights its potential as a source of novel drugs for various diseases. Further research is needed to elucidate the mechanism of action of its bioactive compounds and to develop effective therapeutic interventions based on these compounds.

INTRODUCTION: *Thespesia populnea* also called as the Indian Tulip Tree (Portia Tree), evergreen tree (medium-sized) found in coastal regions throughout India and other tropical regions [1]. The tree has a variety of medicinal properties and has been used by people throughout history to treat a range of illnesses [2]. The bark and fruits of the tree are particularly useful and have been shown to have antibacterial [3], astringent, cooling, depurative, anti-inflammatory, haemostatic and anti-diarrheal properties.

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In Ayurvedic medicine different parts of *Thespesia populnea* including roots, leaves, flowers, fruits and bark are used to treat a variety of disease [4]. Modern research has confirmed the therapeutic potential of *Thespesia populnea*, highlighting the importance of exploring natural remedies and the potential of plants to provide new treatments for a variety of illnesses [5].

Milo tree contains various phytochemicals, including alkaloids, tannins and phenolics, saponins, flavonoids, carbohydrates, proteins and amino acids, phytosterols, mucilage and terpenoids [6]. Alkaloids found in *Thespesia populnea* have been shown to have various biological activities such as anti-inflammatory, analgesic and anti-tumour effects. Tannins and phenolics have antioxidant properties which can help prevent cell

damage caused by free radicals [7]. Saponins in *Thespesia populnea* have cholesterol-lowering and anti-cancer properties while flavonoids have anti-inflammatory, anti-cancer and anti-viral properties. Carbohydrates are the main source of energy in this plant, proteins and amino acids are important for growth and tissue repair [8]. Phytosterols have cholesterol-lowering effects while gum and mucilage can be used as a thickener or emulsifier in food and cosmetics. Finally terpenoids have a variety of biological activities including anti-inflammatory, anti-cancer, and anti-microbial properties. Studies have shown that the fruits of the tree contain populnin which is effective in treating intestinal disorders and is potent against both Gram-negative and Gram-positive bacteria. The fatty oil produced by the tree's seeds has anti-inflammatory and antioxidant properties and is useful in treating congenital disorders [9]. The tree's bark has wound healing properties and has been found to have anti-diabetic propertie [10] and **Fig. 1** shows images of leaves, stem, flowers, bark and seeds of *Thespesia populnea*.

Overall, *Thespesia populnea* is a valuable plant with a range of medicinal properties. Its continued relevance in modern medicine demonstrates the importance of exploring natural remedies and the potential of plants to provide new treatments for a variety of illnesses.

FIG. 1: *THESPESIA POPULNEA* [16]

Synonyms [9]:

English: Portia Tree, Pacific Rosewood, Indian Tulip Tree, Milo, Seaside Mahoe.

Hindi: Portia Vriksh, Singhaphal.

Tamil: Pulichedi, Malip-poo.

Bengali: Bokul, Jalkolhal.

Sanskrit: Samudraphalaka, Jambuka.

Taxonomical Classifications [6, 11]: Taxonomical classification of *Thespesia populnea* are define in **Table 1.**

TABLE 1: TAXONOMICAL CLASSIFICATION OF *THESPESIA POPULNEA*

Kingdom	Planate
Division	Magnoliophyla
Class	Magnoliopsida
Order	Malvale
Family	Malvaceae
Genus	*Thespesia*
Species	*T. populnea* Linn.

Botanical Description of *Thespesia populnea*: *Thespesia populnea* belongs to the family Malvaceae and it is an evergreen tree that can grow up to 20 meters in height. The bark of the tree is dark brown and the leaves are glossy green and broad. The flowers are yellow in colour and have five petals [12]. The fruit of the tree is a hard woody capsule that contains many small seeds. The tree is commonly found in coastal areas and is resistant to salt spray and coastal winds [13].

Traditional Medicinal Uses of *Thespesia populnea*: The **Table 2** summarizes the key feature of *Thespesia populnea* which has been used in traditional medicine for centuries to treat a range of ailments. The fever, dysentery and skin infections have been treated by roots of the tree. The leaves are used to treat coughs, colds and asthma [14]. The flowers are used to treat eye diseases and respiratory disorders. The fruit is used to treat diarrhoea, dysentery and urinary tract infections. The bark of the tree is used to treat skin diseases, fever and coughs [15].

TABLE 2: AYURVEDIC USES OF *THESPESIA POPULNEA* [6, 15, 16, 17]

S. no.	Parts of Plant	Uses	Marketed Ayurvedic Preparation
1.	Flowers, fruits, Bark and leaves	Skin conditions like ringworm, scabies and psoriasis, sprains, bruises and cutaneous diseases	Brand Name - Moolihai Ayurveda Poovarasam Pattai Tablet Main ingredient - *Thespesia Populnea* Dietary supplement
2.	Bark, root, and fruits	Dysentery, Cholera, Haemorrhoids, Urethritis, Gonorrhoea, Migraine and Headache. To remove 'vatta' and 'pitta' and also used as a tonic, aphrodisiac and treatment of burning of body and heart diseases.	Brand Name – DHANYAAS Poovarasam Pattai Powder Main ingredient – *Thespesia Populnea*
3.	Seeds	Congenital disorders	Brand name – MGBN (MG Naturals) Populnea/ Poovarasan Tree

Comprehensive Detail: Biological Activity of *Thespesia populnea*: The **Fig. 2** summarizes the biological activity of *Thespesia populnea* categorized into antimicrobial activity, anticancer, antioxidant, antidiabetic, anti-inflammatory and implantation *etc*.

