

A CRITICAL REVIEW ON THE PHARMACOGNOSTIC FEATURES AND EMERGING PHARMACOLOGICAL APPLICATIONS OF TRIDAX PROCUMBENS

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Abstract

Introduction: *Tridax procumbens* Linn. is a widely distributed medicinal herb used in traditional medicine for fever, wound healing, inflammation, diarrhoea, and hair disorders. The aim of this review is to critically evaluate the pharmacognostic profile, phytochemical constituents, traditional uses, and therapeutic potential of *T. procumbens*.

Novelty Statement: Unlike previously published reviews, the present review critically integrates classical pharmacognostic characteristics with emerging pharmacological evidence, nanotechnology-assisted therapeutic applications, and translational biomedical research involving *Tridax procumbens*.

Methods: Relevant published literature from scientific databases was analyzed, with emphasis on botanical description, phytochemistry, pharmacological studies, and recent technological applications.

Results: The plant contains flavonoids, alkaloids, carotenoids, tannins, sterols, phenolics, and polyacetylenes. Experimental evidence supports antibacterial, antioxidant, anti-inflammatory, hepatoprotective, antidiabetic, immunomodulatory, wound healing, anticancer, antiarthritic, and antihyperlipidemic activities. Recent reports on nanoparticle synthesis and nanofibrous wound dressings further support translational value.

Conclusion: *T. procumbens* demonstrates broad therapeutic promise; however, standardization, toxicity evaluation, and clinical studies remain limited. Future investigations should focus on mechanism-based and clinical validation.

Keywords: *Tridax procumbens*; herbal medicine; pharmacognosy; phytochemistry; pharmacology

Introduction:

In 1753 Linnaeus established *Tridax* with the publication of *T. procumbens* and reported as the most potent species amongst the 30 species of genus *Tridax* [1]. One of the countries in the world well known for its indigenous, valuable flora and fauna with tremendous therapeutic potential is India. Rooted in centuries of practice, traditional Indian medical systems have demonstrated sustained therapeutic value. India features a diverse medical landscape, encompassing indigenous traditions like Ayurveda and Siddha, cross-cultural systems such as Unani and Sowa-Rigpa (Amchi), and widely adopted practices like homeopathy [2-3]. It is a C3 plant native to tropical Americas and reported as a weed of 31 crops in 60 countries [4]. The *Tridax procumbens* family of Linn has long been used for medical conditions such as high blood pressure, malaria, diarrhoea, and bronchial catarrh, as well as to reduce hair loss and hemorrhaging from wounds, bruises, and cuts. It demonstrates broad-spectrum antimicrobial activity including antibacterial [5-6], antifungal [7], and antiplasmodial [8] effects alongside documented antioxidant [9], anticancer [5], and wound-healing properties [10-11]. Belonging to the Asteraceae (Compositae) family, *Tridax procumbens* commonly known as 'Ghamra' or 'coat buttons' due to its button-like flower heads.

Mostly prevalent in tropical and subtropical regions of the world, *T. procumbens* is a plant that can be found growing along roadsides, pastures, fallow ground, dikes, railroads, riverbanks, meadows, dunes, and waste areas. It is believed to have come from Central America. Nigeria was where it was first used as an ornamental plant, but it has since widely spread to other tropical countries. It is referred as a noxious weed in Alabama, Florida, Minnesota, North and South California, and Vermont. In Guatemala, the weed *T. procumbens* grows in a range of habitats, including both dry and moist soil. It is an annual or perennial weed from Central America that is ubiquitous across India, but is especially prevalent in the states of Maharashtra, Madhya Pradesh, and Chhattisgarh. It often takes root at nodes and produces solitary, long-stalked, heterogamous, bisexual blossoms with white flower heads and highly hairy, coarsely serrated, petiolate, ovate or lanceolate leaves [12-14].

