J Herbmed Pharmacol. 2023; 12(1): 25-40.

http://www.herbmedpharmacol.com doi: 10.34172/jhp.2023.03

Journal of Herbmed Pharmacology

Reviewing the reported pharmacognostic and pharmacological investigations on *Tecoma stans* Juss. ex Kunth

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ARTICLE INFO

Article Type:
Review

Article History:
Received: 7 August 2022
Accepted: 14 October 2022

Keywords:
Bignoniaceae
Flavonoids
Alkaloids
Antioxidants
Fatty acids

ABSTRACT

This review is destined for a comprehensive assessment of the phytochemistry and medicinal properties of *Tecoma stans*, a widely used plant in folk cultures, as a traditionally safe and effective treatment for different diseases and complications. The attainable and reachable sources of *T. stans* confirmed its origin, ethnopharmacological properties, and therapeutic medicinal uses. Besides a hundred chemical compounds that have been isolated, the main active constituents are flavonoids, alkaloids, phenolic acids, and fatty acids. *T. stans* exerted many medicinal benefits, including antidiabetic, anti-inflammatory, anti-cancer, anti-microbial, antioxidant, hepatoprotective, cardioprotective, and nephroprotective properties. However, there is a shortage of in vivo studies, especially adequate dosage and toxicity studies. More studies should be carried out for nutritional data. This review represents a scientific understanding of clinical correlations and applications of phytocompounds from *T. stans* in protecting and treating many complaints and disorders.

Implication for health policy/practice/research/medical education:
This work is to present a literature review that categorizes the important phytoconstituents of *Tecoma stans*. Moreover, this review classifies the biological activities of the plant according to the latest published studies. Therefore, it provides beneficial information for future in vivo and clinical studies on *T. stans*.

Please cite this paper as: Khattab A, Awad NE, Fadeel DA, Fadel M. Reviewing the reported pharmacognostic and pharmacological investigations on *Tecoma stans* Juss. ex Kunth. J Herbmed Pharmacol. 2023;12(1):25-40. doi: 10.34172/jhp.2023.03.

Introduction

Tecoma stans (L.) Juss. Ex Kunth (Bignoniaceae) has traditionally been used as a source of medicine contributing to human health and well-being. More than 80% of the world's population uses traditional herbal medicines, especially in the developing world (1). The genetic biodiversity and varieties of traditional medicinal herbs often no longer exist due to growth exploitation, environment-unfriendly harvesting techniques, loss of suitable habitats, and non-monitored dealing with medicinal plants. *T. stans* is a medicinal herb with many uses for the treatment of diabetes mellitus, gastrointestinal tract complaints, and microbial infections. Moreover, it can be used as a strong diuretic, vermifuge, and tonic. The leaves, bark, and root extracts hold biologically active phytoconstituents; therefore, they are used in traditional folk medicines. The preliminary phytochemical analysis resulted in the presence of many active constituents such as alkaloids, flavonoids, tannins, quinones, and traces of saponins and amino acids (2).

The generic name of *T. stans* comes from the word tecomaxochit, which was used by Mexican indigenous peoples to describe plants with tubular flowers, also known as yellow bells, yellow-elder, yellow trumpet bush, trumpet bush, ginger-thomas, esperanza, and tronadora (3). Tecoma is a genus comprising fourteen species of shrubs or small trees in the trumpet vine family, Bignoniaceae. Twelve species are present in the Americas, but the other two species are present in Africa (4). It is distributed throughout South America and India, although its native habitat extends from southern Texas, New Mexico, and Arizona to Bolivia and northern Argentina and from Florida and the Bahamas to Trinidad in the Caribbean. In addition, it is cultivated in tropical and subtropical areas in Africa, Asia, the Pacific Islands, and Australia (3). *T. stans* survives by fully being exposed

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to sunlight and distributes on roadsides. *T. stans* exists in moderate salt and alkaline soil conditions and propagates by seeds and green cuttings (5). The plant takes about two years to bloom (6).

Morphologically, *T. stans* is about 20-30 ft in height with moderate growth, clustered elongated fruits, yellow flowers, green compound, imparipinnate, lanceolate leaves with a serrate margin of 2 to 5 pairs of leaflets with a larger single terminal leaflet. Leaflets are lanceolate, about 10 cm long, with serrated margins, mid-green above, and softly touched. Flowers are presented in trumpet-shaped clusters at the branches' ends and with 5 rounded lobes, 6 cm long, pale to bright yellow. Fruits are narrow, slightly flattened to pointed capsules, about 20 cm long, with many winged young green seeds turned to pale brown on ripening and maintained in untidy clusters on the tree for months (7).