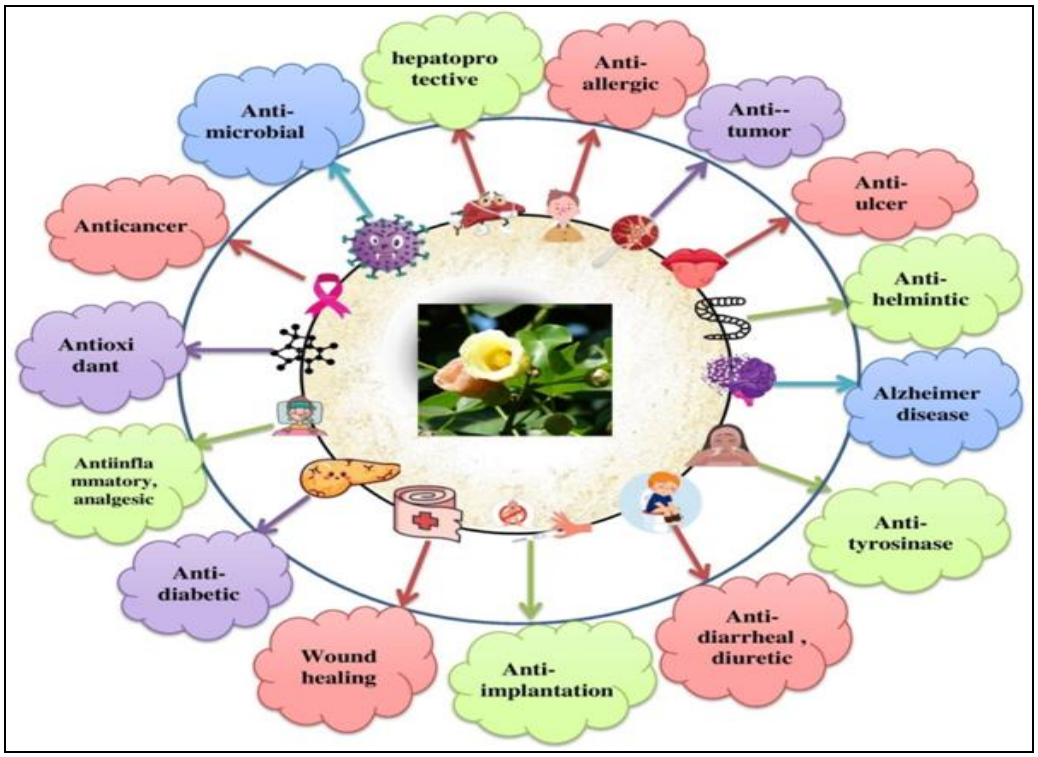
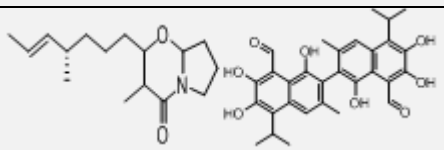
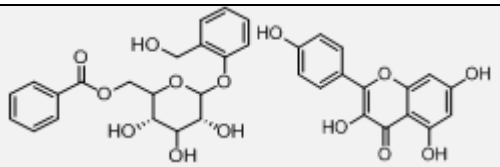
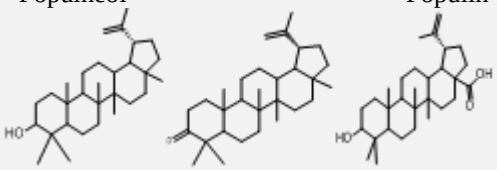
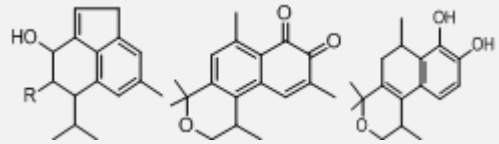
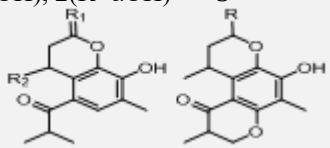
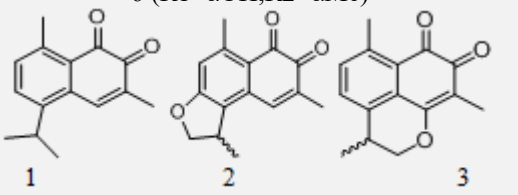
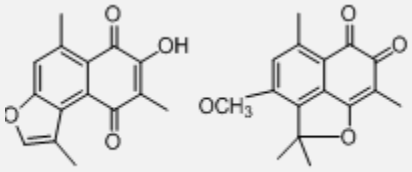
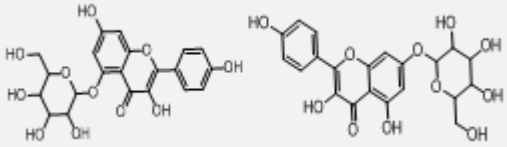
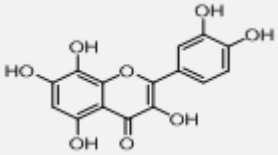