Search Strategy:

To validate a comprehensive overview, a structured literature search we performed across multiple multidisciplinary databases: PubMed, Scopus, Google Scholar, Web of Science, and ScienceDirect. The review strategy focused on identifying studies addressing the pharmacological and phytochemical profiles of *T. procumbens*. Priority was given to peer-reviewed studies and recent reports. Methodology on collection, extraction, isolation, identification of various phytochemicals were analyzed. The pharmacognostic evaluation of *T. procumbens* was executed through sequential morphological identification, microscopic tissue profiling, and secondary metabolite analysis. Concurrently, comprehensive pharmacological studies have established its efficacy across a spectrum of bioactivities, notably its anticancer properties, wound-healing capacity, anti-inflammatory effects, and robust antioxidant and antimicrobial actions. The literature search covers all the original research articles, review article reports, patents from various sources.

Botanical Description and Pharmacognostic Characteristics

T. procumbens bears simple, opposite, exstipulate leaves (3–7 cm) that are ovate-lanceolate with occasional deep teeth along the margins. The leaves have a wedge-shaped base, short petioles, and hairy surfaces. The plant features a branched, hairy stem that grows 30–50 cm tall and roots at its nodes. Its inflorescence is a capitulum that mimics a daisy, composed of three-toothed, light-colored ray florets on the outside and yellow tubular disc florets at the center. The flower head contains two types of florets: outer ray florets and inner disc florets featuring basal placentation. Bearing occasionally three-lobed corollas on elongated peduncles, the plant

develops black, 2.0–2.5 mm long, obconical achenes with a distinctive feathery pappus. The plant fruits and flowers continuously throughout the year, producing hard, bristly achenes equipped with a feathery white pappus at the apex. The abundance of achenes produced by the plant, each of which can travel a short distance when caught in the wind's pappus, lends to its invasiveness. The representations adopted are scales or pappus. The plant's seeds have pendulous embryos and no endosperm [15-18].

Fig. 1. *T. procumbens*.

Traditional and Ethnomedicinal Uses:

Owing to its diverse bioactive constituents, *T. procumbens* is considered a highly valuable therapeutic agent in traditional medicine. The entire plant of *T. procumbens* serves as a Nigerian folklore remedy for fever, typhoid, backaches, and gastrointestinal distress [19-20]. In Ayurvedic system of medicine, *T. procumbens* is integrated into a wide range of polyherbal formulations targeting diverse therapeutic outcomes [21]. It is used as a hair tonic [22]. In Togo, the recently crushed leaves are applied to wounds. The decoction of the leaves is used to treat malaria, gastrointestinal and abdominal mycosis, and pain. The decoction of the leaves is used to cure abdominal and gastrointestinal mycosis, as well as malaria, and to ease discomfort. It is employed in India as an insect deterrent, a diarrhoea remedy, and a means of detecting hemorrhages. Locals in Tamilnadu, India, reportedly utilise the leaf juice to cure wounds, according to a study done there. Fresh leaf extracts are topically administered to alleviate dermatological complaints, showing particular efficacy against scabies. It has also been traditionally employed in the management of rheumatoid arthritis. To alleviate the discomfort of congestive headaches, traditional practices involve the bilateral nasal insertion of cotton plugs saturated with freshly expressed plant juice. To relax the sphincter and promote loose movements in children with chronic constipation, the leaves can be ground into a paste, rolled into a ball, and placed into the rectum [23-26].