Some reviews have already been published regarding the constituents and biomedical applications of T. stans. However, some of the published reviews focused on a particular therapeutic use of *T. stans*, such as its use as an anti-cancer (8) or anti-diabetic (9) remedy, while others covered general information regarding the phytochemistry and the pharmacology of the plant. For example, Anand and Basavaraju (10) categorized the phytoconstituents of *T. stans* according to the part of the plant from which they were isolated and summarized the findings of the earlier studies about the general medicinal use of the plant. Rahmatullah et al (11) summarized the general uses of *T. stans* as a member of the family Bignoniaceae. In this review, we categorized the main phytoconstituents isolated from *T. stans* according to their phytochemical class (such as alkaloids, glycosides, and phenolic compounds). Moreover, we provided a new classification of the most common biological activities of *T. stans* and summarized most of the previously published studies that were concerned with *T. stans*' biomedical uses. The information in this review may be a base for upcoming in vivo and clinical research using *T. stans*.

Taxonomical classification

Domain – Eukaryota
Kingdom – Plantae – plants, Planta, Vegetal, plants
Subkingdom – Viridaeplantae – green plants
Infrakingdom – Streptophyta – land plants
Phylum – Tracheobionta – Vascular plant
Subphylum – Euphyllophytina
Super division – Spermatophyta
Division – Tracheophyta – vascular plants, tracheophytes
Subdivision – Spermatophytina – spermatophytes, seed plants, phanérogames
Infradivision – Angiospermae – flowering plants, angiosperms, plantas comflor, angiosperma, plantes à fleurs, angiospermes, plantes à fruits
Class- Magnoliopsida
Superorder – Asteranae
Order – Lamiales
Family – Bignoniaceae – bignonias
Genus -Tecoma Juss. – trumpetbush
Species – Tecoma stans (L.) Juss. ex Kunth – yellow elder, yellow trumpet flower, trumpet bush, trumpet flower [2].

Vernacular names

Hindi – Piliya/ Pila kaner, English – Yellow bells, Kannada – Koranekelar, Tamil – sonnapatti, Telugu Pachagotla, Bengali – chandaprabha, Marathi – Ghanti ful [2].

Phytochemical constituents

Various compounds that have been recognized in different parts of *T. stans* were classified into alkaloids (Table 1), phenolics (Table 2), flavonoids (Table 3), glycosides (Table 4), carotenoids (Table 5), pentacyclic triterpenoid (Table 6), and miscellaneous compounds (Table 7). All the listed compounds have a significant role in the biomedical impact of the plant.

Biological activities of *Tecoma stans*

There are many studies carried out for recognizing and evaluating the medicinal and biological activities of *T. stans*. The aerial components have been reported to be used in the treatment of gastritis, diarrhea, and stomach problems. Roots were used as a vermifuge, diuretic, tonic, and for the treatment of snake and rat bites, scorpion stings, and syphilis (25). Various phytoconstituents identified and isolated from *T. stans* have exerted many biological properties, including antioxidant, anti-androgenic,

Table 1. Important isolated alkaloids from *Tecoma stans*

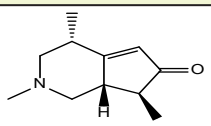
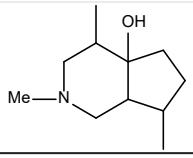
Compound name	Chemical structure	Part of plant/type of extraction
Tecomine		Fruits/aqueous (12). Flowers/methanol (13)
5-Hydroxyskytanthine		Fruits/ethanol (14) Fruits/aqueous (12)