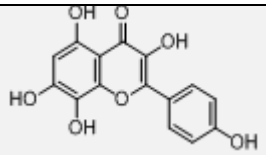
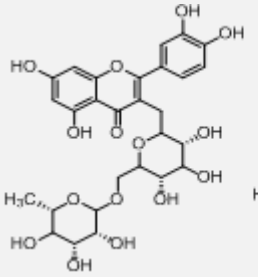
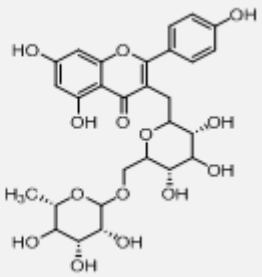
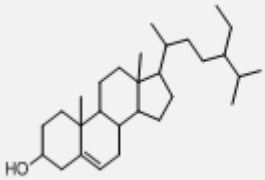
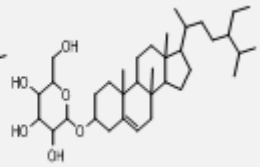
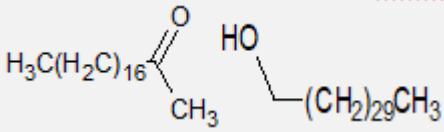
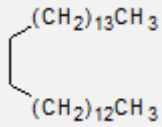
FIG. 2: BIOLOGICAL ACTIVITY OF *THESPESIA POPULNEA*

Phytochemicals of *Thespesia populnea:* The **Table 3** summarizes the phytochemicals found in *Thespesia populnea* categorized into alkaloids, glycosides, terpenes, phenolic compounds (flavonoids), steroids, fatty acids and alkanes. Specific chemicals listed include gossypol, populin, lupenol, kaempferol, β-sitostero and stearic acid with corresponding references.

TABLE 3: PHYTOCHEMICAL OF *THESPESIA POPULNEA* REPORTED BY VARIOUS RESEARCHERS

S. no.	Chemical Category	Chemical constituents	Structure	Reference
1.	Alkaloid	2-(4-hydroxyhept-5-enyl) -3-methyl-hexahydropyrrolo[2, 1-b][1, 3] oxazin-4-one, gossypol	 gossypol	9, 14, 15, 18, 19, 20, 21, 22

2.	Glycoside	Populin, popuneol, populnatin	 Populneol Populin	14, 23
3.	Terpenes	Pentacyclic Triterpenoids- Lupenol, lupenone, betulin	 Lupenol lupenone Betulin	9,14,15,19,20,23,24,25,26,30,31
		Sesquiterpenoids- 1.Populene A 2.Populene B 3.Populene C 4.Populene D 5.Populene E 6.Populene F 7. Populene G 8. Populene H	 1(R=BOH), 2(R=αOH) 3 4  5 (R1=O, R2=Me) 7 (R=βoh), 8 (R=αOH) 6 (R1=αOH,R2=αMe)	
		Sesquiterpenoid quinone- 1. Mansonone C 2. Mansonone D 3. Mansonone E 4. Mansonone F 5. Mansonone G 6. Mansonone H 7. Mansonone S	 1 2 3 4 5 6	
		Sesquiterpene quinone- 1.Thespesenone 2.dehydro-oxoperezinone 6-methyl ether	 1 2	
4.	Phenolic compound (Flavonoids)	Kaempferol, Kaempferol 5-glucosides, kaempferol 7-glucosides	 Kaempferol 5-glucosides Kaempferol 7-glucosides	9,14,19,20,21,27
		Gossypetin	 Gossypetin	

		Herbacetin	 Herbacetin	
		Rutin, kaempferol 3-rutinosides	 Rutin  Kaempferol 3-rutinosides	
5.	Steroids	Polysterol - β- sitosterol, daucosterol, β- sitosterol-β-D-glucoside	 β- sitosterol  Daucosterol	9, 19, 20
6.	Fatty acid	Stearic acid, myricyl alcohol, 1-Hentriacontanol	 Stearic acid 1-Hentriacontanol	9, 20, 27, 26
7.	Alkanes	Nanacosane	 Nanacosane	9, 28

Therapeutic Uses:

Antimicrobial Activity: The **Table 4** summarizes the key information presented in the study by few author on the antimicrobial activity of *Thespesia populnea*. The study focused on the many extract of the plant which was tested against different bacterial species using the several methods.

The extract was found to have varying levels of activity depending on the concentration used [29]. Additionally the plant was found to contain alkaloids, flavonoids, tannins and anthroquinone glycoside *etc*. which may contribute to its antibacterial properties, antiviral and antifungal [30].

TABLE 4: ANTIMICROBIAL ACTIVITY OF *THESPESIA POPULNEA*

S. no.	Author	Extract	Biological test	Method	Result	Ref.
1.	*Saravana kumar et al.* (2009)	Methanolic extract	Antibacterial activity against 13 species	Disc diffusion method,	The extract's activity varied depending on the concentration used: 92.8% at 1000g/ml, 75.7% at 500g/ml, 5% at 250g/ml, and 7.2% at 62.5g/ml and 125g/ml.	34
2.	*Moon et.al.* (2010)	Methanolic extract (leaves) and callus	Antibacterial action against drug-resistant bacterial pathogens.	Bauer-Kirby method	Both leaf and callus extracts showed potential as antibacterial agents. All clinical isolates were resistant to more than one antibiotic.	35
3.	*Senthil et.al.* (2013)	Methanolic flower extract	Antiviral and cytotoxic effects	Cell culture method	Respiratory *syncytial viruses*, *Coxsackie B4* and *vesicular stomatitis* virus were all most effectively combated by methanolic extract. Supports the use of *T. Populnea* as a reliable antibacterial	36

