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A comprehensive review on traditional uses, phytochemical constituents, and pharmacological properties of *Tridax procumbens*

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ABSTRACT

Tridax procumbens Linn. is a medicinal plant traditionally used in folk medicine to treat various conditions such as skin infections, wounds, fever and inflammation. Its therapeutic potential is attributed to a rich diversity of bioactive compounds present within the plant. This review aims to provide an in-depth understanding of *T. procumbens* by analysing literature from databases like PubMed, Scopus, Web of Science, and Google Scholar, including studies published until 2025. Both *in vitro* and *in vivo* studies have explored the therapeutic properties of different parts of *T. procumbens*, revealing its wide spectrum of pharmacological activities. These include analgesic, antidiabetic, antioxidant, anti-urothelic, cardioprotective, larvicidal, wound healing, reproductive, anthelmintic, anti-ulcer, hepatoprotective, antimicrobial, hypolipidemic, anticancer, anti-inflammatory effects. Additionally, this review summarizes the key phytochemicals found in *T. procumbens*, including flavonoids, alkaloids, essential oils, tannins, carotenoids, and saponins. The analysis highlights the abundance of these bioactive compounds in *T. procumbens*, underscoring its substantial pharmacological potential. Given its diverse therapeutic properties, the plant shows promise for development in various sectors, including drug discovery, industrial applications, and the medicinal and commercial industries.

Keywords: Medicinal plant, Pharmacological properties, Phytochemicals, Wound healing, Traditional uses, *Tridax procumbens* Linn.

INTRODUCTION

India ranks among the world's most resource-rich countries when it comes to the diverse genetic heritage of medicinal plants, especially those integral to traditional systems like Ayurveda and Yoga. For generations, herbal solutions have been central to addressing numerous health issues. These plant-derived therapies present a valuable substitute for modern chemical-based medicines, as they are generally well-tolerated and considered both effective and gentle in supporting human well-being [1-4].

Tridax procumbens Linn., commonly known as "Ghamra" and referred to as "coat buttons" in English due to its appearance like a flower, holds a significant place in traditional Ayurvedic healthcare for addressing multiple health issues. In some traditional practices, it is also used similarly to "Bhringraj," a renowned herbal remedy for liver-related conditions. Although previously considered a weed that affected various crops, this plant has a longstanding history of use in regions across Africa, Southeast Asia and South Asia, where it is consumed as a herbal infusion to help manage liver problems, gastrointestinal disturbances like diarrhea and dysentery, as well as respiratory conditions such as bronchial catarrh [5-6]. It is an herbaceous plant, either annual or perennial, originally native to Central America and now widely distributed across India, particularly prevalent as a weed in states like Maharashtra, Madhya Pradesh, and Chhattisgarh. It typically roots at the nodes and bears solitary, long-stemmed yellow composite flowers that are heterogamous and bisexual, accompanied by distinctive white floral heads. The plant features densely hairy, coarsely serrated leaves that are petiolate and shaped either ovate or lanceolate [7].

This review presents a comprehensive and up-to-date synthesis of the botanical profile, phytochemical constituents, and traditional medicinal applications of the selected plant species. A distinctive feature of this work is its structured, table-wise presentation of a wide range of pharmacological activities, including antidiabetic, antioxidant, antiurothelic, cardioprotective, larvicidal, wound healing, reproductive, antihelminthic, antiulcer, hepatoprotective, antimicrobial, hypolipidemic, anticancer, anti-inflammatory, and analgesic effects. By systematically organizing these activities, the review enhances clarity and accessibility, offering a valuable reference for researchers and practitioners exploring the therapeutic potential and pharmacological breadth of the plant. This holistic approach not only consolidates existing knowledge but also highlights promising avenues for future pharmacological and

and clinical investigations.

Habitat

Tridax procumbens thrives in warm and humid climates across the globe, particularly in tropical and subtropical zones, including many regions of India [8]. Coat buttons frequently grow in areas such as roadsides, vacant lots, embankments, railway tracks, riverbanks, grasslands, and sandy soils(dunes). Its ability to spread rapidly and produce a large number of seeds contributes to its aggressive growth and classification as a dominant weed species [9]. Among the approximately 30 species within the Tridax genus, it is considered one of the most vigorous. Originally native to Mexico and parts of Central and South America, it has also found across regions of Tropical America, Asia and Africa [10], as well as in countries like India, Nepal, and Nigeria [11]. Within India, the plant is commonly seen in states such as Andhra Pradesh, Maharashtra, Chhattisgarh, Madhya Pradesh, Gujarat, Odisha, and several others [11-12].

Common name

T. procumbens is commonly known as Coat Buttons and Tridax Daisy (English), Ghamra (Hindi), Jayanti Veda (Sanskrit), Dagdi pala (Marathi), Gaddi Chemanthi (Telugu), Thata poodu (Tamil), Chiravanak (Malayalam), Cadilp Chisaca (Spanish), Herbe Caille (French), Kotobukigiku (Chinese) [13].

Taxonomy of *Tridax procumbens* [14]

Kingdom- Plantae

Subkingdom- Tracheobionta

Division- Spermatophyta

Subdivision- Magnoliophyta

Class- Magnoliopsida

Subclass- Asteridae

Order- Asterales

Family- Asteraceae

Genus- *Tridax*

Species- *procumbens*

Botanical profile

Tridax procumbens is a perennial plant characterized by opposite, feather-like leaves that range from rectangular to oblong in shape, and a trailing stem (Figure 1A). It produces blossoms with white ray florets and yellow central discs, typically appearing during the spring season. The plant features a regrowing stem structure measuring approximately 40.6 inches in width and extending between 4 to 12 inches in length. Its fruit is dark brown to nearly black, elongated in shape, and topped with a modifiable crown of calyx-like bristles. Native to tropical regions, *T. procumbens* is also included on the Federal Pernicious Weed List [15].

Parts of plant

Leaves: The foliage features a pointed apex with toothed margins (Figure 1B). Leaves are simple, grow in opposing pairs, and measure approximately 1–2 cm in length. The lamina is broadly oval, typically ranging from 2–6 cm long and 2–4 cm wide. They have short stalks and are covered with fine hairs on both the upper and lower surfaces [14].

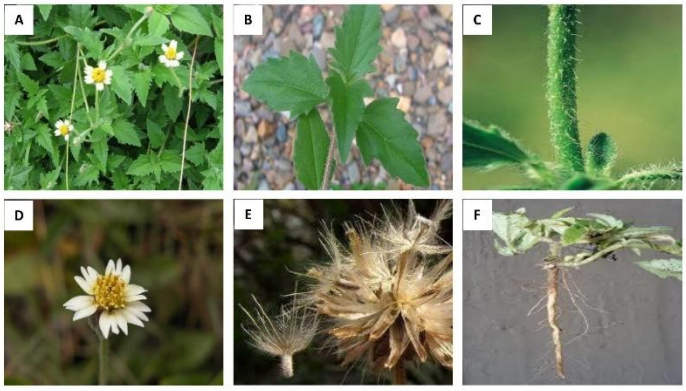


Figure 1: Morphological features of *Tridax procumbens*. A- Whole plant, B- Leaves, C- Stem, D- Flower, E- Seed, F- Root.

Stem: The stem of the plant is cylindrical and covered with coarse, stiff hairs, including multicellular structures with noticeable tuberculation, indicating a well-developed transport system (Figure 1C). It grows in an upward direction, reaching a height of about 30 to 50cm, and is branched with sparse hair coverage. The stems often root at the nodes, contributing to the plant's ability to spread. They are generally slender and pliable, with a creeping or trailing growth habit that allows the plant to form a dense, mat-like cover as it extends along the ground [16].

Flowers: The flower arrangement features a solitary, terminal flower head (capitulum) positioned at the top of a slender, smooth flower stalk (Figure 1D). Each capitulum, measuring around 1–2 cm across, displays both ray and disc florets. At the center are yellow, tube-shaped, bisexual disc florets, encircled by white, strap-like ray florets that are functionally female [17].

Fruits and seeds: *T. procumbens* yields elongated, ridged fruits known as achenes, which are covered with tiny bristles (Figure 1E). Attached to the achene is a pappus measuring about 2 to 3 millimeters long, consisting of soft, white hairs that facilitate wind transport. This adaptation enables the seeds to spread widely, enhancing the plant's ability to colonize new areas [18].

Roots: Being a low-growing plant, *T. procumbens* probably develops a shallow root network concentrated close to the soil surface (Figure 1F). This root system aids in stabilizing the plant while efficiently taking up water and nutrients from the nearby soil [16].

Traditional Medicinal applications:

Originating from India, Nepal, and Nigeria, *T. procumbens* is a wild herb traditionally utilized to address various ailments including bronchial catarrh, diarrhea, inflammation and dysentery. In Ayurvedic medicine, it is also identified as "Bhringraj," valued for its ability to support liver health and promote hair growth [15].

In Nigeria, the whole plant is traditionally employed to manage ailments such as back pain, typhoid, cough, stomach pain, diarrhoea, fever, and epilepsy. Across Africa, it is also used in veterinary care—farmers combine it with *Vigna parkeri* to address chronic mastitis in livestock. The mixture is prepared by grinding the plants together, mixing in salt and water, and applying it to the affected udder. Its antimicrobial activity against bacteria responsible for mastitis has been scientifically examined [7]. In Udaipur, India, locals have long used powdered leaves of *T. procumbens*, often combined with other medicinal plants, as a traditional remedy for managing diabetes. Research has identified this species as a rich source of potassium, a mineral beneficial in relieving muscle cramps and considered a promising candidate for future pharmaceutical applications [19].

In India, this plant is recognized for its ability to repel insects, manage digestive issues like diarrhoea, and control internal bleeding

(Haemorrhage). Study conducted in Tamil Nadu found that local communities commonly use the leaf extract to aid wound healing. The same research highlights *T. procumbens* as one of the most valuable herbs in traditional medicine [16].

T. procumbens is considered a valuable source of plant-based protein and potassium, and it also shows promise as a precursor of vitamin A [20]. The plant's leaves are traditionally applied to cuts, bruises, and injuries to control bleeding, owing to their insect-repelling and antimicrobial properties. For millennia, traditional healing systems have utilized the fresh leaf extract to address conditions such as typhoid, skin ailments, respiratory issues like cough, and to promote blood coagulation. In Guatemala, the plant is commonly used to manage digestive problems, treat ulcers in the mouth, and relieve symptoms of inflamed tonsils and throat infections [21].

Phytochemical constituents

It has been demonstrated in numerous scientific investigations that *T. procumbens* plant contains a variety of phytochemical substances (Figure 2). Alkaloids, flavonoids, saponins, tannins, and carotenoids were found to be present in this medicinal plant based on the phytochemical screening (Figure 3) [22].