Table 1. Continued

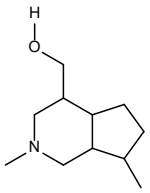
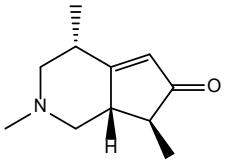
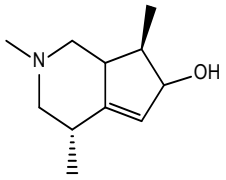
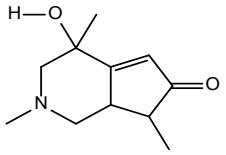
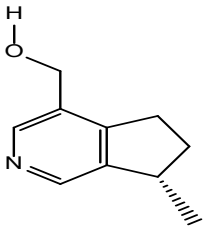
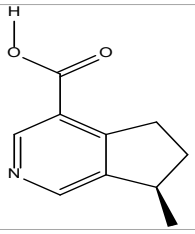
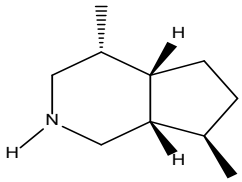
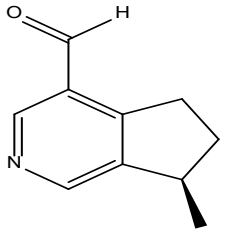
Compound name	Chemical structure	Part of plant/type of extraction
Tecostanine		Leaves/diethyl ether/NH3 15% (10%) (15)
Tecomanine		Fruits/ethanol (16,17)
7-Hydroxydehydroskytanthine		Fruits/ethanol (14)
4-Hydroxytecomanine		Fruits/ethanol (14)
Tecostidine		Root, leaves, and twigs/methanol or ethanol (18)
Boschniakinic acid		Root, leaves, and twigs/methanol or ethanol (18)
N-Normethyl skytanthine		Root, leaves, and twigs/methanol or ethanol (18)
Boschniakine		Root, leaves, and twigs/methanol or ethanol (18) Fruit/aqueous (12)

Table 2. Important isolated phenolics from *Tecoma stans*

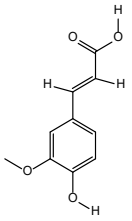
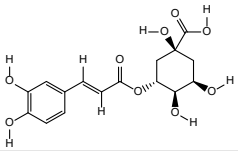
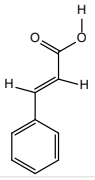
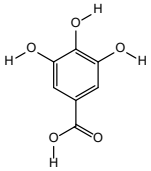
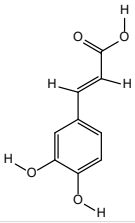
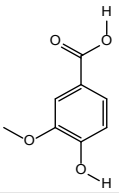
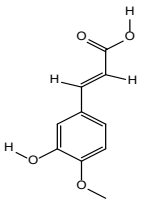
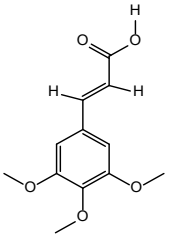
Compound name	Chemical structure	Plant part/type of extract
Ferulic acid		Flowers/methanol (13) Leaves/methanol (16)
Chlorogenic acid		Leaves/hydroethanolic (17) Leaves/methanol (16)
Cinnamic acid		Leaves/hydroethanolic (17) Leaves/methanol (18)
Gallic acid		Leaves/hydroethanolic (17) Leaves/methanol (16)
Caffeic acid		Leaves/hydroethanolic (17) Leaves/methanol (16)
Vanillic acid		Leaves/hydroethanolic (17) Leaves/methanol (16)
Isoferulic acid (3-Hydroxy-4-methoxy cinnamic acid)		Leaves/methanol (17)
3,4,5-Trimethoxy cinnamic acid		Leaves/methanol (16)

Table 2. Continued

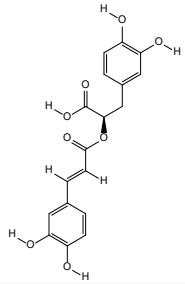
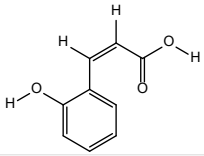
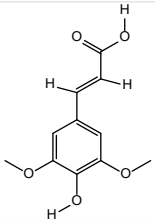
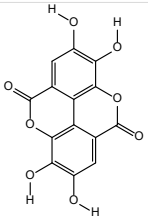
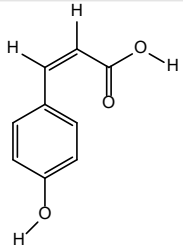
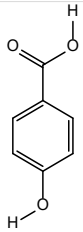
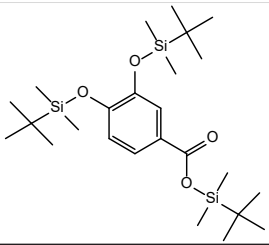
Compound name	Chemical structure	Plant part/type of extract
Rosmarinic acid		Leaves/methanol (16)
O-coumaric acid		Leaves/hydroethanolic (17)
Sinapic acids		Leaves/hydroethanolic (18)
Ellagic acid		Leaves/methanol (16)
P-coumaric acid		Leaves/methanol (16)
P-Hydroxybenzoic acid		Leaves/methanol (16)
Protocatechuic acid		Leaves/methanol (16)