Phytochemical constituents:

Phytochemical screening of *Tridax procumbens* reveals a rich diversity of bioactive compounds, including alkaloids, flavonoids, carotenoids, tannins, and phytosterols such as beta-sitosterol. Furthermore, specific secondary metabolites and fatty acids notably luteolin, quercetin, fumaric acid, an oxoester derivative, and lauric, myristic, palmitic, arachidic, and linoleic acids have been successfully identified. Standard qualitative screening methods were

employed to evaluate the presence of diverse phytochemical constituents within the extracts. The analysis systematically investigated the profiles of alkaloids, saponins, tannins, phytosterols, phenols, phlobatannins, leucoanthocyanins, cardiac glycosides, coumarins, emodins, anthocyanins, proteins, amino acids, and diterpenes. A new flavonoid called procumbenetin that was extracted from aerial parts has been identified as 3, 6 dimethoxy-5, 7, 2', 3', 4'-pentahydroxyflavone on the basis of spectroscopic studies. *Tridax Plant* Flavonoids: Frequently used as an insect deterrent, hair tonic, diarrhoeal remedy, and antifungal [26-29]. New polyacetylene 3S,10R)-tridaxin B, (3S,10S)-tridaxin B, tridaxin F, (3S,10R)-tridaxin A and tridaxin G were isolated and identified using spectroscopic techniques (NMR, UV, IR, MS and optical rotation), the modified Mosher method, electronic circular dichroism (ECD) data and ECD calculation [30]. Eight new compound isolated from *T. procumbens* namely methyl 14-oxooctadecanoate, methyl 14-oxononacosanoate, 3-methylnonadecylbenzene, heptacosanyl cyclohexane carylate, 1(2,2-dimethyl-3-hydroxypropyl)-2-isobutyl phthalate, 12-hydroxytetracosan- 15-one, 32-methyl-30-oxotetratriacont-31-en-1-ol and 30-methyl-28-oxodotriacont-29-en-1-oic acid by spectral data and chemical studies [26]. The main essential oil constituents found in *T. procumbens* are (Z)-falcarinol (2), α -selinene, zerumbone [31]. New phytoconstitutents isolated from ethanol extract of aerial part of *T. procumbens* including a polyacetylene, 1,2-dihydrodendroarboresol B (1), an ionone derivative, (3S,5R,6S,7E)-3-tetradecanoate-5,6-epoxy- β -ionone, and a flavonol diglycoside, quercetagetin-3,6,4'-trimethoxy-7-O-neohesperidoside [32]. A new flavone, 6-methoxy-7,8-dihydroxyflavone, 7-methoxy-6,8- dihydroxyflavone, together with two known flavones wogonin and oroxylin A, were isolated from *Tridax procumbens* [33].

Pharmacological Aspects:

Table 1. Summary of major pharmacological activities

Activity	Extract/Form	Experimental Model	Key Findings
Antimicrobial	Ethanollic / methanolic extracts	In vitro pathogens	Inhibition of bacterial and fungal growth
Anti-inflammatory	Leaf extract	Carrageenan paw edema	Reduced edema and inflammation
Wound healing	Topical formulations	Excision/incision models	Faster contraction and tissue repair

Activity	Extract/Form	Experimental Model	Key Findings
Antidiabetic	Ethanollic extract	Streptozotocin diabetic rats	Lowered blood glucose
Hepatoprotective	Ethanollic extract	Chemical liver injury models	Reduced liver damage markers
Antioxidant	Various extracts	DPPH and related assays	Strong free radical scavenging
Anticancer	Crude extracts / isolates	Cell line studies	Cytotoxic effects in selected models

Tridax procumbens exhibits a broad spectrum of validated pharmacological activities, including potent antioxidant, anti-inflammatory, wound-healing, antimicrobial, and insecticidal properties, alongside documented efficacy in the management of diarrhea and dysentery. Leaf juice is applied topically to the scalp, to accelerate wound healing in acute lesions, and to induce hemostasis. In India, *T. procumbens* is predominantly employed for its insecticidal properties, antifungal activity, and its capacity to act as a local coagulant to check hemorrhaging during wound management. Beyond its traditional applications in treating cutaneous infections and related dermatological disorders, *Tridax procumbens* has emerged as an effective eco-friendly biosorbent. Research demonstrates its capacity to efficiently sequester toxic chromium ions from industrial wastewater effluents.