Various parts of *T. procumbens* L., are known to contain a wide range of bioactive compounds such as flavonoids, carotenoids, alkaloids, lignans, benzoic acid derivatives, hydroxycinnamic acids, phytosterols, proteins, dietary fiber, tannins, calcium oxide and simple sugars. Additionally, studies have identified the presence of β-sitosterol, fumaric acid and oleanolic acid (a pentacyclic triterpenoid). Flower extracts of *T. procumbens* have been found to contain several flavonoid compounds, including luteolin, glucoluteolin, isoquercetin and quercetin. In addition to these, the plant is rich in numerous other phytochemicals such as 2-O-β-D-glucopyranoside, 2,6-dihydroxyacetophenone, echioidinin, dihydroechioidinin, pinostrobin, tectochrysin-5-glucoside, 5,7,8-trimethoxyflavone, skullcapflavone-2-methyl ether, methyl salicylate glucoside, tectochrysin, androechin, 5,7,2′-trimethoxyflavone, skullcapflavone II, 5,7-dimethoxyflavone, echioidin and andrographidine [7].

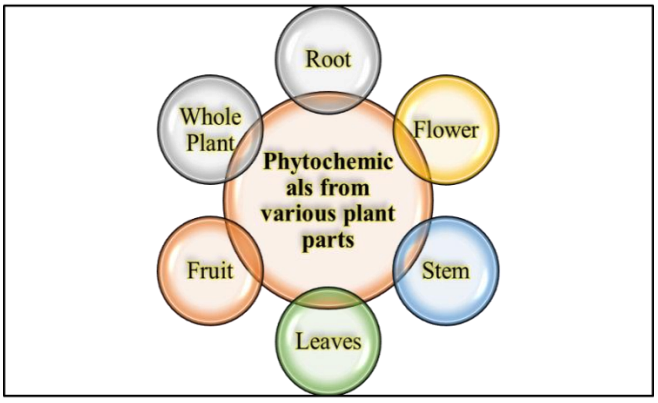


Figure 2: Phytochemicals from various parts of *Tridax procumbens*

Flavonoids

Phytochemical analyses have revealed that *T. procumbens* contains a high concentration of flavonoids, particularly flavones and flavanones, which are characteristic compounds found widely in the Asteraceae family. These bioactive constituents contribute to the plant's antioxidant, liver-protective, antimicrobial, anti-cancer, and wound-healing effects [23].

Luteolin, gluco-luteolin, isoquercetin and quercetin have been reported first time from flowers of *T. procumbens* [11].

An ethanol-based extract of the entire *Tridax procumbens* plant yielded R=Gu 8,3'-dihydroxy-3,7,4'-trimethoxy-6-O-β-D-glucopyranosyl flavone [24]. Additionally, the ethanol extract of the flowers led to the isolation of several flavonoid compounds, including 6-methoxy-7,8-dihydroxyflavone, wogonin, 7-methoxy-6,8-dihydroxyflavone and oroxylin, all of which demonstrated antioxidant properties. Of these, 6-methoxy-7,8-dihydroxyflavone exhibited the highest antioxidant effectiveness, with an EC_{50} value of 21.75 µg/mL [25]. From the aerial portions of plant, researchers identified 3,6-dimethoxy-5,7,2',3',4'-pentahydroxy-7-O-β-D-glucopyranoside [26]. Further investigation using ethanol extracts of the entire plant revealed several additional flavonoid glycosides, including 5,7,3'-trimethyl-4'-methoxy-3-O-β-D-flavonoid glycoside luteolin-7-O-β-D-glucoside, 8,3'-dihydroxy-3,7,4'-trimethoxy-6-O-β-D-flavonoid glycoside, and 4,2,4'-trihydroxy-6'-methoxy-3'-isopentenyl chalcone [27]. According to a study by Idris et al. (2018), plants grown under higher light conditions produced greater amounts of flavonoids and phenolic substances compared to those cultivated in shaded environments. [28].

Alkaloids

T. procumbens has also been found to contain several alkaloids. A phytochemical screening conducted with a water-based leaf extract identified a total of thirty-nine alkaloid compounds, with Akuammidine being the most abundant at 73.91%, followed by Voacangine at 22.33% [20].

Saponins

Saponins, known for their therapeutic and medicinal benefits, have been identified in *T. procumbens*. In particular, a steroidal saponin along with pβ-Sitosterol-3-O-β-D-xylopyranoside has been found in the flowers of this plant species [16].

Benzoic acid derivatives

Several benzoic acid-related compounds have been identified in *T. procumbens*. From the fresh leaf juice, researchers detected vanillic acid, 4-hydroxybenzoic acid, ferulic acid and 4-hydroxybenzaldehyde. In contrast, compounds such as benzyl glucoside, 24-hydroxy-24-vinylcholesterol, 2-hydroxybenzaldehyde and 7-oxositosterol were extracted from the plant's aerial components [29-30].

Lignans

Lignan compounds such as 7-dimethyl ether, apigenin-4', Epieudesmin, Dehydroabietic acid, and Retusin were isolated from fresh leaf juice of *T. procumbens* [29].

Tannins

Tannins, which belong to a class of polyphenolic substances and include amino acids and alkaloids, were extracted and identified from the methanol extract of the aerial parts of *T. procumbens* as reported by Verma and Gupta (1988) [31]. Additionally, compounds such as voacangine, echitamine, caffeic acid, echitamidine and crinamidine were isolated from the fresh leaf juice of the plant [29].

Carotenoids

Carotenoids are lipid-soluble pigments present in leaves that play key roles in plant, including capturing light energy, protection against damage caused by light-induced oxidation, and providing coloration to attract insects [7]. Various forms of these compounds have been extracted from the leaves of *T. procumbens*, such as neoxanthin, violaxanthin, antheraxanthin, lutein, and carotene [29].

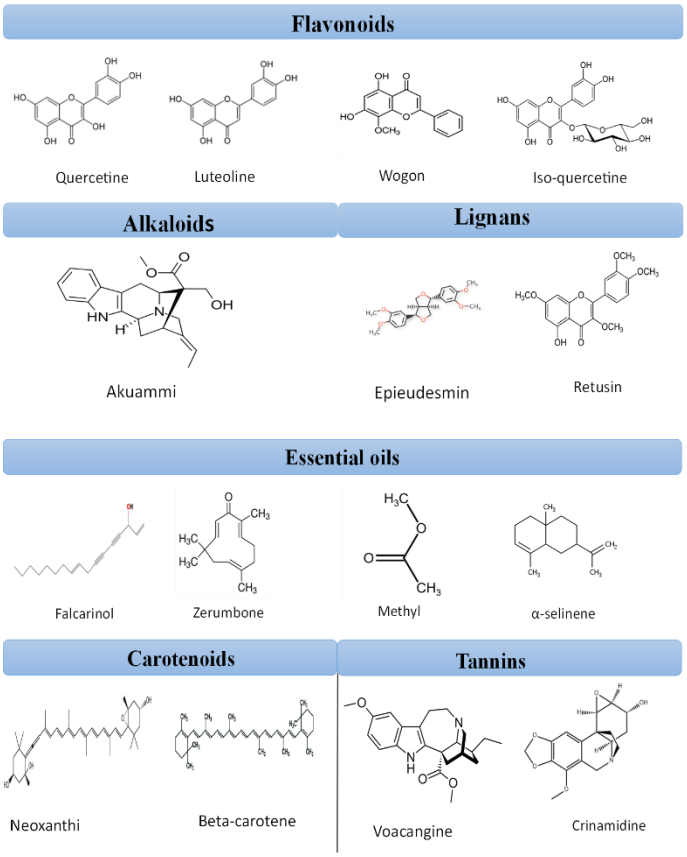
Terpenoids

Terpenoids represent the largest group of natural compounds, followed by saponins, phytosteroids, and carotenoids. Several steroids have been extracted and identified from *T. procumbens*. For instance,

β-sitosterol 3-O-β-D-xylopyranoside was obtained from the flower's ethanol extract [32]. Additionally, lupeol, beta-amyrone, and beta-amyrin were isolated from the methanolic extract of the aerial parts, while butulinic acid and oleanolic acid were extracted from the ethanol extract of the whole plant [24].

Essential oils

Plants produce a wide range of essential oils, though only a few compounds are typically dominant and widespread. These simple molecules serve various vital functions within the plant. Essential oils are recognized as key components of *T. procumbens*. The primary essential oil compounds identified in the flowers include (Z)-falcarinol, zerumbone and α-selinene [34]. Furthermore, methanol extracts from the aerial parts of the plant have yielded compounds such as 3-octene-1-ol, 2-propyl-1-heptanol, 9,12-octadecadienoic acid ethyl ester, hexadecanoic acid ethyl ester, 9-octadecenoic acid, 32-methyl-30-oxotetratriacont-31-en-1-ol, 2-methyl octadecanoate, dotriacontanol and 30-methyl-28-oxodotriacont-29-en-1-oic acid [31,35].



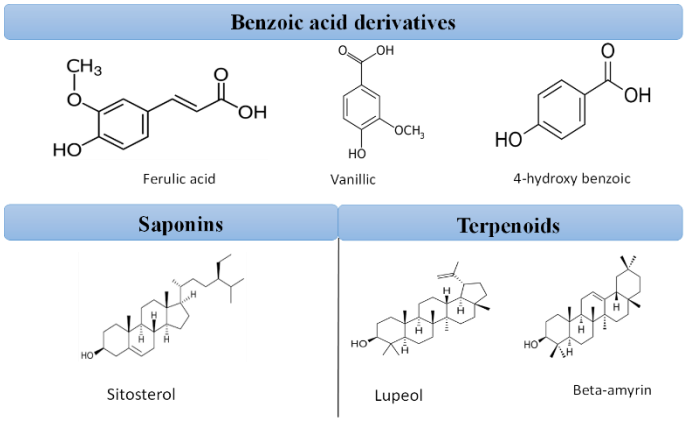


Figure 3: Major phytochemicals of *Tridax procumbens*

Pharmacological properties

The main pharmacological properties of this plant are displayed in the Table 1 and Figure 4. The plant's various activities are arranged in the table based on the year of publication, the plant part used for treatment, the type of extract used, the doses used, the mode of administration, the length of the experiment, the study model, and the effects observed.

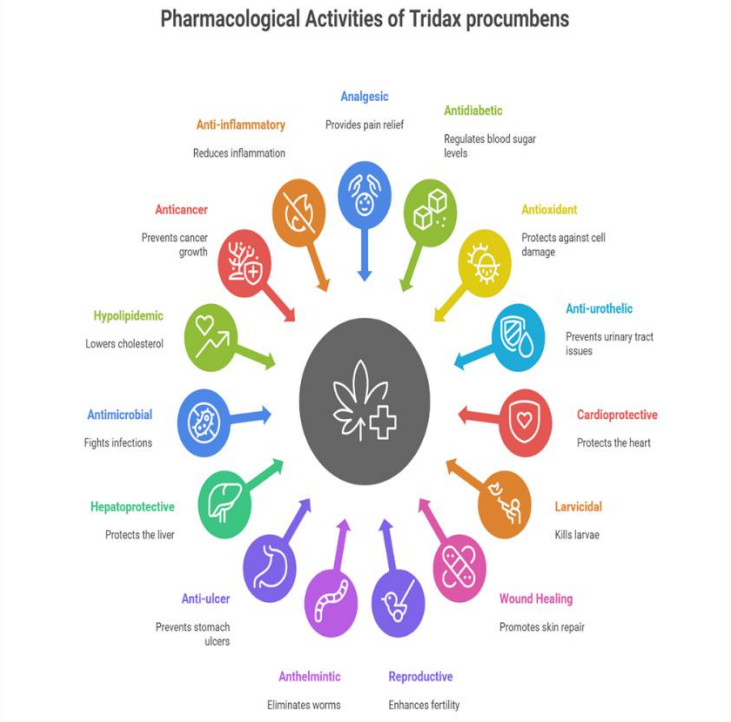


Figure 4: Various pharmacological activities of *Tridax procumbens*

Table 1: Various pharmacological activities of *Tridax procumbens* L.