Table 3. Important isolated flavonoids from *Tecoma stans*

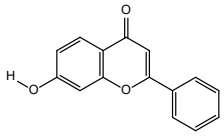
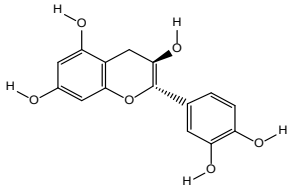
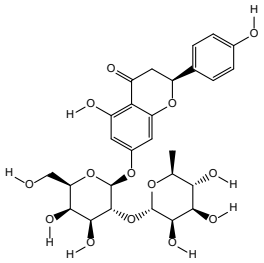
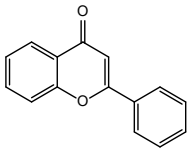
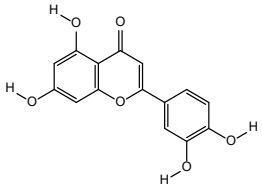
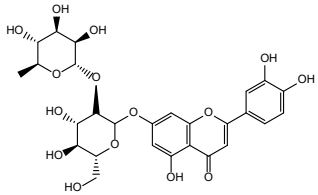
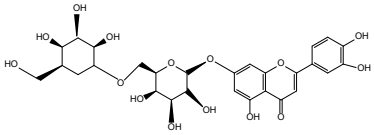
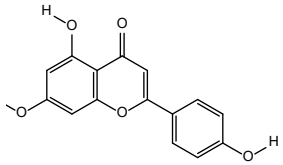
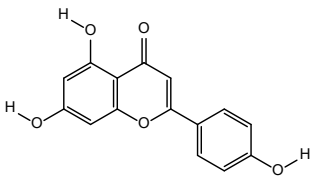
Compound name	Chemical structure	Part of plant
7-Hydroxyflavone		Leaves/methanol (16)
Catechin		Leaves/methanol (16)
Naringin		Leaves/methanol (16)
Flavanone		Leaves/hydroethanolic (17)
Luteolin		Leaves/hydroethanolic (17)
Luteolin 7-O-β-D-neohespridoside		Fruit/ethanol (12)
Luteolin 7-O-β-D-glucopyranoside		Fruit/ethanol (12)
Diosmetin 7-O-β-D-glucopyranoside		Flower/ethanol (12)
Apigenin		Leaves/hydroethanolic extract (12) -Leaves/methanol (16)

Table 3. Continued

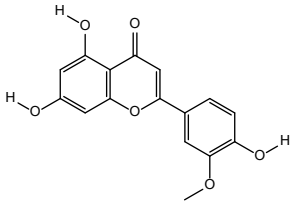
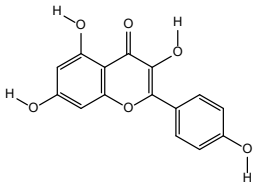
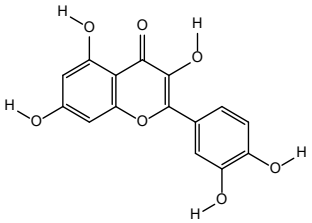
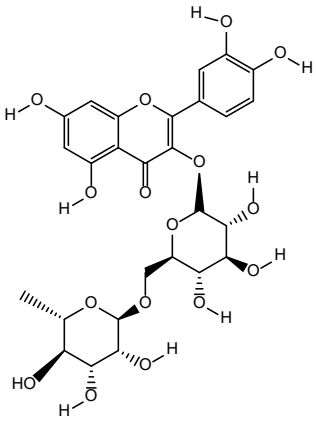
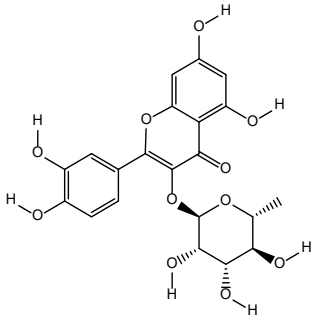
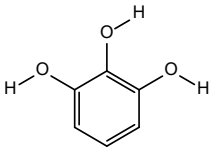
Compound name	Chemical structure	Part of plant
Chrysoeriol		Leaves/hydroethanolic extract (12) -Flowers, methanol (13)
Kaempferol		Leaves/hydroethanolic (17) -Leaves/methanol (16)
Quercetin		Leaves/hydroethanolic (17) -Leaves/methanol (16)
Rutin		Flowers/alcohol (19) -Fruits/ethanol (12) -Leaves/methanol (16)
Quercitrin		Leaves/methanol (16)
Pyrogallol		Leaves /methanol (16)