1. **Antibacterial Activity:** Although *T. procumbens* is a cosmopolitan tropical herb recognized for overall antimicrobial benefits, recent bioassays indicate that the antibacterial profile of the ethanolic leaf extract is selectively constrained to combating *Pseudomonas aeruginosa* strains. The whole-plant extracts of *Tridax procumbens* possess notable antibacterial efficacy. Utilizing the standard disc diffusion assay, the present study demonstrated robust antibacterial activity of the whole-plant matrix against the Gram-negative pathogen *Pseudomonas aeruginosa*. Chloroform, methanol, ethanol, and water extracts of *Tridax procumbens* leaves were evaluated for their antibacterial activity. The test pathogens included *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus*, and *Enterobacter aerogenes* [5,6]. Ruthenium nanoparticles were green-synthesized using *Tridax procumbens* leaf extract and optimized for reaction conditions. Characterization confirmed uniform spherical RuNPs (~11–13 nm). They exhibited strong antibacterial, antifungal (against *Candida albicans*), and antioxidant activity. The study demonstrates an eco-friendly approach with promising biomedical and green chemistry applications [34].

2. Antifungal Activity: *Tridax procumbens* was tested against human skin pathogens *Microsporum fulvum*, *Microsporum gypseum*, *Trichophyton mentagrophytes*, *Trichophyton rubrum*, *Trichophyton beigelii* and *candida albicans*. The dichloromethane-soluble fraction of the methanol extract exhibited pronounced antifungal efficacy. Characterization via GC-MS analysis resolved a total of 26 volatile compounds within the bioactive matrix [29].
3. Hypotensive effect: The effects of an aqueous *Tridax* leaf extract on the heart were examined in an anaesthetized wistar albino rat. The extract caused a greater decrease in mean arterial blood pressure at higher doses compared to lower ones. Additionally, higher doses significantly decreased heart rate, whereas lower doses had no impact on heart rate. These findings suggest that *Tridax* leaves possess significant hypotensive activity [35].
4. Immunomodulatory Activity: The ethanol-insoluble fraction of the aqueous extract of *Tridax procumbens* exhibits significant immunomodulatory activity. Pharmacological evaluation demonstrates that it elevates total leukocyte counts, enhances the phagocytic index, and stimulates the proliferation of antibody-producing splenic lymphocytes [36].
5. Antidiabetic Activity: In the classical Ayurvedic paradigm, diabetes is designated as Madhumeha, a metabolic state resulting in pathological sugar saturation across physiological fluids such as blood, urine, perspiration, and mucus. The present study investigated the hypoglycemic potential of *T. procumbens* leaf extracts, prepared via petroleum ether extraction at 60–80°C, utilizing a Wistar rat model (150-200gm). Blood sugar level measured using a digital glucometer. In rats with a model of streptozotocin (50 mg/jk, i.p.) and nicotinamide (120 mg/kg, i.p) injection-induced diabetes, oral treatment of *Tridax* leaf extracts for 21 days at a dose of 250 mg/kg and 500mg/kg resulted in a considerable reduction in blood glucose levels, according to experimental studies. The effects of *Tridax* extract on diabetes showed significant antidiabetic activity. Additionally, it supports the conventional view that *Tridax* has an anti-diabetic impact [37].
6. Anti-inflammatory Activity: To evaluate the anti-inflammatory potential of *Tridax procumbens*, leaf extracts (200 mg/kg) were administered both independently and in combination with ibuprofen using a carrageenan-induced paw edema Wistar rat model. Monotherapy with the *T. procumbens* extract exhibited an edema inhibition profile comparable to that of standard ibuprofen. Notably, co-administration of the extract alongside ibuprofen produced a significant additive anti-inflammatory effect, markedly enhancing the overall percentage inhibition of paw edema compared to either treatment alone. Orally administered dosages of a water soluble powder containing *Tridax* leaf

extract were given to rats. The results demonstrated the extract's effectiveness as an analgesic. The amount of *Tridax procumbens* L administered reduced the abdominal writhing [38]. *Tridax procumbens* leaves extract based chitosan gel showed maximum inhibition at 50µL concentration of bovine serum albumin denaturation assay and egg albumin denaturation assay. The antioxidant activity assessed by DPPH and H₂O₂ method it revealed that both standard and test gel showed high inhibitory percentage [39].