Plant activity	Part used	Extract	Dose/Mode/ Duration	Animal Model	Effects observed	References
Antidiabetic activity	Leaves	Alcoholic, dried aqueous, and petroleum ether (60-80°C) extracts	200 mg/Kg b. wt/day, orally for 7 days	ALX-induced Wistar rats	Experimental studies have shown that both aqueous and alcoholic extracts significantly reduced blood glucose levels in ALX-induced diabetic rats, whereas the petroleum extract demonstrated weak anti-diabetic activity.	[36]
	Whole plant	Methanolic extract	250 and 500 mg/Kg b. wt/day, orally for 30 days	ALX-induced diabetic rats	Treatment with *T. procumbens* extract led to a marked reduction in fasting FBG in diabetic rats. While the antihyperglycemic effect became evident by the seventh day, a more substantial decline was observed by day 30, indicating resettlement toward normalization. Additionally, the treated diabetic rats exhibited improvement in body weight, suggesting signs of physical recovery.	[37]
	Whole plant	Methanolic extract	250 and 500 mg/Kg b. wt/day, orally for 21 days	STZ-induced diabetic Wistar rats	The treated group exhibited a notable decline in blood glucose levels compared to the diabetic control group. By the conclusion of the study, the treatment effectively restored STZ-induced elevated glucose levels to near-normal values.	[38]
	Root	Methanolic extract	55mg/kg b. wt/day, intraperitoneal (i.p) for 21 days	STZ-induced diabetic rats	The methanolic extract of *T. procumbens* effectively reduced serum glucose concentrations in rats with diabetes.	[39]
	Whole plant	chloroform, Petroleum ether, and methanol extract	10, 20, 40, 60, 80 & 100 µg/ml	*In-vitro*	The methanol extract of *T. procumbens* demonstrated the strongest α-amylase inhibition, with an IC_{50} value below 10 µg/mL. In comparison, the petroleum ether extract displayed inhibitory effects with an IC_{50} of 70 µg/mL, while the chloroform extract also showed activity, recording an IC_{50} of less than 100 µg/mL.	[40]
	Leaves and flowers	Water and methanolic extract	-	*In-vitro*	The methanolic extract of the flower showed the highest α-amylase inhibition of 20.7 ± 2.54% at pH 3. In contrast, the aqueous extract exhibited peak inhibitory activity at pH 7. This was followed by the aqueous leaf extract and its methanolic counterpart, both demonstrating maximum inhibition at pH 3.	[41]
	Leaves	Ethanolic extract	200 mg/Kg b. wt/day, orally for 7 days	ALX-induced Wistar rats	The ethanolic extract of *T. procumbens* significantly reduced blood glucose levels in ALX-induced diabetic rats, indicating its potential anti-diabetic properties.	[42]
	Leaf	Green synthesized zinc oxide nanoparticles (ZnO NPs)	100 and 200 mg/Kg b. wt/day, orally for 21 days	STZ-induced diabetic rats	Green-synthesized ZnO nanoparticles significantly reduced blood glucose levels ($p < 0.05$) in a dose-dependent fashion and also helped prevent body weight loss. The pancreas of treated animals appeared largely normal, showing restoration of the islets of Langerhans (IL) and only minor necrotic changes.	[43]
	Leaves	Hydromethanolic Extract	200 and 400mg/kg b.wt/day, for 14 days.	STZ-induced diabetic Swiss albino mice	The findings indicated that the hydromethanolic extract of *T. procumbens* leaves possesses notable antihyperglycemic effects, as it effectively lowered blood glucose levels in diabetic mice. However, the extract showed no significant impact on reversing body weight loss or correcting diabetic dyslipidemia in the treated animals.	[44]
	Whole plant	Methanolic extract	150 and 300mg/kg b.wt/day, through oral gavage for 21 days.	STZ-induced diabetic Wistar rats	Treatment with *T. procumbens* extract in diabetic rats significantly improved FBG, mitigated body weight loss, normalized serum and pancreatic insulin levels, and restored pancreatic histology.	[45]
	Whole plant	Methanolic extract	10, 20, and 60 µg/ml	L6 myoblast cells (*In-vitro*)	The methanolic extract exhibited a mild antidiabetic effect, evidenced by a slight reduction in serum glucose levels and an increase in glucose uptake by L6 myoblast cells.	[46]
Anti-oxidant activity	Whole plant	Ethanolic extract	0.5,1.0, 2.0 and 4.0g/kg b.wt/day, orally for 15 days	Hyperoxaluria induced oxidative stress male albino rats	In the treated rats, the dose-dependent decrease in kidney malondialdehyde (MDA) levels suggests a reduction in lipid peroxidation (LPO) and oxidative damage. Additionally, elevated levels of catalase (CAT) and glutathione (GSH) further confirmed the alleviation of oxidative stress.	[47]
	Leaves and flowers	Water and methanolic extract	-	*In-vitro*	The highest hydroxyl radical scavenging activity was observed in the water extracts of the flower and leaf, measuring 33.5±1.2% and 27.32±0.98%, respectively. The methanolic flower extract showed a scavenging activity of 22.5±2.14%, while the methanolic leaf extract recorded 17.25±1.34%. These findings indicate that the water extracts exhibit greater hydroxyl radical scavenging capacity compared to the methanolic extracts.	[41]

	Whole plant e	Ethyl acetate extract	-	*In-vitro*	The ethyl acetate extract showed the strongest antioxidant activity, exhibiting the lowest IC_{50} values in both DPPH and ABTS radical scavenging assays (0.13 and 0.45 mg/mL, respectively). The antioxidant capacity of *T. procumbens* extracts was found to correlate with their total phenolic and flavonoid content.	[48]
	Leaves	Methanolic extract	62.5, 125, 250, 500, 1000, 2000 µg/ml	*In-vitro*	The plant extracts likely exhibit considerable antioxidant properties, potentially through the suppression of DPPH free radicals that contribute to oxidative processes. The IC_{50} values determined by the DPPH scavenging assay were 99.31 µg/mL for the standard and 488.80 µg/mL for the leaf extract.	[49]
	Whole plant	Ethanolic extract	1.0 and 250 g/ml	*In-vitro*	The DPPH radical scavenging assay results for *T. procumbens* demonstrated a strong antioxidant effect, with a 96.70% activity observed at a concentration of 250 µg/mL. The extract also exhibited a reductive potential of 0.89 nm. The study concluded that the antioxidant activity of *T. procumbens* is closely linked to its total phenolic content.	[50]
	Whole plant	Hydroalcoholic extract	10-50µg/mL	*In-vitro*	The extract of *T. procumbens* exhibited greater antioxidant activity with an IC_{50} value of 22.7795±0.8208 µg/mL compared to the crude extract, which had an IC_{50} of 23.347±0.7344 µg/mL. These results were evaluated against the standard antioxidant Quercetin, which showed an IC_{50} of 18.0707±3.607 µg/mL. The findings indicate that the antioxidant potential of *T. procumbens* is largely influenced by its total phenolic and flavonoid content.	[51]
	Leaves	Methanolic extract	50,100,150,200, 250 and 300 µg/mL	*In-vitro*	The DPPH radical scavenging activity of the tested extract increased with concentration. The greatest inhibition of DPPH radicals, 83.66±3.21%, was recorded at the highest concentration of 300 µg/mL. Significant differences ($p<0.05$) were observed in antioxidant activity across the various concentrations of the extract. The methanolic extract of exhibited an IC_{50} value of 151.23 µg/mL, which is comparable to the standard antioxidant Butylated hydroxytoluene (BHT) with an IC_{50} of 64.90 ± 0.75 µg/mL.	[52]
	Whole plant	Crude extract	250, 375 and 500mg/kg b. wt/day, orally for 28 days	STZ-induced diabetic Wistar rats	Rats treated with *T. procumbens* extract showed a significant decrease in TBARS levels, along with elevated levels of CAT and SOD compared to untreated diabetic rats.	[53]
	Whole plant	Methanolic extract	150 and 300mg/kg b. wt/day, through oral gavage for 21 days.	STZ-induced diabetic Wistar rats	Treatment with the extract enhanced antioxidant defenses, demonstrated by elevated levels of catalase (CAT), superoxide dismutase (SOD), and glutathione (GSH), alongside a reduction in malondialdehyde (MDA). This indicates the extract's antioxidant properties.	[45]
	Whole plant	Ethanolic extract	0.2, 0.4, 0.6, 0.8, 1 mg/ml	*In-vitro*	The extract of *T. procumbens* demonstrated the highest effectiveness in scavenging DPPH and hydroxyl radicals, with IC_{50} values of 0.15, 0.12, 0.008, and 42.39 µg/mL, respectively. Its capacity to neutralize nitric oxide and hydrogen peroxide radicals might be due to a variety of antioxidant processes.	[54]
	Whole plant	Methanol and aqueous extract	20, 40, 60, 80, and 100 ug/ml	*In-vitro*	The methanolic extract showed greater antioxidant activity compared to the aqueous extract, with an IC_{50} of 75.40 µg/mL. The aqueous extract and ascorbic acid exhibited IC_{50} values of 112.19 µg/mL and 40.48 µg/mL, respectively. The antioxidant effects of *T. procumbens* were strongly linked to its levels of phenolic and flavonoid compounds.	[55]
	Leaves stem and flowers	Hexane and methanolic extract	2, 10, 25, and 50 µg/mL	*In-vitro*	The hexane extract exhibited the strongest antioxidant activity compared to the methanolic extract, as reflected by IC_{50} values of 33.14 µg/mL and 34.52 µg/mL in the DPPH assay for hexane and methanolic extracts, respectively. Similarly, in the nitric oxide scavenging assay, the IC_{50} values were 16.74 µg/mL for the hexane extract and 34.26 µg/mL for the methanolic extract.	[56]
	Whole plant	Isolated oil (denoted as TPMG oil) from methanol extract	12.5, 31.5, 62.5, 125, 250, and 500 µg/mL	*In-vitro*	The findings indicate that the percentage of DPPH radical scavenging inhibition increases proportionally with concentrations ranging from 100 to 500 µg/mL. The essential oil demonstrated an IC_{50} value of 18.34 µg/mL, showing significant antioxidant effects ($P < 0.05$). TPMG oil exhibited antioxidant properties that may help prevent and delay the progression of aging-related diseases linked to oxidative stress.	[57]
	Flower	Methanolic and hydro alcoholic	4–64 µg/mL	*In-vitro*	Using the DPPH assay, the methanolic extract exhibited an IC_{50} of 88.64±1.0 µg/mL, while the hydro-alcoholic extract showed a value of 70.3±1.1 µg/mL. In the nitric oxide assay, the methanolic extract had an IC_{50} of	[58]