					agent for the treatment of infectious illnesses.	
4.	*Krishna moorthy et.al.* (2014)	Leaves extract with hexane, chloroform, ethyl acetate and methanol	Antimicrobial activity	Disc diffusion method, Determination of (MBC), (MFC) and (MIC)	With a mean zone of inhibition of 14.8 mm, chloroform extract exhibited the most antibacterial activity against *Staphylococcus aureus.* With a mean zone of inhibition of 22.8 mm, methanol extract had the most antifungal efficacy against *Aspergillus fumigatus*. The lowest MIC and MBC values for *S. Aureus* that were obtained while using chloroform extract were 62.5 and 125 g/ml, respectively. The lowest MIC and MFC values for *A. Fumigatus* and *Microsporumgypseum* against methanol extract were 62.5 and 125 g/ml, respectively.	37
5.	*Pratab et.al* (2010)	Leaf extracts (hot and cold) in seven solvents	Antibacterial and antifungal activities	Disc diffusion	The maximum antibacterial activity against *Bacillus cereus* (14 mm) and *Staphylococcus epidermidis* (15 mm) was demonstrated by methanol cold extract, while *Pseudomonas aeruginosa* was inhibited by hot hexane extract with a 12 mm inhibition zone. All seven solvents showed inhibitory zones against *Candida albicans* in both their cold and hot extracts.	38
6.	*Florance et.al* (2016)	Acetone extract fraction of stem bark	Antimicrobial activity against 4 bacterial and 3 fungal strains	Cup plate method	The fraction exhibited higher antibacterial activity than antifungal activity, with moderate activity against all *Candidal species*	39
7.	*Kumar et.al.,* (2016)	Leaves Dried extracts	Antimicrobial activity against *Aspergillus nige*r, *Pseudomonas aeruginosa*, *Escherichia coli* and *Candida albicans*	Agar cup method	High antibacterial activity, low antifungal activity, leaves are a rich source of primary and secondary metabolites with antimicrobial activity	40
8.	*Savithra mma et.al.* (2017)	Yanadi tribe's traditional medicinal plants;	Antimicrobial activity	Disc diffusion assay	Methanol extract plant showed potential inhibitory activity against *Klebsiella pneumonia* and *Rhizopusarrhizus*, among bacteria and fungi, respectively. The correlation of medicinal data with Dr. Duke's Phytochemical and Ethnobotanical Database and existing literature revealed high medicinal significance of claimed data of this tribe.	41
9.	*Narayan an et.al. (2022)*	Aqueous bark extract combined with copper metal	Antimicrobial action against bacteria (*Candida albicans*, *Trichophyton rubrum)* as well as fungal types (*Streptococcus pyogenes*, *Staphylococcus aureus)*	UV-Vis spectroscopy, SEM, particle size distribution, EDX, FTIR, and Zeta potential are used to characterise synthesised	The fungal strain of *Trichophyton rubrum* (MTCC 296) demonstrated a high zone of inhibition in comparison to other microbial strains, and the cuonps shown excellent antibacterial efficacy against skin infection-causing microorganisms.	42

				nanoparticles.		
10.	Kumar et.al, (2022)	Leaf extract in ethanol, chloroform, and sequentially extracted water (SEWE).	*Rhodococcusequi* has in vitro antibacterial activity against *Vap A* and *Vap C* positive strains.	Disc diffusion method, followed by polarity-based and solubility-based fractionation	Ethanol leaves extract was effective against *R. Equi.* Using, solubility-based fractionations of chloroformic leaves extract were discovered to be ineffective against *R. Equi*. However, given its wide availability and antibacterial action against *R. Equi*, leaves may be used as a disinfectant to kill the organism.	[43]
11.	*Whangchai et.al.* (2023)	*Thespesia populnea* extract-coated nano-zirconium	Antimicrobial activity against *E. Coli, Bacillus subtilis, Staphylococcus aureus* and *Pseudomonas aeruginosa*	Well diffusion	The synthesized nanoparticles showed a high toxicity against the bacterial species studied, indicating potential for use in wound dressings. UV-Vis spectroscopy indicated the nanoparticles would possess antimicrobial activity, XRD analysis confirmed their crystalline nature, and TEM analysis revealed their smaller size (about 10 nm).	[44]
12.	Viswanatha *et.al.* (2008)	ALTP	Antimicrobial activity	Cup plate technique	Significant antibacterial efficacy was demonstrated by [AQTP/ALTP] against [the studied bacterial species], however Ciprofloxacin's reference standard drug's zone of inhibition was greater.	[45]

Anticancer and Cytotoxic Effect: *Thespesia populnea* has shown potential anticancer and cytotoxic effects in various studies reported that eleven previously known chemicals and eight novel sesquiterpenoids called populene A–H were isolated and identified from *Thespesia populnea*. Two compounds, Mansonone E and (+)-gossypol showed high cytotoxic activity against four cancer cell lines [46]. The *Thespesia populnea* bark ethanolic extract demonstrated chemo preventive ability against carcinogenesis induced by 7,12-dimethylbenz[a]anthracene (DMBA) in hamster buccal pouch. The extract significantly reduced the amount, type and burden of tumours and had an anti-lipid peroxidative impact and improved antioxidant status in rats treated with DMBA[47]. Extracts from stem bark and leaves exhibited high cytotoxicity against cancer cell lines Ehrlich ascites carcinoma and Dalton's lymphoma ascites. The chloroform extract from *T. populnea*exhibited the highest levels of cytotoxicity [48].