Table 4. Important isolated glycosides from *Tecoma stans*

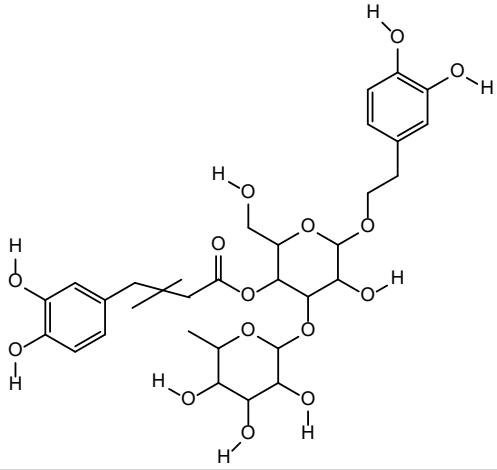
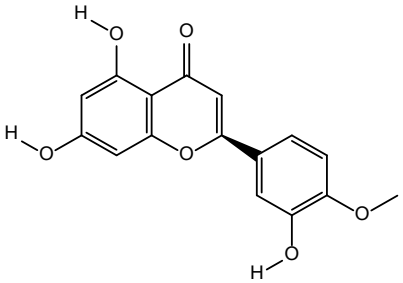
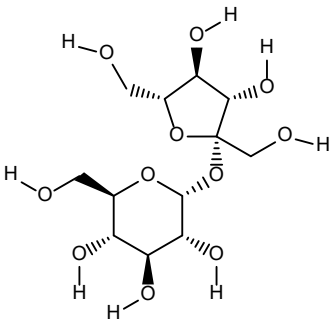
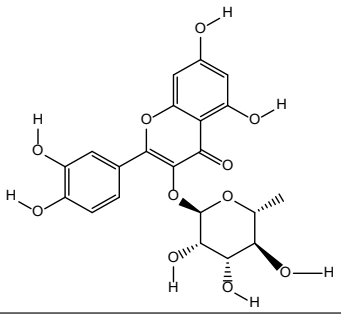
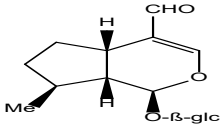
Compound name	Chemical structure	Plant part
Verbascoside		Leaves/hydroethanolic (17) Flower, fruit/ethanol (12)
Hesperetin		Leaves/methanol (16)
Sucrose		Fruit/ethanol (12)
Plantarenaloside		Leaves/chloroform, methanol (20)
5-Deoxystansioside		Leaves/chloroform, methanol (20)

Table 5. Important isolated carotenoids from *Tecoma stans*

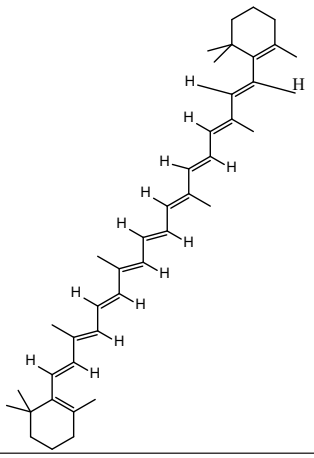
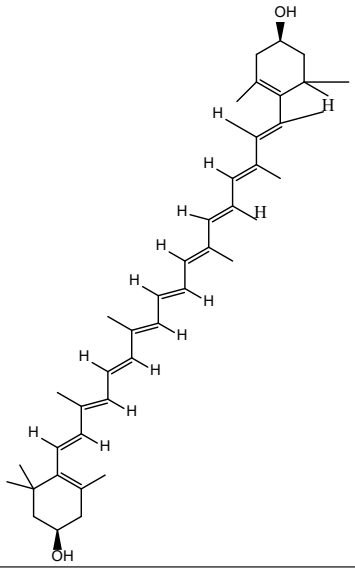
Compound name	Chemical structure	Plant part
β-carotene		Flowers/ethanol (21)
Zeaxanthin		Flowers/aqueous (22)