7. **Hepatoprotective Activity:** The aerial parts of *Tridax* showed hepatoprotective qualities. Strong protection from the hepatocellular damage brought on by D-galactosamine/lipopolysaccharide is provided by the plant. (DGalN/LPS). It has been proposed that D-GalN/LPS is hepatotoxic because it has the potential to kill liver cells. There are similarities between the human viral hepatitis lesion and the D-GalN-induced multifocal necrosis. Due to the endotoxin toxicity of this amino sugar, which is known to selectively disrupt transcription and indirectly hepatic protein synthesis, fulminant hepatitis is brought on within 8 hours of treatment. The potential of the ethanolic extract to protect the liver When *T. procumbens* (100, 200, 300, and 400mg/kg body weight, orally) was administered to male albino rats, the liver damage caused by paracetamol (acetaminophen) (2gm/kg body weight) was gradually reversed. The ethanol extract considerably lowers the liver's lipid peroxidation (LPO), while also raising the levels of superoxide dismutase (SOD), catalase (CAT), glutathione, and glycogen. The efficiency of the ethanol extract has been confirmed by a histological examination of liver sections [40] .
8. **Wound healing Activity:** Wound healing, a dynamic and intricate process, has the capacity to regenerate cellular layers and tissue layers. *Tridax procumbens* L. aqueous extract from the entire plant can promote both normal and immune-compromised wound healing in mice. Several *T. procumbens* extracts have been studied for their potential to treat wounds in both in-vivo and in-vitro settings [41]. A recent in-vivo experiment examined the ointment formulation of extract delivered participants using excision wound models. Ointment formulation of extract 1-4mg/g applied twice a day showed a significant amount of wound contraction in the excision model. An excision wound was treated with formulation for 15 days. 3 days after changes in the wound area were noticed. The size of the wound was measured using graph paper. The level of hydroxyproline, collagen, and hexosamine in *Tridax procumbens* significantly increased, indicating the plant's powerful wound-healing ability. This study developed an antibacterial bilayered nanofibrous wound dressing composed of PCL/PVA-chitosan infused with *Tridax procumbens* leaf extract.

The membrane was fabricated via electrospinning and optimized at 800 µg/mL extract concentration. It showed stronger antibacterial activity against *E. coli* than *S. aureus*, along with good cell viability in L929 cells. In vivo studies on mice demonstrated enhanced wound healing in both biopsy and burn models, with faster recovery in biopsy wounds. Histological analysis confirmed reduced inflammation and improved re-epithelialization. Increased VEGF and CD31 and decreased Wnt and TGF-β expression indicated effective tissue regeneration, suggesting strong potential as a wound dressing material [42].