					66.8±1.1 µg/mL, and the hydro-alcoholic extract demonstrated 60.7±1.1 µg/mL. These results indicate that *T. procumbens* possesses significant antioxidant activity.	
	Leaves	Methanolic extract	0%, 0.2%, 0.4%, and 0.8% of leaf extract, orally for 60 days	*Labeo rohita* fingerlings	Feeding fish a diet containing 0.8% leaf extract enhanced the production of antioxidant enzymes (GPx, SOD, and CAT), indicating that adding the extract to their diet could reduce oxidative stress. The improved antioxidant capacity in rohu is likely associated with phenolic compounds like tannins, flavonoids and phenol-carboxylic acids present in the extract.	[59]
Reproductive activity	Leaves	Ethanolic extract	0, 100, 200, 400 and 800mg/kg b. wt/day, through orally for 28days.	Male Albino Wistar rats	The findings of this study indicate that the ethanolic leaf extract of *Tridax procumbens* can enhance semen parameters—such as motility, concentration, and morphology—and boost the secretion of testosterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH) in male Wistar rats, particularly at a dosage of 800 mg/kg. These effects are likely attributed to the bioactive constituents present in the extract, including flavonoids, steroids and carbohydrates.	[60]
	Leaves	Aqueous extract	100 and 200 mg/Kg b. wt/day, orally for 3 weeks	N nitro-L-arginine-methyl ester (L-NAME) induced hypertensive rats	The aqueous extract led to a reduction in systolic, diastolic, and mean arterial pressure in the groups treated with both L-NAME and the extracts, compared to the group receiving L-NAME alone (40 mg/kg). In the L-NAME group, there was a decline in relative weights of the prostate and seminal vesicles, as well as reductions in sperm motility, viability, and count, when compared to both the control and extract-treated groups. Fertility was successful in all groups except the L-NAME group, which showed 0% fertility, although no significant differences were observed in average litter size or weight. Testosterone levels rise significantly in the extract-treated groups, and no visible damage was detected in the testes of any treated animals.	[61]
	Leaves	Ethanolic extract	100mg/kg b. wt/day, through oral gavage for 7weeks.	Chronic variable stress (CVS)-induced erectile dysfunction (ED) male Wistar rats	In the groups supplemented with the ethanolic extract, serum cortisol levels showed a marked decline, while testosterone levels were notably elevated compared to the group exposed solely to chronic variable stress (CVS). Additionally, the CVS-only group exhibited a significant drop in sperm motility (%) and a rise in abnormal sperm forms, whereas these parameters improved in the groups receiving the extract and Vitamin C.	[62]
Anti-urolithic activity	Whole plant	Ethanolic extract	0.5,1.0, 2.0 and 4.0g/kg b. wt/day, orally for 15 days	Ethylene glycol and ammonium chloride induced calcium oxalate urolithiasis male albino rats	The extract demonstrated a dose-dependent decrease in urinary and kidney levels of calcium and oxalate compared to control rats, suggesting a reduction in urinary supersaturation of calcium oxalate (CaOx). Additionally, the treatment lowered elevated urinary creatinine levels, indicating enhanced kidney function. .	[47]
	Leaves	Petroleum ether, chloroform, ethyl acetate, benzene,ethanol, aqueous and methanolic extract	50, 100, 200, 400, 800, 1600 and 3200 µg/mL	*In-vitro*	In this study, the presence of plant extracts led to a noticeable reduction in both the length and width of calcium oxalate crystals. The average crystal size formed with the extracts was smaller than that observed in the untreated control. The findings suggest that the extracts effectively interfered with the key stages of stone development, including nucleation, crystal growth, and aggregation.	[63]
	Whole plant	Aqueous and methanolic extracts	10mg of both extracts	*In-vitro*	The study revealed that both methanolic and aqueous extracts of *T. procumbens* exhibited significant calcium oxalate dissolving abilities, with the aqueous extract demonstrating greater effectiveness than the methanolic one. These results provide initial evidence supporting the lithotriptic potential of *T. procumbens*.	[64]
	Leaves	Methanolic extract	10, 20 mg	Experimentally prepared calcium oxalate crystals	Calcium oxalate crystal dissolution was observed at 68.02% with a 10 mg dose and 72.41% with a 20 mg dose, indicating that *T. procumbens* exhibits a notable anti-urolithiatic effect.	[65]
Anti-microbial activity	Leaves and flowers	Methanolic and water extracts	100µl	*Bacillus cereus, Pseudomonas fluroscence, Escherichia*	*P. aeruginosa* showed the highest sensitivity to the extracts compared to other tested microbes. The methanolic flower extract effectively inhibited the growth of *E. coli, P. aeruginosa, and B. cereus*, while the methanolic leaf extract produced the largest inhibition zone against *P. fluorescens*.	[41]

				Coli, Pseudomonas aragenosa		
	Roots	Ethanol, benzene and petroleum ether extracts	400 µg/ml	*Staphylococcus aureus, Salmonella typhii, Escherichia coli, Shigella flaxineri and Klebsiella pneumoniae*	Petroleum ether and ethanolic extracts demonstrated notably stronger antimicrobial activity compared to the benzene extract. The ethanolic extract exhibited the widest inhibition zones, measuring between 7–12 mm, followed by the petroleum ether extract with zones of 6–11 mm, while the benzene extract showed smaller zones ranging from 5–8 mm. These findings highlight the plant's promising therapeutic potential against microbial infections. Specifically, the ethanolic extract was most effective against *E. coli* and *S. aureus* (7–12 mm), the petroleum ether extract showed the greatest inhibition against *K. pneumoniae*, and the benzene fraction produced consistent inhibition across all tested bacterial strains.	[66]
	Leaves	Ethanolic and aqueous extract	250, 200, 100 and 50mg/ml	*Staphylococcus aureus* and *Escherichia coli*	Both ethanol and water extracts were biologically active against the two microbes. Ethanol extract showed greater inhibition (9.29 mm) in comparison to water extract (7.19 mm). *Escherichia coli* showed greater susceptibility as compared to *Staphylococcus aureus*.	[67]
	Whole plant	Acetone, 50%ethanolic and methanolic extracts	50mg/ml	*Vibrio cholerae, Salmonella typhimurium, Escherichia coli,* and *Klebsiella pneumoniae*	The acetone extract showed strong antimicrobial activity against *E. coli* and *Vibrio cholerae*, while the 50% ethanolic extract was particularly effective against *Klebsiella pneumoniae*. In contrast, the methanolic extract exhibited activity solely against *V. cholerae*.	[68]
	Leaves	Methanolic extract	500µg/ml and 250µg/ml	*Vibrio cholera, Salmonella typhi, Escherichia coli, Staphylococcus aureus, Bacillus cereus, Bacillus subtilis, Candida albicans, Aspergillus fumigatus and Aspergillus niger*	The methanolic extract exhibited broad antimicrobial effects against *Vibrio cholerae*, *Bacillus subtilis* and *E. coli* at a concentration of 500 µg/mL, while at 250 µg/mL most bacteria were resistant except for *B. cereus*. *Salmonella typhi* was completely resistant to both concentrations of the extract. The inhibition zones for bacteria ranged from 8 to 14 mm. Regarding fungi, all tested strains—including *Aspergillus fumigatus*, *Aspergillus niger*, and *Candida albicans*—were sensitive to the extract at both 250 and 500 µg/mL, with inhibition zones measuring between 9 and 15 mm. Among these, *Aspergillus niger* and *Candida albicans* showed the greatest sensitivity to the extract.	[69]
	Whole plant	Ether(residue), Ethyl acetate, Water(filtrate), Chloroform, Chloroform & Methanol (3:1)	-	*Escherichia coli & Klebsella*	The findings of this study demonstrated that extracts and fractions derived from *T. procumbens* exhibited antibacterial effects against certain bacterial strains. The ethyl acetate fraction of the residue (fats and waxes) and the chloroform fraction of the filtrate (terpenoids and phenolics) showed activity against *Klebsiella* species. Additionally, the ether fraction of the residue (fibers), chloroform fraction of the filtrate (terpenoids and phenolics), and the chloroform-methanol (3:1) fraction of the filtrate (alkaloids) were effective against *E. coli* bacteria.	[70]
	Leaves	Methanolic extract	25mg/well	*Pseudomonas aeruginosa* and *Staphylococcus aureus.*	Using the agar well diffusion technique at a concentration of 25 mg per well, *P. aeruginosa* exhibited a ZOI measuring 3.3 cm, while *S. aureus* showed a ZOI of 1.7 cm at the same extract concentration. In the modified agar well diffusion method, the ZOI for *P. aeruginosa* and *S. aureus* were recorded as 3.4 cm and 2 cm, respectively. In the disc diffusion assay, *S. aureus* displayed a ZOI of 0.8 cm at 4 mg per disc, whereas *P. aeruginosa* had the largest inhibition zones, measuring 2.4 cm at 4 mg/disc and 2.1 cm at 3.2 mg/disc. Colony-forming units per milliliter (cfu/mL) decreased in a dose-dependent fashion in bacteria treated with the extract compared to untreated controls, as shown by both spread plate and absorbance analyses. Overall, the methanolic extract demonstrated	[71]

					stronger bactericidal effects against *P. aeruginosa* than *S. aureus* across all tested methods.	
	Leaves	Ethanolic extract	100 µg/ml	*Klebsiella pneumoniae, Pseudomonas auruginosa, and Staphylococcus aureus, Escherichia coli*.	The ZOI assay demonstrated that the ethanolic extract of *Tridax* exhibited stronger antibacterial effects against Gram-positive bacteria, with inhibition zones measuring 20 mm for *S. aureus* and 16 mm for *K. pneumoniae*, compared to Gram-negative bacteria such as *P. aeruginosa* (17 mm) and *E. coli* (16 mm). Fabric samples treated with a 16% concentration of the extract showed greater antimicrobial activity than those treated with 8%. These results indicate that the extract is more effective in controlling Gram-positive pathogens than Gram-negative ones.	[72]
	Whole plant	Hexane, Chloroform, ethyl acetate, Aqueous extract	40, 30, 25, 20, 10, 5, 2.5, 1.5, 1.25 mg/mL	*Proteus mirabilis, Staphylococcus aureus, Escherichia coli, and Bacillus subtilis*	The ethyl acetate extract exhibited the most potent inhibitory effects against all tested bacterial strains, with minimum inhibitory concentrations ranging from 10 to 25 mg/mL. The hexane extract showed antibacterial activity against *E. coli* and *S. aureus*, whereas the chloroform extract was effective only against *S. aureus*.	[48]
	Whole plant	Ethanolic, methanolic, ethyl acetate, chloroform, benzene, petroleum ether extract	-	*Proteus vulgaris, Shigellaflexneri Bacillus subtilis, Staphylococcus aureus, Chryseobacteriumgleum, Klebsiella pneumoniae, Enterobacter aerogenes, Aspergillus fumigatus, Aspergillus niger, Candida albicans, and Aspergillus flavus.*	The leaf juice produced a 28 mm zone of inhibition against *B. subtilis*, while the flower juice showed a 17 mm zone against *C. albicans*. The aqueous decoction exhibited a 14 mm inhibition zone against *C. gleum*. Additionally, ethanol, methanol, chloroform, and ethyl acetate extracts demonstrated microbial inhibition zones of 17 mm, 14 mm, and 14 mm, respectively. Various formulations of *Tridax* displayed distinct and notable antimicrobial effects against a different microorganism.	[73]
	Leaves	Leaves based chitosan gel	25, 50 and 100µL	*Streptococcus mutans, Lactobacillus, Enterococcus faecali,* and *Candida albicans*	The chitosan gel formulated with *T. procumbens* leaf extract demonstrated its strongest antimicrobial effect at a concentration of 100 µL, producing inhibition zones of 10 mm against *S. mutans*, 13 mm against *Lactobacillus*, 12 mm against *E. faecalis*, and 25 mm against *C. albicans*.	[74]
	Stem	Methanolic extract	-	*Escherichia coli, Shigella flexneri*, *Salmonella enterica typhimurium*, and *Staphylococcus aureus*	The plant extract exhibited antibacterial effects against all tested bacterial strains. The highest inhibition was observed against *S. flexneri* (16.0 ± 1.2 mm), whereas the lowest was recorded for *S. aureus* (4.0 ± 0.5 mm). This indicates that Gram-negative bacteria were more susceptible to the extract compared to Gram-positive bacteria.	[75]
	Leaves, stems and flowers	Ethanolic extract	-	*Streptococcus mutans and Enterococcus faecalis*	The findings indicated that stem, leaf, and flower extracts of *T. procumbens* at concentrations of 20%, 40%, and 60% exhibited antibacterial effects against *S. mutans* and *E. faecalis*, categorized as resistant to moderate. The minimum inhibitory concentration (MIC) for *S. mutans* was 2.5% for stem, 10% for leaf, and 5% for flower extracts, while the minimum bactericidal concentration (MBC) values were 10%, 20%, and 20%, respectively. For *E. faecalis*, the MIC values were 5% for stem, 10% for both leaf and flower extracts, with MBC values of	[76]