Table 6. Important pentacyclic triterpenoid compounds from *Tecoma stans*

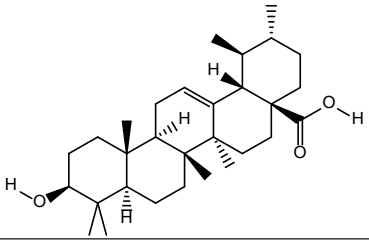
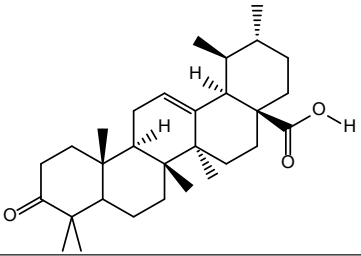
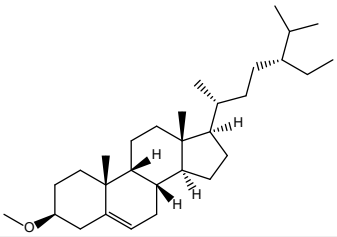
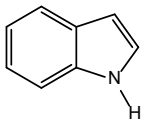
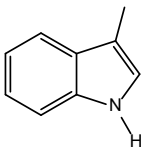
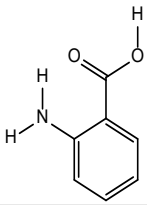
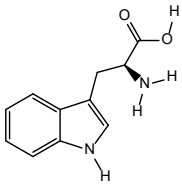
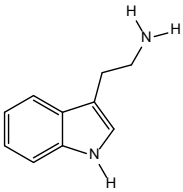
Compound name	Chemical structure	Part of plant
Ursolic acid		Leaves/Ethyl acetate (23) Flowers/methanol (13)
3-Oxo-urs-12-en-28-oic acid		Flowers/methanol (13)

Table 7. Important miscellaneous compounds of *Tecoma stans*

Compound name	Chemical structure	Part of plant	Chemical class
β-Sitosterols		Leaves/ Hydroethanolic (17)	Phyto sterols
Indole		Leaves/methanol (24)	Indolic compounds
skatole		Leaves/methanol (24)	Indolic compounds
Anthranilic acid		Leaves/methanol (24)	Amino benzoates
Tryptophan		Leaves/methanol (24)	Amino Acids
Tryptamine		Leaves/methanol (24)	Amines

antifungal, lubricant, alpha-reductase inhibitor, immunomodulator, hypocholesterolemic, antihistaminic, antiarthritic, antieczemic, antiacne, protective cancer, and hepatoprotective activities (10). *T. stans* was also found to exert potential antimicrobial activities against a wide range of microbial strains listed in Table 8. The medicinal activities against bowel diseases such as anti-spasmodic, antidiarrhea, anti-ulcer, and anthelmintic activities are listed in Table 9**.** Various miscellaneous activities such as inhibiting platelet aggregation, anti-urolithiasis, anti-inflammatory, anti-arthritis, antioxidant, antiproliferation, anti-cancer, anti-diabetic, and antidepressant properties are listed in Table 10. Other miscellaneous pharmaceutical applications are listed in Table 11.

Plant safety and toxicity

The safety and toxicity of the plant were studied and concluded that the median acute toxicity (LD50) of *T. stans* extract was identified to be <5000 mg/kg body weight in mice. Sub-chronic use for 28 days showed significant weight gain, decrease in platelet levels, decrease in white blood cells, and elevation in blood glucose in comparison to the normal. The hydroethanolic extract showed no adverse events on vital organs and was safe in moderate doses (74).

Conclusion

From this review, it can be deduced that *Tecoma stans* (family Bignoniaceae) is rich in various types of active constituents possessing diverse biological properties such as anti-infective, anti-hyperlipidemic, hepatoprotective, cardioprotective, nephroprotective activities. Therefore, it would be important to extensively investigate the phytochemicals and pharmacological activities for future drug discovery and development.

Table 8. Summary of the previous studies about the antimicrobial activities of *Tecoma stans*

Biological activity	Part used	Type of extract	Name of strain
Antibacterial activities	Flowers	Ethanol, ethyl acetate, dichloromethane	*Escherichia coli,* and *Enterococcus faecalis* (26)
	Branches and leaves	Methanol	*Staphylococcus aureus* (ATCC# 6538), methicillin-resistant *Staphylococcus aureus* (MRSA*)* 10, and MRSA 11 (27)
	Flowers	N-hexane	*Streptococcus mutants,* harmful bacteria, cause tooth decay, so *T. stans* could be used in toothpaste and mouthwashes as an anti-oral pathogen (28)
	Leaves, callus	Methanol, chloroform	*Staphylococcus aureus, B. subtilis, Escherichia coli, and Pseudomonas aeruginosa* (29)
	Flowers	Water	*Staphylococcus aureus* and *Escherichia coli* (30)
	Leaves	Water, ethanol, and chloroform	*Pseudomonas aeruginosa* (31)
	Flowers	Ethanolic	*B. subtilis, E. coli, S. aureus, P. mirabilis, and K. pneumoniae* (32)
	Plant materials	Chloroform, butanol, and ethyl acetate	*E. coli, P. aeruginosa, and S. aureus* (33)
	Flowers	Methanolic	*E. coli, Entero bacterium*, and *bacillus creases*. Gram-negative strains were more susceptible to raw materials than gram-positive strains (34)
	Plant parts	Ethanol, methanol, and water extracts	*E. coli, Klebsiella pneumonia, Clavibacter michiganensis* sub sp*. Michiganensis, Xanthomonas axonopodis* pv*. malvacearum, Pseudomonas fluorescens, Pseudomonas aeruginosa,* and *Staphylococcus aureus* (35)
Antifungal activities	Flowers	Ethanolic	*Penicillium* spp (32)
	Leaves	Water, ethanol, chloroform	*Aspergillus niger* (31)
	Plant materials	N-hexane, ethyl acetate	*Fusarium solani* and *Aspergillus niger* (33)
	Plant parts	Ethanol, methanol, and water extracts	All species of *Aspergillus* and *Alternaria* (35)
	Leaves	Petroleum ether, chloroform, ethanol	*Candida albicans, Cryptococcus neoformans, and Microsporum gypseum* (38)
	Root	Dichloromethane and methanol	Saccharomyces and *Candida Albicans* (37)
Antiviral Activity	Trunks, leaves	Ethanol	*Zika* virus (38)