9. **Anti-cancerous Activity:** A variety of phytochemicals are used to both prevent and treat cancer by lowering angiogenesis and, in turn, metastasis. Test subjects for *Tridax procumbens* anticancer properties were human lung cancer cells A-549 and breast cancer cell MCF-7 line. *Tridax* leaves were extracted using methanol, ethanol and ethyl acetate. The MTT method and cell viability were used to assess anticancer activity. *Tridax* extract tests for cell viability were conducted. The fundamental MTT-based method in this experiment changed into an intractable, purple-blue Formazan precipitate. This reaction is carried out by the mitochondrial succinate dehydrogenase, which is produced by active cells. The spectrophotometric measurement of live cells is carried out at 570 nm. The extract demonstrated 82.28% cytotoxicity against cancer cells within 24 hours, but the water extract's anticancer impact was incredibly feeble. The results of this study showed that floral crude extract had anti-cancer properties [43]. Different isolated polyacetylenes studied for their cytotoxicity study on human tumor cell (K562, K562/ADR, AGS, MGC-803, SPC-A-1 and MDA-MB-231). Isolated compounds 3S,10R)-tridaxin B, (3S,10S)-tridaxin B and tridaxin F showed substantial cytotoxic effects against the K562 cell line with half-maximal inhibitory concentration (IC₅₀) values of 2.62, 14.43 and 17.91 µM, respectively. Western blot analysis confirmed the cytotoxicity through dose dependent apoptosis pathway. The (3S,10R)-tridaxin A and tridaxin G showed significant inhibitory effects on lipopolysaccharide-stimulated nitric oxide production in RAW 264.7 macrophages, with IC₅₀ values of 15.92 and 20.35 µM, respectively [44].
10. **Antihyperlipidemic Activity:** *Tridax procumbens* whole extract significantly decreased intracellular lipid accumulation. The observed antihyperlipidemic action of *Tridax procumbens* is closely mediated by its endogenous antioxidant components, which mitigate oxidative stress-induced lipid peroxidation. The lipid-lowering efficacy of the extract was further validated in an in vitro model using HepG2 human hepatoma cells.

Remarkably, when the cells were co-treated with oleic acid and *T. procumbens* extract, the plant extract effectively prevented oleic acid-induced cellular steatosis and blocked subsequent lipid droplet formation [37].

11. Hemostatic Activity: Various leaf extracts of *Tridax procumbens* were systematically evaluated to determine their local hemostatic activity and procoagulant potential. The hemostatic potential of *T. procumbens* was evaluated by measuring the in vitro clotting parameters of ten human subjects. The ethanolic leaf extract consistently abbreviated the coagulation window, thereby confirming its significant procoagulant properties and its capacity to enhance clot formation mechanics [45].
12. Anti-arthritis Activity: Arthritis encompasses a range of inflammatory conditions that induce severe structural harm within the joints. The escalating burden of this illness is closely correlated with modern lifestyle shifts, where physical strain and insufficient systemic hydration accelerate joint wear and tear. Several investigations have evaluated the anti-arthritis potential of *Tridax procumbens* ethanolic extracts at dosages of 250 mg/kg and 500 mg/kg. In these studies, indomethacin 10 mg/kg was utilized as the standard positive reference control. *Tridax procumbens* whole plant extract considerably decreased the signs and symptoms of arthritis in the Freud's Complete Adjuvant model [46].
13. Anti-diarrheal Activity: The antidiarrheal activity of *Tridax procumbens* aqueous and ethanolic leaf extracts was also evaluated using castor oil-induced diarrhea and barium sulfate milk gastrointestinal motility models. To discover novel anti-diarrheal agents, sequential extracts (hexane, chloroform, butanol, alcohol, and aqueous) prepared from different parts of 31 indigenous Indian medicinal plants were screened for antisecretory properties against *E. coli*. Notably, *T. procumbens* fractions emerged as highly effective candidates, displaying robust inhibitory profiles against enterotoxin-induced fluid secretion [9].
14. Hair growth promoting Activity: The petroleum ether fraction partitioned from the ethanolic extract of *Tridax procumbens* demonstrated pronounced hair growth-promoting activity upon both topical application and oral administration in albino rat models. It was discovered that the aerial *T. procumbens* parts of the ethanolic extract may promote hair development. In albino rats over a period of 20 days, both the oral (100 mg/kg/day) and 10% ointment administration techniques were effective. When extract function activity was totaled using several solvents, it was discovered that the percentage examined for this attribute, petrol, was active. Column chromatography of the petrol function and

comparable screening were used to propose the activity in the initial function. There are three groups, each with 25 creatures. Rats given an oral dose of the ethanolic extract grow their hair more quickly than the control group rats. Several observations were recorded regarding the animals that were given the ointment treatment. The process of hair development had also started by day 14 and was almost finished by day 21 of therapy, despite there having been virtually no activity up to day 10 of treatment [47].