Thespesia populnea stem bark's fractional acetone extract exhibited anticancer activity against the HEp2 cell line at a low cytotoxicity on normal cells [39]. A decoction composed of *Thespesia populnea* was found to inhibit HEp-2 cancer cell proliferation and promote apoptosis without being toxic to Artemia salina[49]. *Thespesia populnea* extract was used to produce bio-fabricated silver nanoparticles (AgNPs) which showed dose-dependent toxicity on human prostate and liver cancer cell lines causing the treated cells to undergo apoptosis [50, 51].

Anti-Inflammatory, Analgesic, Antipyretic, Antinociceptive and Antiarthritic Activity: *Thespesia populnea* has been studied for its anti-inflammatory, analgesic, antipyretic, antinociceptive and antiarthritic activities. Different parts of the plant such as seeds, flowers, roots and leaves have been examined for their therapeutic potential. The fatty acids isolated from the seed oil of *T. Populnea*using petroleum ether and ethanol were palmitic and stearic acid which showed anti-inflammatory and analgesic effects in rat models. The EtOAc fraction had the most significant effect while TPOUM showed considerable anti-inflammatory and analgesic activity [52].

T. Populnea flower and root extracts significantly reduced the development of granuloma tissue, vascular permeability and showed notable analgesic activity in the hot-plate test. Both extracts also reduced paw thickness in the rat test for adjuvant-induced arthritis. The total flavonoid content of *T. Populnea* flower and root extracts was

also determined [53]. The saponin fraction of *Thespesia populnea* showed anti-inflammatory effects in several inflammation models in rodents. SFTP greatly reduced the oedema caused by carrageenan, histamine and 5-HT in rat paws, the vascular permeability in mice caused by acetic acid and the inflammation caused by the carrageenan-induced pleurisy in rats. Moreover, it prevented heat-induced in-vitro protein denaturation [54].

A study investigated the dose- and duration-dependent response of *T. Populnea* extract on its anti-inflammatory activity using experimental mouse models and reported that significantly reduced acute inflammation induced by carrageenan and formalin-induced edema [55]. *T. Populnea* leaves (aqueous and ethanol) extracts significantly reduced paw edema brought on by carrageenan in rats and mice and showed analgesic effects in mechanical, thermal and chemical pain tests at doses of 400, 200 and 100 mg/kg [56].

The antipyretic activity of *T. Populnea* extracts was studied by inducing fever in rats with brewer yeast and administering extracts at a dose of 500 mg/kg orally. The extracts reduced the elevated body temperature in rats compared to the standard drug paracetamol [57]. The studies investigated and confirm that the *T. Populnea* flowers ethanolic extract for anti-inflammatory activity using HRBC and albumin denaturation methods [58].

Antioxidant Activity: Various parts of the *Thespesia populnea*including the stem bark, leaves, fruits and flowers have been evaluated for their antioxidant properties in different *in-vitro* and *in-vivo* models. Studies have shown that the stem bark extract of *T. Populnea*contains high concentrations of flavonoids, phenolics and tannins which exhibit strong antioxidant activity. The extract has been found to scavenge DPPH and superoxide radicals, prevent lipid peroxidation and exhibit reducing power. Gallic acid which is responsible for the antioxidant activity was estimated to be present in a concentration of 10.11% w/w. The effective concentration (EC_{50}) of the extract for DPPH radical scavenging was 12.08g [59]. Similarly the leaves of *T. Populnea* have also been found to contain significant amounts of gallic acid equivalents and (-)-Epigallocatechin gallate equivalents which contribute to their antioxidant properties. The EC_{50} of the leaf extract for deoxyribose, nitric oxide scavenging and DPPH assays were 7.24±0.50, 14.02±0.66 and 53.21±2.82 g/ml respectively [60].

In a study on rats with alcohol-induced oxidative damage, *T. Populnea* leaf extracts were found to prevent histopathological degenerative alterations in hepatic and renal cells. This suggests that the leaf extracts may prevent alcohol-related damage to hepatic and renal organs by lowering oxidative stress [61]. The bark extract of *T. Populnea* has also been studied for its preventive effects against oxidative damage caused by mercury in Swiss albino mice liver. The extract was found to prevent alterations in liver enzymes and antioxidant enzymes as well as the creation of fat cysts and binucleated cells[62]. Additionally the fruit and flower extracts of *T. Populnea* have also exhibited significant antioxidant activity in various in vitro models. The fruit extracts have been found to scavenge DPPH, superoxide anion, hydroxyl radical and nitric oxide while the flower extracts have been found to exhibit antioxidant activity using DPPH and ABTS techniques [58, 63]. Overall, these studies suggest that *T. Populnea* may be a potential source of natural antioxidants.

Anti-Psoriatic Activity: *Thespesia populnea* has been known for decades to have anti-psoriatic properties and the present study looked into this claim. Phytochemical analysis of different parts of the plant including leaves and barkrevealed the presence of triterpenoids, tannins, glycosides, phytosterols and flavonoids which are responsible for the plant's anti-psoriatic activity. *Thespesia populnea* bark extract and isolated three compounds TpS-2, TpF-1 and TpF-2. Using the Perry's scientific mouse tail model various extracts and isolated compounds were examined for their anti-psoriatic action when applied topically. TpF-2 and the pet-ether extract demonstrated the most promising outcomes [64, 66].