					10%, 40%, and 40%, respectively. Among these, the stem extract demonstrated the strongest antibacterial activity.	
	Leaves	Water, hydro ethanol and ethyl acetate extract	250-300 µg/ml	*Staphylococcus aureus Escherichia coli, and Lactobacillus*	Both the hydroethanolic and ethyl acetate extracts inhibited the growth of all the selected bacterial species, although their levels of effectiveness varied. The ethyl acetate extract demonstrated greater antibacterial activity compared to the hydroethanolic extract.	[77]
	Leaves	Silver, zinc and copper nanoparticles (AgNPs, ZnNPs and CuNPs)	-	*E. coli, Pseudomonas glycinea, Ralstonia solanecearum, Streptococcus faecalis, Xanthromonas phasaoli, Staphylococcus aureus, Salmonella typhi, Enterobacter aerogenes,*	The ZnNP synthesized from *T. procumbens* exhibited strong antibacterial effects against the tested pathogens, with the exception of *E. coli* and *Pseudomonas glycinea*. In contrast, the AgNPs showed only moderate inhibitory activity, excluding *P. glycinea*, which remained resistant. Meanwhile, CuNPs displayed a consistent but mild antibacterial effect across all tested strains. Notably, the extract and all three nanoparticles completely inhibited the growth of *Ralstonia solanacearum*, *Enterobacter aerogenes*, *Staphylococcus aureus*, and *Salmonella typhi*. Furthermore, the *T. procumbens* extract proved to be effective against both Gram-positive and Gram-negative bacterial species.	[78]
	Stem	Stem extract-based chitosan gel,	25, 50, and 100 µL	*Pseudomonas aeruginosa*	In the MIC assay, the absorbance values decreased progressively over time at all concentrations, showing its inhibitory effect. With the increase in concentration, the inhibitory effect of *T. procumbens* stem extract-based chitosan gel against *P. aeruginosa* also increased.	[79]
Anti-helminthic activity	Leaves	Methanolic extract	10, 20, 30mg/ml	Indian adult earthworm (*Pheritima posthuma*)	In the evaluation of anthelmintic activity, the methanolic extract induced paralysis at 15, 3, and 2 minutes for concentrations of 10 mg/ml, 20 mg/ml, and 30 mg/ml, respectively. The corresponding times to death were 50, 16, and 13 minutes. These findings indicate that the plant extract exhibits an anthelmintic effect that increases with increasing dosage.	[80]
	Stem	ethanol, chloroform, ethyl acetate,aqueous extracts	20,50,100 mg/ml	Indian adult earthworm (*Pheritima posthuma*)	During the assessment of its wormicidal potential, the methanolic extract caused immobilization at 15, 3, and 2 minutes for doses of 10 mg/ml, 20 mg/ml, and 30 mg/ml, respectively. The organisms were completely killed at 50, 16, and 13 minutes at the same concentrations. These observations suggest that the extract possesses a concentration-dependent anthelmintic property.	[81]
	Whole plant	Ethanol, aqueous extracts	25,50,75 mg/ml	Indian adult earthworm (*Pheritima posthuma*)	Analysis of the results indicates that higher concentrations lead to shorter times for both paralysis and death. The ethanolic extract at 75 mg/ml caused paralysis in 6.66 minutes and death in 17.83 minutes, demonstrating greater efficacy than the aqueous extract. This highlights a clear dose-responsive and notable anthelmintic effect when compared to the standard drug Albendazole. Among all the tested extracts, the ethanolic extract was the most effective, inducing paralysis and mortality in earthworms more rapidly, followed by the aqueous extract.	[82]
	Leaves	Aqueous and ethanolic extract	50 and 100mg/ml	Indian adult earthworm (*Pheritima posthuma*)	The data clearly indicate that increasing the extract concentration results in reduced times for both paralysis and death. At 100 mg/ml, the ethanolic extract effectively induced both paralysis and mortality in earthworms, demonstrating a strong and concentration-dependent anthelmintic effect. Compared to the reference drug mebendazole, this extract showed notable potency. Among all the tested extracts, the ethanolic extract proved to be the most efficient, producing the quickest paralysis and lethality, followed by the aqueous extract.	[83]
	Leaves	Aqueous and chloroform extracts	25 and 50 mg/ml	Indian adult earthworm (*Pheritima posthuma*)	Both aqueous and chloroform extracts exhibited anthelmintic effects in a concentration-dependent fashion, with the 50 mg/ml dose producing the fastest onset of paralysis and death in worms. Based on these findings, it can be inferred that *T. procumbens*, traditionally utilized by tribal communities for treating intestinal worm infections, demonstrates notable anthelmintic potential. At a concentration of 50 mg/ml, the chloroform extract induced paralysis in 24.18 ± 0.98 minutes and caused death within 52.44 ± 2.0 minutes.	[84]
	Whole plant	Aqueous, acetone,	10,30,50 mg/ml	Indian adult earthworm	The methanolic extract at concentrations of 10, 30, and 50 mg/ml resulted in paralysis times of 114.5, 72.5, and 64	[85]

		petroleum and methanolic extracts		(*Pheritima posthuma*)	minutes, respectively, while death occurred at 125, 84, and 78 minutes for the same doses. Among the tested groups, the methanolic extract at 50 mg/ml concentration demonstrated the most effective paralysis (64 minutes) and marked anthelmintic action, with a death time of 78 minutes. These findings suggest that the methanolic extract of *T. procumbens* exhibits strong anthelmintic properties against *Pheretima posthuma*, surpassing the efficacy of the reference drug.	
	Leaves	Ethanolic extract	2, 4, or 6 g/kg diet, thrice a day for 8 weeks	Nile tilapia, *Oreochromis niloticus,* juveniles	The findings indicate that incorporating ethanolic extract of *T. procumbens* (TPLE) into the diet had no adverse impact on fish health, while enhancing feed intake and nutrient assimilation. Notably, optimal dietary levels of 4–6 g TPLE per kg of feed significantly boosted the resistance of Nile tilapia against possible infections caused by the monogenean parasite i.e., *Dactylogyrus vastator*.	[86]
	Whole plant	Aqueous, methanol and chloroform	50 and 100 mg/ml	Adult Indian earthworms (*Eisenia fetida*)	The data indicate that increasing the extract concentration leads to a reduction in both paralysis and mortality times. Elevated doses of the methanol and chloroform extracts from *T. procumbens* induced paralysis more rapidly and resulted in quicker death. Overall, this study demonstrates that the methanol and chloroform extracts of *T. procumbens Linn.* possess strong anthelmintic properties comparable to the standard drug i.e., Albendazole.	[87]
	Stems	Ethanolic extract	20mg/ml, 40mg/ml and 60mg/ml	Indian adult earthworm (*Pheritima posthuma*)	The stem extract of *T. procumbens* demonstrated enhanced anthelmintic effects against parasitic worms as its concentration increased. Albendazole, used as a standard at 20 mg/ml, exhibited paralysis and death times of 17 and 24 minutes, respectively. In comparison, the ethanolic extract at 60 mg/ml caused paralysis and death at 18 and 28 minutes, respectively. These findings indicate that the ethanolic stem extract of *T. procumbens* possesses dose-dependent anthelmintic activity.	[88]
Hepatoprotective activity	Aerial parts	Ethanolic extract	300 mg/kg b.wt/day, orally for 10 days	D-galactosamine/lipopolysaccharide-induced hepatitis in rats	Rats pretreated with the chloroform-insoluble fraction of the ethanolic extract showed normalization of altered biochemical markers, including aspartate transaminase, alanine transaminase, alkaline phosphatase, lactate dehydrogenase, gamma glutamyl transferase, and bilirubin levels in both serum and liver. Additionally, the pretreatment significantly alleviated liver damage caused by d-GalN/LPS, as demonstrated by the absence of cellular necrosis and inflammatory cell infiltration around the central zone.	[89]
	Whole plant	Ethanolic extract	100, 200, 300 and 400mg/kg b.wt/day, *p. o.* (post oesophagus) for 7 days	Paracetamol- induced toxicity in male Wistar rat	Administration of the extract resulted in improvements across all liver function markers, including serum AST, ALT, ALP, bilirubin, and total serum protein levels. Treatment with *T. procumbens* in rats subjected to paracetamol toxicity facilitated the regeneration of hepatocytes and reduced necrotic damage.	[90]
	Leaf	Aqueous extract	100, 200, and 300mg/kg b. wt/day, orally	Carbon Tetrachloride (CCl_4)-Induced Liver Injury in Wistar Rats	The plasma levels of total bilirubin and total protein in the treated animals were reduced compared to the test control group. This protective effect appeared to be dose-dependent, with doses of 200 and 300 mg/kg showing greater efficacy. Relative to the test control, the treatment significantly decreased ($P<0.05$) the activities of alkaline phosphatase by 54.91-100.52%, aspartate transaminase by 37.74-64.79%, and alanine transaminase by 32.96-57.82% in a dose-related manner.	[91]
	Flowers	Aqueous and Methanolic extract.	200, 400 mg/kg b. wt/day, orally for 7 days	Dgalectosamine induced Hepatotoxicity in Male Wistar Rats	The groups treated with the methanolic extract at doses of 200 and 400 mg/kg body weight exhibited a notable reduction in elevated levels of ALT, total bilirubin, AST, total protein, and serum creatinine. These biochemical values were comparable to those observed in the control group and the standard hepatoprotective drug, silymarin. Both silymarin and the methanolic extract significantly ($P<0.05$) normalized the altered enzyme levels. Additionally, the methanolic extract demonstrated a more pronounced effect than the aqueous extract.	[92]
	Leaves	Methanolic extract	500 mg/kg b.wt/day, orally for 21 days	Isoniazid-rifampicin induced toxicity in male Wistar rat	Treatment with the extract resulted in significant improvements across all liver function test (LFT) parameters compared to the Liv-52 (standard drug) group, including ALP ($p=0.001$), SGPT ($p=0.003$), SGOT ($p=0.03$), and direct bilirubin ($p=0.022$).	[93]
	Leaves, stem, flowers	Methanolic extract	500 mg/kg b.wt/day, orally for 14 days	isoniazid-rifampicin (INH-RIF) induced	A marked increase in serum liver enzymes was detected ($P<0.001$), accompanied by a notable reduction in SOD and CAT levels in the toxic group. In contrast, the treatment groups, when compared to the standard drug	[94]