15. Insecticidal Activity: The essential oils extracted from *T. procumbens* killed cockroaches, house flies, mosquito larvae, *Dysdercus similes*, and mosquito eggs. *T. procumbens* essential oils shown significant insect repellent effectiveness when tested against three different types of ants. The absence of cattle attack or grazing on *T. procumbens* during collection shows that the plants contain insecticidal or insect repellent qualities [48].
16. Antimicrobial Activity: *Aspergillus Niger*, a novel flavone-producing fungus, infected tomato fruit shows the *T. procumbens* Linn effect, which illustrates the mycelia growth of isolated infections. Both extracts exhibit a significant reduction in mycelia development at higher doses. The antibacterial activity of 16 different weights of plant residue (30 & 40 mg) was evaluated using the filter paper disc diffusion method against three gramme positive bacteria and seven gramme negative bacteria. The entire aerial region's n-hexane extract was allegedly ineffective against *Escherichia coli*, *Samonella group C* [9].
17. Anti-parasitic Activity: *T. procumbens* (an oxylipin) has been tested for the treatment of some conditions caused by protozoal infections, such as malaria, diarrhoea, colic, and vaginitis, through a bioassay-guided fractionation with a methanol extract to isolate an active chemical, (3,S)-16,17-Didehydrofalcarninol. *Tridax* appeared to have antileishmanial qualities when using crude extracts from the entire plant. The antiplasmodial properties of extracts from the flowers, leaves, and stem of *T. procumbens* in water, chloroform, ethyl acetate, and ethanol were investigated in a study carried out in Ghana. *T. procumbens'* ability to protect red blood cells from *P. falciparum* harm was demonstrated in a study using the tetrazolium-based colorimetric assay, showing that the species' aqueous and ethanolic extracts have antiplasmodial properties. *Tridax procumbens* demonstrates considerable therapeutic potential to combat a disease that kills millions of people globally [8].
18. Anti-ulcer Activity: To investigate the gastroprotective potential of *Tridax procumbens* Linn., albino rats were administered the crude methanolic extract, followed by the assessment of tissue myeloperoxidase activity as a definitive marker of anti-inflammatory and ulcer-preventive activity. The results revealed that the experimental control's

myeloperoxidase activity (4.74 U/g) was higher than that of the 100 mg/kg methanol extract (2.74 U/g). The results of this study indicate that the whole plant methanolic extract of *Tridax procumbens* Linn (100 mg/kg) possesses ulcer-prevention and protection qualities and may help prevent ulcerative colitis [49].

19. Anti-obesity Activity: Biochemical analysis of the research animals treated with the plant decoctions revealed a pronounced modulation of the systemic lipid profile, characterized by significant increases in high-density lipoprotein (HDL) cholesterol, total cholesterol, triglycerides, free fatty acids, and total protein concentrations [50].
20. Anti-malarial Activity: The chloroquine-resistant strain of *Plasmodium falciparum* exhibited pronounced resistance to the anti-plasmodial effects of both the aqueous and ethanolic decoctions. However, the decoctions elicited negligible hemolytic activity against human erythrocytes in vitro, though comprehensive in vivo animal toxicity profiles remain to be established [8].
21. Repellent Activity: *Tridax procumbens* Linn leaves were steam-distilled to obtain the essential oils. In mosquito cages against the malaria parasite *Anopheles stephensi*, the extracted oil's topical repellent abilities were tested. In three different dosages (2, 4, and 6 percentage), all of the essential oils were examined. It was discovered that the essential oils of *Tridax* had the highest repellency impact of these (>300 minutes 6 percentage concentration), indicating that *Tridax* are promising as repellents against *Anopheles stephensi* [51].
22. Anti-tuberculosis activity: Anti-tuberculosis activity was studied using H37Rv *Mycobacterium* strain. The sample is susceptible to H37Rv at a minimum inhibitory concentration (MIC) of 600 µg/mL, according to the Microplate Alamar Blue Assay (MABA). Rifampicin was used as a standard control. MTT assay was used to determine the antiproliferative, functional group, and mechanism of action of secondary metabolites [52].
23. Anti-oxidant activity: Three isolated compounds -O-methyl quercetin-4' -O-β-D-glucopyranoside, Queracetangatin-3, 6-4' -trihydroxy-7-O-β-D-glucopyranoside, Queracetangatin-3, 6-4' -trihydroxy-7-O-neohesperidoside showed antioxidant capacity as IC₂₀ > 100 µmol/L by in-vitro antioxidant assay using DPPH method [53]. In a different study, researchers used Trolox and L-ascorbic acid standards to examine the antioxidant properties of aerial portions of *T. procumbens* extracts and fractions containing flavonoids including Centaureidin, Centaurein, and Bergenin using the free radical scavenging method [54]. Two isolated flavones 8, 3'-dihydroxy-3,7,4'-trimethoxy-