Table 9. Summary of the previous studies of bowel biological activities of *Tecoma stans*

Biological activity	Part used	Extraction	Summary of the studies
Antispasmodic activity	Leaves	Hydroalcoholic	The antispasmodic effect of the extract may be due to the involvement of calcium channels, without interfering with opioid receptors, β-adrenoceptors, and potassium channels (39).
Antidiarrheal	Flowers	Ethanol	Antidiarrheal-dependent action was significantly identified. There was a potential decrease in fecal fluctuations frequency (40).
Antiulcer	Leaves	Methanol	Flavonoid contents were responsible for the significant effective protection of gastric mucosa against aspirin-induced ulcers at all doses (41)
Activity against inflammatory bowel disease	Flower	Ethanol	The extract exerted anti-inflammatory and antioxidant properties that significantly ameliorate colitis (42).
Anthelmintic activity	Leaves	Methanol	*T. stans* exerted molluscicidal activities on B. Alexandrina snails, thus it could be an effective, cheap, and environmentally safe agent to control the spread of schistosomiasis (43).
	Flower, root	Ethanol	*T. stans* was proven to treat helminthiasis. The flower and roots of *T. stans* decoction are used for intestinal worms. Leaves also had anthelmintic activity (44).

Table 10. Summary of the previous studies of miscellaneous activities of *Tecoma stans*

Biological activity	Part used	Type of extract	Summary
Inhibition of induced-platelets aggregation	Leaves	Aqueous	Extracts of *T. stans* exerted a protective function against the proliferation of rabbit artery skin. *T. stans* significantly inhibited capillary permeability in rabbits in a concentration-dependent manner (45).
Nephroprotective activities	Flowers	Ethyl acetate	The extract exerted protective activity in albino rats against gentamicin-induced nephrotoxicity (46).
Cardioprotective activity	Leaves	Aqueous	The extract exerted strong anti-aggregate activities with thrombin-induced aggregated human platelets (47).
	Leaves	Ethyl acetate, methylene chloride (fractions)	The ethyl acetate fraction showed a maximum reduction of triglyceride, very low-density lipoprotein, and atherogenic index. The methylene chloride fraction riches, in alkaloids, reduced the low-density lipoprotein levels, while the flavonoid fraction (rutin rich) raised the high-density lipoprotein levels (48).
	Flowers	Ethanol	Polyphenolic constituents such as (flavonoids and tannins) showed effective antioxidant properties. Moreover, the extract stopped the deviation of reduced glutathione, superoxide dismutase, and catalase levels in a dose-dependent manner (49).
	Flower	Hydro ethanol	The extract inhibited the elevation in serum cholesterol and triglyceride levels (50).
Hepatoprotective activity	Leaves	Hydroethanolic solution	The extract exerted hepatoprotective activities against liver damage induced by carbon tetrachloride and acetaminophen caused in rats (51).
Antidepressant activities	Flowers	Methanolic and aqueous	These extracts contained Flavonoids that exert antidepressant activity (52).
Wound healing activity	Flower	Ethanol	Ointment of the extract was identified to heal all wound models with significant improvement of all parameters (53).
	Bark	Petroleum ether, chloroform, and methanol	The methanolic extract resulted in wound healing improvement due to the presence of phytocomponents likes, phenols, flavonoids phytosterols, triterpene, glycosides, saponins, and tannins. The antimicrobial effects of *T. stans* play a role in wound healing (54).
Anti-inflammatory activity	Bark, leaves, flowers	Ethanol	The leaf and flower worked better than the bark. The extract of the leaves and flowers of *T. stan* was found to be 100% more effective against inflammation than the common drug ibuprofen (55).
	Flowers	Methanol	The extract showed marked anti-nociceptive activity. This may be due to the presence of flavonoids which may play a role in the inhibition of prostaglandin synthesis (56).
	Leaves	Alcohol and aqueous	Both extracts exhibited dose-dependent activity. Alcohol extract showed the highest reduction of inflammation after 24 hrs., because of the presence of higher phenolic and flavonoid content (57).
Anti-arthritic activity	Stem	Methanol	The extract potentially reduced protein denaturation and decreased the inflammation volume. The anti-arthritic activity may be due to the flavonoids, alkaloids, steroids, and glycosides in the extract (58).
	Leaves	Alcohol, water, Petroleum ether, chloroform, methanol.	Alcohol, Water successive methanol extracts exhibited significant Antiarthritic activity (59).