The methanolic leaf extracts of *Thespesia populnea* and found that it demonstrated a higher anti-psoriatic activity than the standard drug Retion-A (0.05%). The study also revealed that the methanolic leaf extract of *Thespesia populnea* can target E2A gene expression for psoriasis levels indicating its potential as a promising antipsoriatic

drug [65]. The ethanolic extract of *Thespesia populnea* leaves, using the Mouse-Tail model extract was topically applied for 14 days resulting in significant increases in the orthokeratosis region and relative epidermal thickness compared to the control group. This indicates the extract's notable anti-psoriatic activity [67]. Overall, *Thespesia populnea* extracts have been shown to promote epidermal differentiation and normal keratinization of keratinocyte produce significant orthokeratosis and demonstrate higher antipsoriatic activity. The dose and chemical responsible for antipsoriatic activity vary depending on the part of the plant and the extraction method used [68].

Antidiabetic and α- Amylase Inhibitory Activity: *Thespesia populnea* has been studied for its potential anti-diabetic effects in various parts of the plant. The ethanolic extracts from plant bark and leaf were found to have anti-diabetic effects in rats induced by streptozotocin. The extracts possibly inhibited free radical generation and their effects were comparable to the standard drug glibenclamide [69]. *T. populnea* leaves were found to be effective as a α-amylase inhibitor which could help manage postprandial hyperglycaemia in diabetes. The study involved fractionating the extracts using solvents of different polarity and analysing their metabolite [70].

T. populnea fruit pulp extracts were found to have antihyperglycaemic and antihyperlipidemic effects in rats induced by alloxan. The ethanol and aqueous extracts both substantially reduced blood glucose levels and improved lipid profiles after 28 days of medication at a therapeutic level of 200 mg/kg. The extract phytochemical composition and acute toxicity were also studied [71, 72]. A sesquiterpene extracted from *Thespesia populnea* bark showed potential anti-diabetic properties in glucose-loaded and healthy animals. The compounds vanadium complex was found to have anti-hyperglycaemic and hypoglycaemic effects [73]. *T. Populnea* seed extract and ethanol were found to have hypoglycaemic activity in normal and diabetic rats induced by alloxan. Both extracts significantly decreased blood glucose levels at days 21 and 28 of the subacute investigation. They also increased glucose tolerance in an oral glucose tolerance test at two dosing levels (Dose: 200-400 mg/kg) [74].

Wound Healing Activity: Studies on *Thespesia populnea* have shown its potential for wound healing. An ethanol extract of *T. populnea* bark was found to be effective in wound healing using excision wound models. It was used in traditional medicine to treat wounds in gels containing 2.5% and 5% of the extract [75]. A topical gel with wound healing and antibacterial properties was created using an alcoholic extract of *T. populnea* leaves. The gel was optimized using propylene glycol and carbopol. Studies on antimicrobial activity and *in-vivo* wound healing were comparable to Soframycin gel [76]. The aqueous extract from *T. Populnea* fruit showed significant action in excision and incision wound models in rats. The study supports the conventional use of *T. populnea* fruit treatment for healing wounds [77]. Various *T. Populnea* leaf extracts (petroleum ether, alcohol and aqueous) were evaluated for their ability to treat albino rat excision and incision wound models. The aqueous extract performed better than the alcoholic and petroleum ether extracts in both models for wound healing. The extracts were tested on rats under light ether anaesthesia and the leaves of *T. populnea* were found to contain flavonoids, phytosterols and alkaloids [78].

Anti-Implantation Activity: Female albino rats were used to test the anti-implantation activity of pure principles isolated from petroleum-acetate and crude alcoholic seed extracts of *T. populnea*. Rats were given the substances from the 1st to the 7th day and on the 10th day of pregnancy the number of corpora lutea and implantation sites was counted. At 110 mg/kg b.w., chromatographic pure principles demonstrated considerable anti-implantation action (60%) while EAc extract shown 48.6% efficacy. The resulting alcoholic extract had no discernible effect. The active ingredients in PE and EAc extracts were discovered to be a combination of two classes of long-chain fatty acids had anti-implantation activity [79].

Antidiarrheal Activity: *Thespesia populnea* stem bark extract fractions were examined for their potential to treat diarrhoea. The methanolic and residue fractions were found to be efficient in lowering faeces bulk in the diarrhoea model, however the ethyl acetate fraction did not show a significant effect. The residual fraction had anti-

secretory and anti-motility properties and was more powerful than the methanolic fraction [80, 81].

Diuretic Activity: This study examined the diuretic efficacy of *Thespesia populnea* bark powder in rats after extracting it using various solvents. When administered at a dose of 400 mg/kg the extract significantly increased both the volume and ion concentration of the urine. The extract was discovered to have both natriuretic and diuretic properties as well as polyphenolic chemicals, carbs and proteins. A standard for comparison was furosemide [82].

Antityrosinase Activity: The need for skin-lightening products is great which has sparked research into new compounds that can lighten skin. In this study tyrosinase inhibitors from eight medicinal plants that have historically been used to treat skin conditions were sought for. LDOPA was used as the substrate for the *in-vitro* tests and kojic acid served as the positive control. With an IC_{50} value of 190 g/mL *Thespesia populnea* bark showed the greatest tyrosinase inhibitionthan kojic acid has a substantially lower IC_{50} value (3.4 g/mL) [83].

Alzheimer Disease: *T. populnea* bark's effects on mice cognition, cholinesterase activity and total cholesterol levels were assessed in this study. Young and old mice received three doses (100, 200 and 400 mg/kg) of the ethanolic extract of *T. populnea* orally over the course of seven days. According to the findings *T. populnea* extract enhanced memory in both young and old mice and prevented amnesia brought on by scopolamine and diazepam. *T. populnea* bark has been shown to improve cognition, lower cholesterol, inhibit cholinesterase and reduce inflammation making it a viable treatment for Alzheimer's disease [84, 85].