6-O- β -When compared to standard control Trolox ($IC_{50} = 0.00948$ mg/mL), D-glucopyranosyl flavone and 6,8,3'-trihydroxy-3,7,4'-trimethoxyflavone shown strong antioxidant activity ($IC_{50} = 0.03180$ mg/mL and 0.04618 mg/mL, respectively) [55]. Due to its high phenolic compound composition, ethanol extract was found to have a strong reductive potential at concentrations of 12 mg/g GAE. This finding led to the conclusion that the extract had a very good antioxidant index when compared to reference compounds [56]. Acetone and aqueous extracts have strong antioxidant activity against DPPH (34.88%) and H_2O_2 (9.03%) radicals because they include flavonoids and phenolic components. Strong antioxidant activity in methanol, ethanol, and ethyl acetate extracts has been demonstrated in the majority of these *T. procumbens* experiments, indicating a direct correlation between the extracts' phenolic constituents and flavonoids [57].

Emerging Applications:

Recent studies describe green synthesis of metal nanoparticles using *T. procumbens* extracts and incorporation into nanofibrous wound dressings. These systems may improve antimicrobial performance and tissue regeneration.

Safety, Toxicity and Limitations:

Despite encouraging preclinical findings, the safety profile of *T. procumbens* has not been comprehensively established. Available studies are limited by heterogeneous extraction procedures, variable dosing strategies, and insufficient long-term toxicological assessment. Data regarding reproductive toxicity, genotoxicity, chronic exposure, and herb–drug interaction potential remain sparse. Furthermore, the absence of universally accepted phytochemical markers and standardized formulations restricts reproducibility across studies. These limitations should be addressed before large-scale clinical translation is considered.

Future Perspectives

Future investigations should prioritize identification of validated bioactive markers, development of standardized extracts, and elucidation of molecular mechanisms using contemporary omics and systems pharmacology approaches. Robust pharmacokinetic characterization and dose-response studies are also warranted. Importantly, well-designed randomized clinical trials are required to establish therapeutic efficacy and safety in humans. In parallel, nanotechnology-enabled delivery systems and advanced biomaterials may significantly enhance bioavailability, target specificity, and translational utility of *T. procumbens*-derived therapeutics

Conclusion: *Tridax procumbens* represents a pharmacologically promising medicinal species with substantial ethnomedicinal relevance and steadily expanding scientific support. Its chemically diverse metabolome appears to mediate multiple therapeutic effects, particularly in wound repair, inflammatory modulation, metabolic disorders, hepatoprotection, and antimicrobial applications. Nevertheless, the current evidence base remains predominantly preclinical. Rigorous standardization, mechanistic validation, toxicological profiling, and clinical investigation are now essential to facilitate its progression from traditional remedy to evidence-based therapeutic candidate.

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