Table 10. Continued

Biological activity	Part used	Type of extract	Summary
Antioxidant activities	Leaves, branches	Methanol	The crude extract exhibited significant activity of 80% maximum scavenging potential (27).
	Leaves, flowers	Methanol	The higher concentrations showed higher antioxidant activities than the standard ascorbic acid (60).
	Root, bark	Ethanol	*T. stans* was most efficient in a concentration-dependent manner in comparison to different plants by using a 2,2-diphenyl-1-picryl-hydrazyl-hydrate (DPPH) radical, superoxide anion radical, and nitric oxide radical scavenging capabilities for antioxidants (61).
	Leaves, branches	Ethyl acetate, chloroform, methanol	*T. stans* leaves and branches ethyl acetate fraction exerted the best total antioxidant activity followed by chloroform fraction of leaves extracts, methanol extract from leaves, and then methanol extract of branches (62).
	Plant Parts	Methanol, ethanol, water Plant parts	All solvent fractions showed strong radical scavenging activity from a ferric-reducing antioxidant power assay and DPPH (35).
Anti-proliferative, cytotoxic, and anticancer activities	Branches, leaves	Methanol	Anticancer dose-dependent activity against the rhabdomyosarcoma cell line was exhibited by the methanolic extract (27).
	Leaves, flowers	Methanol	Used as a remedy for lung cancer and can be an effective ingredient in cancer drug recipes (60).
	Leaves	Ethanolic	The extract exhibited anticancer activity against breast cancer cell line (MCF-7) with different concentrations (63).
	Leaves	Water	Cytotoxic effects of *T. stans* were concentration, and time-dependent against a (HepG2) cell line in the presence and absence of fetal bovine serum (64, 65).
Antidiabetic activity	Stem	Ethanol	The extract could prevent subsequent diabetic complications as diabetic nephropathy and retinopathy (12).
	Flowers	Ethanol	*T. stans* showed significant anti-apoptotic potential. Significantly reduced myocyte loss augmented the cardiac activity in rats with diabetes (66).
	Flowers	Alcohol and water	The extracts reduced blood glucose (67).
	Leaves	Water and alcohol	Both *T. stans* (L.) Kunth cv. Nalgonda 1 and *T. stans* (L.) Kunth cv. Warangal 1 extracts could lower blood glucose levels after a reduction in the breakdown of carbohydrates to light sugars (68).

Table 11. Summary of the previous studies of pharmaceutical activities of *Tecoma stans*

Pharmaceutical activities	Part used	Type of extract	Summary
As a natural dye	Flowers	Ethanol, and ethanol, a water mixture	Flowers of *T. stans* could be a potential natural source of yellow colorant (69). Moreover, they were used as natural dye sensitizers in dye solar cells (70).
As reducing/capping agent	Leaves	Water	The extract was used as a reducing agent in the synthesis of the reduced graphene oxide which was used for the removal of Ni from water (71).
		Water	The extract was used as a reducing agent and capping agent in the synthesis and stabilization of silver nanoparticles (72).
As an insecticide agent	Leaves	Ethanol	Leaf extract showed larvicidal activity against the mosquito species *Culex pipiens* L. (Diptera: Culicidae) (73).

Author's contributions

NEW and MF conceptualized the study. AK and DAF prepared the manuscript. All authors reviewed, confirmed, and approved the final version of the manuscript.

Conflict of interests

No potential conflict of interest was reported by the authors.

Ethical considerations

Ethical issues (including plagiarism, data fabrication, double publication, etc.) have been completely observed by the authors.

Funding/Support

This study received no funding or grant.

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