4Anthelmintic Activity: *Thespesia populnea* root extracts were produced in 0.1%, 0.2%, and 0.5% concentrations of ethyl acetate, methanol and chloroform and petroleum ether for this study to assess their anthelmintic potential. The extracts were tested against *Pheritima posthuma* and *Ascaris lumbricoides* with petroleum ether extract (0.5%) showing significant activity. The time taken for paralysis and death against *Pheritima posthuma* was 9.25 min and 15.8 min respectively and against *Ascaris lumbricoides* was 4.50 min and 9.25 min respectively [86]. Using *Pheritimaposthuma* earthworms it was determined whether a herbal formulation containing *Thespesia populnea* had any anthelmintic properties. The formulations ethanolic extract demonstrated greater activity than the aqueous extract in tests measuring the paralysis and death times of the worms and piperazine citrate was employed as the standard drug[87].

Antiulcer Activity: *Thespesia populnea* leaf terpenoid fraction was examined for its ability to treat ulcers in this study. Rats with stomach ulcerations were given different doses of the TF orally and various parameters were used to evaluate its effectiveness. The findings indicated that the TF had cytoprotective benefits by decreasing the ulcer index in a dose-dependent manner, decreasing gastric secretions and increasing pH and potassium ion output. Additionally, the TF increased mucin and total carbohydrate activity. These results demonstrate that the TF has strong anti-ulcer action and support the traditional usage of *T. populnea* for the treatment of stomach ulcers [88].

The potential of *Thespesia populnea* heartwood in treating ulcerative colitis (UC) was evaluated using an intrarectal DNBS-induced UC model in mice. The aqueous extract showed significant improvement in macroscopic and microscopic scores, decreased MDA and MPO levels, restored Hb concentration and decreased protease activity in DNBS-treated mice. The results suggest that *T. Populnea* heartwood aqueous extract is effective in treating UC [89].

Antitumor Activity: Using animal studies, the anti-tumour potential of *T. Populnea* was investigated. *T. populnea* methanol extract treatment considerably slowed the growth of solid tumours in mice. In tumour-bearing rats the extract decreased serum GGT and NO levels as well as tumour cell GSH levels ($p<0.01$). As well, hosts who received extract showed a significant rise in their haemoglobin levels and total WBC count. Based on this research it is possible to use *T. populnea* extract as a natural anti-tumour agent [55].

Anti-Allergic Activity: This study examined into the ethanolic bark extract of *Thespesia populnea* anti-anaphylactic and mast cell moderating

properties. Compound 48/80- in rat peritoneal mast cells induced mast cell degranulation was used to assess the stabilising activity of mast cells. Mast cell degranulation was greatly decreased by TPEE at a dose of 60 mg/ml. Rats exposed to Compound 48/80 were counted to determine the mortality rate which was used to assess antianaphylactic activity. TPEE had antianaphylactic activity comparable to ketotifen at a dose of 400mg/kg. These results point to TPEE potential as an anti-allergic drug by showing that it reduces mast cell degranulation mast cell-derived allergic reactions (immediate-type) [90].

Antihepatotoxicity Activity: *Thespesia populnea* has shown potential for its antihepatotoxic activity and hepatoprotective properties. The ethanol extract fractions of *Thespesia populnea* were evaluated for their antihepatotoxic activity using the carbon tetrachloride (CCl_4) liver injury model in rats. All examined fractions showed potential antihepatotoxic activity and a rare flavonoid called quercetin-7-O-rhamnoglucoside was extracted from the plant. *Thespesia Populnea*and the isolated flavonoid may have therapeutic properties for liver damage [91]. *Thespesia populnea* was studied along with other herbs to identify phytocompounds with potential anti-hepatitis B viral activity. The study utilized chemical databases and publications to assess druggability and toxicity. *Thespesia populnea* exhibited high connectivity with multiple targets and pathways particularly involving the hub protein EGFR and the compound Gossypetin. The discovered moieties could potentially be therapeutically employed to target hepatocellular carcinoma (HCC) associated with hepatitis B virus (HBV) [92].

Thespesia populnea bark extracts were tested for their hepatoprotective properties against liver damage induced by carbon tetrachloride (CCl4). Methanol (MET) and aqueous (AET) extracts were evaluated at two dose levels (250 and 500 mg/kg). The extracts demonstrated dose-dependent reduction of biochemical markers associated with liver damage and increased levels of total protein. Histopathological analysis showed modest hepatocytic damage. MET extract showed greater hepatoprotection compared to AET. *Thespesia populnea* bark extracts have potential as a treatment for liver injury [93, 94]. Overall, *Thespesia populnea* exhibits antihepatotoxic and hepatoprotective properties and the plant's extracts and isolated compounds have shown promising results in protecting the liver from damage.

Immunomodulatory Activity: *Thespesia populnea* leaf methanolic extract was studied at three doses (100, 200 and 400 mg/kg) for its immunomodulatory effect. Levamisole and cyclophosphamide were the two commonly used immunosuppressive and immunomodulatory medications. At 400 mg/kg p.o., b.w., the extract significantly ($P<0.01$) enhanced the DTH response and higher doses of the extract improved the antibody titre response to SRBC. At 200 mg/kg p.o., b.w., METP also counteracted Cyclophosphamide-induced myelosuppression with WBC counts returning to normal levels ($P<0.001$). Triterpenoids, flavonoids, phenolic, amino acids, proteins and steroidal compounds were found in phytochemical screening which may be the reason of the immunomodulatory activity viewed. Based on the study *T. populnea*may be explored as a potential complementary therapeutic agent [95].