				toxicity in male Wistar rat	Silymarin, effectively prevented the elevation of liver enzymes and promoted an increase in CAT, SOD, and total protein levels (P>0.05). Pretreatment with the extract demonstrated strong protective effects against the toxin, as evidenced by the preservation of hepatic cord structure and the absence of necrosis in liver histological analysis.	
	Whole plant	Ethanolic extract	100, 200 and 400mg/kg b.wt/day, orally for 10 days	Rifampicin (RIF)induced Hepatotoxicity in Male Albino Rats	Administration of a toxic dose of rifampicin (RIF) led to elevated serum levels of ALT, AST, and ALP, along with reduced activities of SOD and CAT in the liver compared to the normal control group. Additionally, RIF toxicity caused an increase in hepatic TBARS (Thiobarbituric Acid Reactive Substances) levels, while total serum protein, hepatic GSH, and tissue glycogen levels were significantly decreased. However, co-treatment with *T. procumbens* extract in RIF-intoxicated rats effectively reversed these toxic alterations. Histopathological examination revealed that rifampicin induced centrilobular necrosis, inflammation, and hepatocyte accumulation around the terminal hepatic venule, whereas administration of *T. procumbens* extract mitigated these damages in liver tissue.	[95]
	Leaf	Aqueous extract	50, 75, and 100mg/kg b.wt/day, orally for 14 days	Doxorubicin-induced Wistar rats	The levels of hepatic malondialdehyde, calcium, sodium, and cholesterol, along with plasma activities of aspartate transaminase, alanine transaminase, and alkaline phosphatase, as well as the plasma albumin-to-globulin ratio in the test control group, were significantly (P<0.05) elevated compared to all other groups. Conversely, the test control exhibited notably (P<0.05) reduced plasma concentrations of globulin, albumin, total protein, and total bilirubin; lower hepatic levels of ascorbic acid, magnesium, chloride, and potassium; and decreased hepatic activities of catalase, glutathione peroxidase, and superoxide dismutase relative to the other groups.	[96]
	Whole plant	Methanolic extract	200, 400 mg/kg b.wt/day, orally for 28 days	isoniazid-rifampicin induced toxicity in male Wistar rat	Treatment with the extract fully restored normal levels of hepatic antioxidants (SOD, GPx, CAT, and GSH) and significantly decreased the production of hepatic MDA. Additionally, supplementation with the extract effectively lowered the elevated serum alkaline phosphatase, transaminases, and lactate dehydrogenase levels close to normal. Total protein and albumin concentrations also showed an increase following the treatment.	[97]
Hypolipidemic activity	Whole plant	Ethanolic extract	250 and 500 mg/kg b. wt/day, p.o. for 21 consecutive days.	STZ-induced diabetic Wistar rats	Treatment with the ethanolic extract of the whole *T. procumbens* plant in STZ-induced diabetic rats helped maintain normal lipid profiles by preventing the rise in total cholesterol, triglycerides, and LDL cholesterol, while also countering the reduction in HDL cholesterol. Liver function markers, including SGPT and SGOT, remained within normal ranges in both the extract and glibenclamide-treated groups, whereas the diabetic control group exhibited significantly elevated levels of these enzymes by the end of the study (P < 0.001).	[38]
	Whole plant	Ethanolic extract	250 and 500mg/kg b. wt/day, p.o. for 21 consecutive days	High cholesterol diet (HCD) fed-male Wistar rats	Administration of the plant extract led to a marked decrease in total cholesterol, triglycerides, and LDL cholesterol levels, along with a notable increase in HDL cholesterol across all treated groups. These findings indicate that the ethanolic extract of *T. procumbens* possesses strong hypolipidemic properties, likely attributed to its flavonoid and tannin content.	[98]
	Aerial parts	Ethanol aqueous extract	20 mg/ml	HepG2 cells	The leaf extract of *T. procumbens* significantly reduced lipid accumulation in HepG2 cells when compared to the model control. Since hepatic lipid accumulation and oxidative stress are key factors in the development of non-alcoholic fatty liver disease (NAFLD), it is proposed that the lipid-lowering and antioxidant properties of *T. procumbens* leaves may help mitigate the progression of NAFLD.	[99]
	Leaves and stems	Hydroethanolic extract	300 and 500mg/kg b.wt/day, orally for 15 days	Adult Wistar rats	A dose-dependent reduction in blood cholesterol was observed when compared to the control group, along with a notable decrease in triglyceride levels at a dose of 300 mg/kg body weight. Both administered doses showed no signs of liver or kidney toxicity. The hydroethanolic extract of *T. procumbens* demonstrated its potential to manage lipid levels in the bloodstream of Wistar rats, suggesting its usefulness in combating dyslipidemia associated with obesity.	[100]
	Flower	Methanolic extract	500mg/kg b.wt/day, orally for 7 days	Male albino Wistar rats	The extract significantly lowered levels of cholesterol, triglycerides, LDL, and VLDL, while promoting an increase in HDL, highlighting its anti-lipidemic potential and its ability to reduce cardiovascular risk associated	[101]

					with elevated lipid levels and weight gain.	
	Leaves and stem	Hydro-ethanolic extract	500mg/kg b.wt/day, orally for 14 days	fatty and sweet diet fed Wistar rats	Rats administered with *T. procumbens* extract during the induction phase exhibited reduced weight gain and prevent rise in blood sugar and triglyceride levels, indicating its protective effect against metabolic disturbances.	[102]
Anti-ulcer activity	Whole plant	methanolic extract	100 mg/kg b.wt/day, p.o. for 5 days	Acetic acid induced ulcerative colitis in Wistar rats	The findings of this study revealed that myeloperoxidase activity in the group treated with 100 mg/kg of the methanolic extract was 2.74 U/g, representing nearly a 50% reduction compared to the experimental control group, which recorded 4.74 U/g. In comparison, the standard drug prednisolone at 5 mg/kg demonstrated activity of 0.85 U/g. Based on these results, it can be inferred that the methanolic extract exhibits protective and preventive effects against ulcer formation and may hold therapeutic potential for managing ulcerative colitis.	[103]
	Leaves	Ethanolic extract	200 and 400mg/kg b.wt/day, orally for 14 days	Ethanol and indomethacin induced gastric ulcers in rats	The ethanol extract at a dose of 400 mg/kg demonstrated a dose-related reduction in ulcer lesion index (9.76 ± 0.06), along with notable effects on gastric volume (4.38 ± 0.89) and pH (4.8 ± 0.88) in rats with ethanol-induced gastric ulcers. Additionally, this dose helped restore antioxidant enzyme levels such as reduced GSH, SOD, and CAT in the stomach. Histological analysis revealed the presence of numerous fibroblast cells, further supporting the extract's protective and healing properties.	[104]
	Leaves	Ethanolic extract	100 and 250mg/kg b.wt/day, orally for 21 days	Ethanol Induced Gastric Ulceration in Wistar Rats	The findings indicated that treatment with the extracts significantly ($p<0.05$) elevated gastric juice pH, ranging from 3.7 ± 0.36 to 4.47 ± 0.15, compared to the control group, which had a pH of 1.46 ± 0.14. Ulcer protection percentages in extract-treated groups varied between 49.5% and 97.6%, showing a dose-responsive effect. At a dosage of 250 mg/kg, the extract achieved 97.6% inhibition of gastric lesions, closely matching the 98.7% protection observed in the omeprazole-treated group.	[105]
	Aerial part	Hydro-alcoholic extract	300 mg/kg b.wt/day, orally	Diclofenac sodium induced ulcer in adult Wistar rats	The extract of *T. procumbens* proved more effective in decreasing both the frequency and weight of stools, while also significantly delaying the onset of diarrhea in both experimental models. The percentage reduction in defecation with the extract was recorded at 44.92% and 55.88%, compared to 76.81% and 78.97% observed with the standard treatment. The antiulcer potential of the extract was evident through a lowered ulcer index, reduced gastric volume and total acidity, along with an elevated gastric pH in both models tested.	[106]
Larvicidal activity	Leaves	Hexane, Acetone, Ethyl acetate and Methanol extract	31.25 to 500 ppm,	Dengue vector, *Aedes aegypti* and Bancroftian filariasis vector, *Culex quinquefasciatus*	The extracts obtained using Hexane, Ethyl acetate, and Acetone solvents caused moderate larval mortality, while the Methanol extract exhibited the highest mortality rate in two mosquito species. Among the various solvent-based extracts tested, the study revealed the following results for larvicidal activity against *Aedes aegypti*: LC50 values were 393.34, 174.06, 97.93, and 52.87 ppm, and LC90 values were 1180.02, 522.18, 293.79, and 158.61 ppm for Hexane, Ethyl acetate, Acetone, and Methanol, respectively. The correlation coefficients (r^2) recorded were 0.879, 0.999, 0.982, and 0.867. Against *Culex quinquefasciatus* larvae, the LC50 values were 450.62, 224.60, 195.03, and 94.19 ppm, while LC90 values were 1351.86, 673.8, 585.09, and 282.57 ppm, with r^2 values of 0.789, 0.897, 0.888, and 0.779, respectively.	[107]
	Whole plant	Aqueous, Petroleum ether, Chloroform, Ethanol, and Methanol extracts	-	*Anopheles stephensi* (Liston), *Aedes aegypti* (L) and *Culex quinquefasciatus* (Say).	Anopheles mosquitoes exhibited the greatest sensitivity, with an LC50 of 53.459 ppm and an LC90 of 156.497 ppm after 24 hours of exposure, compared to Aedes, which showed an LC50 of 53.416 ppm and an LC90 of 164.467 ppm. Both the crude methanol and ethanol extracts from this plant demonstrated strong larvicidal activity.	[108]
	Whole plant	SDS-AgNPs, and Tween 20-AgNPs	1, 2, 3, 4 & 5 ppm	*Anopheles stephensi* mosquito IV instar and Pupa larvae	The findings indicated that both SDS-AgNPs and Tween 20-AgNPs demonstrated strong toxicity against fourth instar larvae and pupae, achieving complete mortality at a concentration of 5 ppm. In contrast, the *T. procumbens* extract (TPE) alone showed minimal lethality. The LC50 values showed that SDS-AgNPs were the most effective (1.900 and 1.719), followed closely by Tween 20-AgNPs (1.933 and 2.274), and then TPE (1.235 and 1.321) for the fourth instar and pupal stages, respectively.	[109]
	Leaves	Aqueous extract	50, 100, 150, 200 and 250 ppm	*Culex quinquefasciatus* larvae	This research clearly demonstrates that *T. procumbens* leaves possess both insecticidal and larvicidal effects against mosquitoes. The LC50 values were recorded as	[110]

					187.5 ppm after 24 hours and 144.7 ppm after 48 hours of exposure.	
	Whole plant	Essential oils	20,40, 60, 80, and 100 µg /mL	*Aedes aegypti*	At concentrations of 80 and 100 µg/mL, larvicidal effects were observed within 24 hours, resulting in over 50% mortality. The calculated LC50 was 86.163 µg/mL, with a correlation coefficient (R2) of 0.936. After 48 hours, the essential oil exhibited larvicidal action at 60, 80, and 100 µg/mL, showing an LC50 of 76.524 µg/mL and an R2 value of 0.923. However, these values were significantly higher compared to the reference larvicide esbiothrin, which demonstrated an LC50 of just 0.0034 µg/mL.	[111]
	Leaves	Ethanolic extract	62.5, 125, 250, 500, and 1000 mg/ l	Larvae of *Aedes aegypti* L. and *Ae. albopictus* Skuse	No larval deaths were recorded in either control group. At the highest tested concentration after 72 hours, *Aedes aegypti* larvae showed 100% mortality, while *Aedes albopictus* exhibited 97% mortality. The ethanolic leaf extract of *T. procumbens* produced LC50 values of 288.40, 120.33, and 77.62 mg/L for *Ae. aegypti* and 812.83, 338.84, and 128.83 mg/L for *Ae. albopictus* at 24, 48, and 72 hours, respectively. These results indicate that *T. procumbens* extract is more effective against *Ae. aegypti* larvae as compared to *Ae. albopictus*.	[112]
	Leaves	Ethanolic extract	25, 50, 75, 100, and 125 ppm.	*Aedes aegypti*, *Anopheles stephensi*, and *Culex quinquefasciatus* larvae.	An increase in the concentration of ethanol-based plant extracts corresponded to enhanced larvicidal effectiveness against the selected mosquito species. The ethanol extract of the medicinal plant exhibited the greatest mortality rates against larvae of *Anopheles stephensi*, *Culex quinquefasciatus* and *Aedes aegypti*.	[113]
Anti-inflammatory activity	Leaves	Alcoholic and hydroalcoholic extract	100, 250 and 500 mg/ kg b. wt/day, orally	Carrageenan-induced paw oedema Wistar rats	Administration of the extract reduced paw edema by 4.54%, 15.28%, and 22.2% during the first hour, and by 10.82%, 16.80%, and 25.4% by the third hour of the experiment, respectively.	[114]
	Leaves	β-sitosterol, stigmasterol and their acetylated derivatives	25mg/ kg b. wt/day, orally	Carrageenan-induced paw oedema Wistar rats	Both β-sitosterol and stigmasterol demonstrated notable inhibition of carrageenan-induced inflammation, with 65% and 67% reduction, respectively, closely matching the 68% inhibition shown by the reference drug. Their derivatives, betasitosteryl acetate and stigmasteryl acetate, exhibited slightly lower anti-inflammatory effects at 61% and 62%, respectively. These findings suggest that the phytosterols and their derivatives from *T. procumbens* leaves hold potential as promising candidates for the development of anti-inflammatory therapeutics.	[115]
	Aerial parts	Aqueous extract	20, 40, 60, 80 and 100 µg/ml	*In-vitro (*HRBC membrane stabilization activity)	The inhibition rate varied between 60% and 93% across concentrations ranging from 20 to 100 µg/mL. The plant extract exhibited a dose-dependent effect in stabilizing the HRBC membrane. In comparison, the standard compound showed 65% inhibition. The extract demonstrated greater effectiveness in preventing heat-induced hemolysis than the standard. These findings highlight the plant extract's strong anti-inflammatory potential, likely attributed to the presence of phytochemicals such as flavonoids and phenolics.	[116]
	Leaves	Ethanolic extract	0, 50 and 100 mg/ kg b. wt/day, intraperitoneally (i.p.) for 5 days	Carrageenan induced mice	A marked reduction in paw swelling ($P \leq 0.01$) and improved tissue architecture were observed in the treatment groups within 24 hours, as compared to the untreated controls. RT-PCR analysis revealed a statistically significant ($P \leq 0.01$) downregulation in the expression of TNF-α and COX2, as evidenced by decreased band intensity in treated mice. Furthermore, qPCR results indicated a dose-dependent decline in relative quantification (RQ) values for TNF-α (18.985 ± 0.230, 12.140 ± 1.121, and 6.718 ± 0.807) and COX2 (15.583 ± 1.043, 7.725 ± 1.013, and 5.075 ± 0.615) across the three dosage levels, when compared to the control group, which showed higher expression levels (TNF-α: 27.107 ± 2.254; COX2: 20.626 ± 1.477).	[117]
	Aerial parts	Aqueous extract	20, 40, 60, 80, and 100 g/ml	*In-vitro* (protein denaturation inhibition, HRBC membrane stabilization and proteinase inhibitory	The results revealed that the aqueous extract of *T. procumbens* leaves, at a concentration of 100 µg/mL, achieved an 88.9% inhibition rate. Other tested concentrations—80 µg/mL (77.8%), 60 µg/mL (77.6%), 40 µg/mL (55.45%), and 20 µg/mL (44.6%)—also demonstrated notable anti-inflammatory effects. In contrast, the standard drug aspirin showed only 35% inhibition. Compared to aspirin, the plant extract exhibited a significantly stronger anti-inflammatory response. These findings suggest that *T. procumbens* may play a role in modulating autoantigen activity and	[118]

				activities)	protecting proteins from denaturation during inflammation.	
	Leaves	Ethanolic extract	200 and 400 mg/ kg b.wt/day, vocally for 7 days	Irish Moss-triggered inflammation in Wistar rats	At a dosage of 400 mg/kg, a notable reduction in inflammation was observed—48% after 3 hours, which further increased to 52% over time. The anti-inflammatory performance of the extract was considerable and closely aligned with that of the standard drug indomethacin (10 mg/kg). Treatment with *T. procumbens* at 200 mg/kg and 400 mg/kg led to significant decreases in granuloma mass, measuring 38.16 ± 0.04 g (7.4% inhibition) and 34.58 ± 0.04 g (16.1% inhibition), respectively. Although the 400 mg/kg dose reduced granuloma formation effectively, its impact was slightly less than that of the conventional anti-inflammatory agent dexamethasone, which showed a granuloma weight of 28.92 ± 0.04 g (29.8% inhibition).	[119]
	Leaves	Ethanolic and aqueous extract	1mg/ml and 2mg/ml	*In-vitro*	All tested samples demonstrated notable anti-inflammatory effects when compared to the standard drug, diclofenac sodium. Among them, the aqueous extract of *Tridax procumbens* exhibited stronger anti-inflammatory activity than the alcoholic extract. Phytochemical analysis revealed the presence of flavonoids in *T. procumbens*, which are likely contributors to its anti-inflammatory action—potentially through the inhibition of interleukins (IL) and tumor necrosis factor-alpha (TNF-α).	[120]
	Whole plant	Methanolic extract	150 and 300mg/kg b.wt/day, through oral gavage for 21 days.	STZ-induced diabetic Wistar rats	Administration of the extract markedly ($p < 0.001$) normalized the activity of inflammatory markers i.e., COX-2 and NF-κB back to baseline levels. Notably, the concentrations of NOx and NF-κB in rats treated with the extract were significantly ($p < 0.05$) reduced compared to those in the normal control group.	[45]
	Leaf	*T. procumbens* chitosan (TPC) gel	10, 20, 30, 40, and 50 µL	*In-vitro* [Bovine serum albumin (BSA) denaturation assay, Egg albumin (EA) denaturation assay]	The TPC gel exhibited a more potent anti-inflammatory effect than the standard drug in both tests, reflected by higher inhibition percentages at all tested concentrations. The gel's inhibitory activity progressively increased with concentration, approaching nearly 100% inhibition at 50 µL. Results from both assays indicate that raising the gel concentration enhances its anti-inflammatory effect, demonstrating a clear dose-dependent relationship.	[121]
	Leaves	Hydroalcoholic Extract	200,400,600, 800 and 1000µg/ml	*In-vitro* (Membrane Stabilization Method and Albumin Denaturation Method)	The hydroalcoholic extract of *T. procumbens* showed the highest stabilization percentage of 74.39±3.25% at 1000 µg/mL, while the lowest protection of 24.53±2.45% was observed at 200 µg/mL. Compared to the reference drug diclofenac sodium, the extract displayed notable anti-inflammatory activity. Additionally, the extract exhibited significant in vitro anti-inflammatory effects by inhibiting protein denaturation, with maximum inhibition of 63.39±1.38% at 1000 µg/mL and the minimum inhibition of 30.15±1.12% at 200 µg/mL.	[122]
Cardioprotective activity	Leaves	Aqueous extract	3, 6 and 9mg/kg b. wt/day, intravenously	Anaesthetized Sprague-Dawley rats	Administration of the extract led to a significant, dose-dependent decline in mean arterial blood pressure, with larger doses producing a more pronounced decrease than smaller ones. Additionally, the higher doses of 6 mg/kg and 9 mg/kg significantly lowered heart rate, whereas the 3 mg/kg dose showed no notable effect on heart rate. Both the bradycardiac and hypotensive effects occurred rapidly. These findings support the notion that *T. procumbens* leaves possess antihypertensive properties, likely mediated through stimulation of muscarinic cholinergic receptors.	[123]
	Leaves	Ethanolic extract	100, 200 and 300mg/kg b. wt/day, orally for 15 days	Isoproterenol induced myocardial infarction in albino rats	The ethanolic extract demonstrated a notable cardioprotective effect by decreasing biochemical markers such as enzymes (ALT, ACP, AST, and ALP), lipid components (total cholesterol, free fatty acids, triglycerides, and phospholipids), and lipoproteins including LDL and VLDL in a dose-dependent manner. Additionally, treatment with *T. procumbens* significantly improved antioxidant levels, including SOD, glutathione peroxidase, catalase, and glutathione reductase, as the concentration increased.	[124]
	Leaves	Aqueous extract	50, 75 and 100 mg/kg b. wt/day, orally for 14 days	Doxorubicin-induced cardiotoxicity in Wistar rats	The plasma levels of creatine kinase, AST, and lactate dehydrogenase were significantly ($p < 0.05$) elevated in the test control group compared to the treated groups. Similarly, concentrations of cardiac malondialdehyde, sodium, cholesterol, calcium, chloride, and triglycerides	[125]