Synergistic Activity: Oxytetracycline and a methanolic extract of *Thespesia populnea* were used in this study to create an antimicrobial combination for diseases that are multidrug resistant. For 12 gram positive and gram negative bacteria the extract's MIC in combination with oxytetracycline varied from 62.5 g/mL to 1000 g/mL. Using Kirby and Bauer techniques, synergistic activity was confirmed with 83.3% of combinations illustrating synergism against all 12 bacteria. The strongest synergism was seen in the case of *Shigella boydii* (ATCC8700). Overall, the research points to this combination's potential as an economically sound medical strategy for infections that are resistant to many drugs [96].

Antisteroidogenic Activity: Female albino mice were used in the study to test the anti-steroidogenic effects of several *T. populnea* extracts. The weight of the ovaries and uterus was reduced significantly after treatment with *T. populnea* extract while the quantity of ascorbic acid and cholesterol was significantly increased in the ovaries. After 15 days of treatment the study also detected a considerable suppression of critical ovarian steroidogenesis enzymes such as glucose – 6 - phosphate

dehydrogenase and 5, 3 - hydroxy steroid dehydrogenase [97].

Other Uses:

As Natural Dye: *Thespesia populnea* bark has been utilized in various studies for its natural dyeing properties on fabrics.

Natural Dye Extraction: The ethanolic extract of *Thespesia Populnea*bark was used to extract a natural dye for potential replacement of synthetic dyes in food and cosmetics. The extracted dye was applied to different fabrics including cotton, buttercrep, polymer, chiken, lone, ulene and tarakasa. The results demonstrated good dyeing properties with cotton and tarakasa showing the best results. The dyeing properties remained unaffected by washing, soap and sunlight exposure suggesting the suitability of *T. Populnea* bark extract as a natural dye for fabric [98].

Sustainable Natural Dyeing: This study focused on sustainable natural dyeing using organic mordants and *Thespesia populnea* fruit dye extraction. Ultrasonic bath dyeing was compared with traditional water bath dyeing on textiles such as silk, cotton and nylon. The results revealed that ultrasonic dyeing was superior in terms of energy conservation and dye exhaustion. This research suggests energy-saving dyeing techniques and environmentally safe, non-hazardous sustainable natural dyeing utilizing natural mordants [99].

Flower Composite and Fabric Finishing: The Soxhlet apparatus was used to create composites using flowers from *Thespesia Populnea.* These composites along with alum, $CuSO_4$ and $FeSO_4$ as mordants were applied to finish polyester and cotton fabrics. The finished fabrics exhibited good performance in tests for wash fastness against washing, alkalis and acids, perspiration and light. Additionally, the flower composites showed synergistic antibacterial action against *S. aureus* and *E. coli*. Although the resultant fabrics experienced slight reductions in tensile strength, air permeability, dimensional stability and increased pilling their GSM (Grams per Square Meter) was higher than that of the control fabrics [100]. In summary, *Thespesia populnea* bark extract offers promising natural dyeing properties for fabrics demonstrating good dyeing performance and durability. The utilization of organic mordants and sustainable dyeing techniques further enhances the potential of *Thespesia populnea* as an environmentally friendly alternative in the textile industry.

As Biodiesel: Milo (*T. Populnea*) seed oil is being evaluated as a possible feedstock in the research for unconventional seed oil sources for the production of biodiesel. The two cyclopropane fatty acids and 8, 9-methylene-8-heptadecenoic (malvalic) used in the production of biodiesel fuel are reported here for the first time. The crude oil was Trans esterified with sodium methoxide as catalyst going to result in biodiesel. Antioxidants would be needed in order to achieve standards for the 2.91 h oxidative stability. Overall, the results showed potential for *Thespesia populnea* seed oil as an unconventional feedstock for biodiesel synthesis comparing strongly with ASTM D6751 and EN 14214 requirements [101].

Anticorrosive Activity: *Thespesia populnea* plant extracts containing Phytol, n-Hexadecanoic acid, Linoleic acid and trans-Squalene were active components identified for inhibiting metal corrosion. The 500 ppm optimum concentration delivered protection with efficiencies ranging from 97% to 98%. According to electrochemical impedance spectroscopy (EIS) studies the TiO2-TP composite coating developed using the plant extract demonstrated remarkable potential in the paint industry with efficiency of 91.6%, 97.9% and 98.5% at 80°C in 1M HCl and rainwater mediums respectively. This green inhibitor and composite coating are highly recommended for industrial application and are in line with green protocols [102].

CONCLUSION: *Thespesia populnea* is a plant that has been used in Ayurvedic medicine for a long time and recent research has confirmed its medicinal properties. The plant's different parts including the bark, fruit, stem, seed oil, leaves and roots contain a variety of therapeutically useful substances. Among the significant chemical constituents of this plant are gossypol, gossipetin, lupenol and harbacetin. These chemicals have a variety of biological effects including anti-inflammatory, antioxidant, hepatoprotective, anti-cancer and anti-fertility qualities.

Further study is required to better understand the mechanisms of action of the plant components found in *Thespesia populnea* which has the potential to be utilised as an alternative treatment for a number of ailments. In general this plant is a great source of organic chemicals that can be investigated to provide novel therapies for various health conditions.

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