					were markedly higher ($p < 0.05$) in the test control than in the treated animals. Conversely, the heart tissue levels of reduced glutathione, ascorbic acid, magnesium, and potassium, along with the activities of glutathione peroxidase, superoxide dismutase, catalase, Ca^{2+}-ATPase, Mg^{2+}-ATPase, Na^{+},K^{+}-ATPase, creatine kinase, and lactate dehydrogenase, were significantly ($p < 0.05$) reduced in the test control group compared to those receiving treatment. These findings indicate that pre-treatment with the extracts and metformin provided cardioprotection by mitigating doxorubicin-induced oxidative damage, normalizing plasma cardiac biomarkers, lipid and electrolyte imbalances, and enhancing the function of cardiac ATPases and key enzymes such as creatine kinase and lactate dehydrogenase.	
Wound-healing activity	Whole plant	Aqueous and ethanolic extracts	200 mg/kg, topically on wounded site for 15 days	Adult Wistar rats	On the 15th day, biochemical analysis of excised tissue revealed elevated levels of tissue markers such as collagen, hydroxyproline, and hexosamine in the groups treated with the plant extract. A statistically significant decrease in wound size was observed in the treated groups compared to the untreated control group ($P<0.05$). Histological examination further confirmed enhanced granulation tissue formation and accelerated collagen turnover in the treated samples.	[126]
	Leaves	Ethanolic extract ointment	80 and 100 mg/gm, on dermal wound for 15 days	Swiss male albino mice	The ointment formulated with the ethanolic extract of *T. procumbens* demonstrated notable wound healing properties and effectively promoted wound closure, particularly at a concentration of 100 mg/g. However, the standard Betadine exhibited a greater degree of wound contraction at the same concentration when compared to the test formulation.	[127]
	Aerial parts	Hydro-methanolic extract based gel	2 and 5mg/kg b. wt/day, on wound for 12 days	ALX-induced immune Compromised mice	Wound contraction was initiated by day 3 across all experimental groups. However, the pace of healing became more pronounced in the standard and extract-treated groups during the later stages compared to the control and vehicle-treated animals. By day 6, a significant increase in wound closure was evident in all treatment groups relative to the controls and vehicle group. On the 12th day following injury, the standard treatment group achieved 82.97% wound healing, while the gel-treated groups at doses of 5 mg/kg and 2 mg/kg showed 86.95% and 72.15% healing, respectively. In contrast, the non-treated controls showed markedly lower healing percentages: 49.73% in the non-diabetic group, 43.54% in diabetic animals, and 46.72% in the vehicle group.	[128]
	Leaves	Hydro-alcoholic extract-based ointment	80, 100mg/gm, topical application	Swiss male albino mice	Application of the ointment to excision wounds in mice resulted in a markedly accelerated healing process and achieved superior wound closure compared to the base formulation without the extract. These findings highlight the promising potential of the plant for further investigation in the treatment of skin-related conditions.	[129]
	Leaves	Tridax Hydroxyapatite nanoparticles TP(HAP)	10, 20, 30, 40, and 50 µL, for 12 days	Adult zebrafish	The zebrafish model demonstrated wound recovery through fin regeneration observed on days 6 and 12. Histological analysis of the untreated wounded group showed a normal epithelial layer, with caudal fin regrowth measuring 3 mm on day 6 and 6 mm by day 12. Treatment with *T. procumbens* notably accelerated the repair process by promoting faster epithelial restoration. The significant wound healing efficacy of the herbal preparation is likely due to the presence of bioactive phytochemicals that contribute to wound healing.	[130]
	Leaves	Ethanolic extract based ointment	2.5% and 5% w/w, topically for 16 days	STZ-induced diabetic Wistar rats	In the excision wound model, animals receiving 2.5% and 5% w/w ointment exhibited marked improvements in wound contraction, epithelialization time, and wound healing score. Levels of hydroxyproline, total protein, and DNA content in the regenerating tissue were elevated in both diabetic and non-diabetic groups when compared to the control and even the standard treatment. All assessed parameters showed a notable therapeutic effect at both dosages. The observed wound healing activity is likely attributed to the presence of flavonoids and tannins, which play a key role in the wound repair.	[131]
	Whole plant	Tridax Ash (Bhasma), Tridax Paste (Kalka), Tridax Oil	Ash (Bhasma)– Dusting locally, Paste (Kalka)– Painting Locally,	Albino Wistar rats	Different preparation of Tridax had shown different pattern of activity in initial, intermediate and late phase of wound healing. Such as Ash and Kalka has shown rapid wound contraction in initial stage whereas oil failed to contract wound. On contrary Oil caused to dilate the	[73]

		(Taila), Tridax aqueous extract (Ghana), Tridax Ethanolic Extract	Oil–Local application, Aqueous extract (Ghana)–1gm/ml solution local application, ethanolic extract–50mg/ml solution local application		wound area in some cases in initial stage. Ethanolic extract of Tridax promoted wound contraction in intermediate stage of wound healing whereas it delayed the last stage of tissue repair. This typical behavior may be due to the phytochemical contents of Tridax in that particular dosage form, may be due to physical nature of dosage forms such as absorbent nature of Ash, the drying and contracting nature of Kalka, and the moisture-retaining effect of the oil or it may be due to the combined action of phytochemicals, vehicles and physical nature of the dosage form.	
	Leaves	Leaf extract loaded PVA film	50, 25 ml, and 12.5 ml	*In-vitro* (L929 mouse fibroblast cell)	The findings revealed that films formulated with 12.5 ml of dried *T. procumbens* leaf extract effectively minimized the scratch area, achieving approximately 94% closure within 24 hours, with no signs of cytotoxicity. Among the tested concentrations, the 12.5 ml extract-based film outperformed the 25 ml and 50 ml formulations in both fresh and dried extract-incorporated films in terms of wound healing efficiency. Enhanced viability and motility of L929 mouse fibroblast cells further support the film's promising potential for use in wound care applications.	[132]
	Leaves	Ethanolic extract based herbal gel	-	Adult Wistar rats	The study demonstrated that films containing 12.5 ml of dried *T. procumbens* leaf extract significantly reduced the scratch wound area, achieving nearly 94% closure within 24 hours, without exhibiting cytotoxic effects. This concentration (12.5 ml) showed superior healing efficacy compared to films incorporating 25 ml and 50 ml of the extract, whether from fresh or dried extract. Additionally, the increased proliferation and migration of L929 mouse fibroblast cells suggest that the developed film holds strong potential for wound healing applications.	[133]
Analgesic activity	Leaves	Ethanolic and ethyl acetate extract	200, 300mg/kg b. wt/day, post oesophagus	Acetic acid and NaCl induced albino rabbits	The leaves of *T. procumbens* demonstrate pain-relieving and fever-reducing properties, as evidenced by a reduction in number of wriths induced by acetic acid and sodium chloride, as well as a decrease in elevated body temperature in rabbits. These effects are likely due to the presence of flavonoids and other polyphenolic compounds in the plant extracts. Among the tested extracts, the ethanolic one showed a more pronounced analgesic effect compared to the ethyl acetate extract.	[134]
	Leaves	Aqueous and ethanolic extracts	100,200 and 400 mpk	Male C57 BL6/J mice (25-30g) and male Sprague-Dawley rats	In the formalin-induced pain model, the late phase of sustained discomfort—beginning approximately 20 minutes post-injection and continuing for 40 to 60 minutes—is believed to result from alterations in tissue and spinal cord dorsal horn function. Treatment with the plant extract led to a marked suppression of pain during this phase. Likewise, in the acetic acid-abdominal constriction test, the extract produced a significant, dose-dependent decrease in the number of abdominal writhing. In the CFA-induced hyper-analgesia model, oral administration of the extract notably alleviated mechanical hypersensitivity in rats.	[135]
	Leaves	Leaf juice	50µl of leaf juice, orally	Swiss albino mice (Mus musculus)	The findings from the acetic acid-induced writhing assay revealed a marked reduction in the number of writhes following administration of fresh *T. procumbens* leaf juice. This effect was comparable to that observed with Voveran treatment. These observations suggest that *T. procumbens* possesses potent peripheral analgesic properties, likely by modulating prostaglandin-mediated pain mechanisms.	[136]
	Leaves	Ethanolic extract	200, 400mg/kg b. wt/day	Swiss albino mice	Ethanolic leaf extract of *T. procumbens*, administered at doses of 200 and 400 mg/kg, exhibited significant pain-relieving activity. Its effects were comparable to those of the standard analgesic, hydrocodone. The maximum analgesic response was observed at the 400 mg/kg dose, reaching a peak response time of 120 minutes (7.2 ± 0.44). The tail immersion test in hot water demonstrated a notable delay in pain perception.	[137]
Anti-cancer activity	Leaves	Aqueous extract, and polymeric nanoparticles	100, 200, 300, 400, 500 µg/mL	HeLa cell lines (Cervical cancer cells)	A comparison between the control and *T. procumbens* samples demonstrated notable differences in cell growth inhibition. The cold aqueous extract, at a concentration of 300 µg/mL, achieved the highest inhibition rate of 21.3%. In contrast, the nanoparticle formulation of the same extract exhibited slightly higher inhibition i.e., 22.24% at a significantly lower concentration of 50 µg/mL. These findings indicate that cell growth suppression increased with rising concentrations of both forms. Importantly, the IC50 value was lower for the nanoparticle formulation,	[138]

					suggesting enhanced potency. While approximately 20% inhibition was observed at 300 µg/mL of the crude extract, a comparable effect was achieved using only 50 µg/mL of the nanoparticle formulation. Overall, the results suggest that the polymer-based nanoparticles derived from the cold extract possess superior anticancer efficacy compared to the crude extract.	
	Leaves	Essential oils	18.5-300 µg/ml	Human breast cancer cell line (MCF-7)	The findings indicated that the essential oil exhibited a dose-dependent effect on the MCF-7 cell line. The IC50 was determined to be 96.6 µg/mL. This cytotoxic activity could be attributed to the bioactive terpenoid compounds present in the oil.	[139]
	Leaf, stem and flowers	Small peptides (SPs)	1 to 25µg/ml	Human breast cancer metastatic cell line (MDA MB 231)	Microscopic images revealed noticeable morphological alterations between untreated cells, treated samples, and cells exposed to the highest concentration of 25 µg/mL. Compared to the control group, the treated cells exhibited signs of shrinkage, loss of adherence to the substartum, and cell blabbing. At the 25 µg/mL concentration of leaf-derived SPs, numerous dead cells were observed floating or detached. Among all SP variants tested, the leaf SPs demonstrated the most potent effect, with the lowest IC50 value recorded at 4 µg/mL.	[140]
	Leaves	Methanol (TPM), ethanol (TPE) and chloroform (TPC) extracts	31.25, 62.5, 125, 250 and 500 µg/ml	Breast cancer cell lines-MCF-7 (benign) and MDA-MB-231 (metastatic)	In the initial evaluation of the extracts on the MCF-7 breast cancer cell line, the TPC extract demonstrated notable cytotoxic activity, with an IC50 of 136 ± 2.1 µg/mL ($p < 0.001$), outperforming both the methanol extract (IC50: 190 ± 2.2 µg/mL) and the ethanol extract (IC50: 248 ± 3.2 µg/mL). For the MDA-MB-231 cell line, the TPC extract showed an IC50 of 129.1 ± 2.3 µg/mL ($p < 0.001$), while the standard drug cisplatin (positive control) exhibited a significantly lower IC50 of 0.5 ± 0.13 µg/mL. However, the difference in cytotoxicity of the TPC extract between the two breast cancer cell lines was not statistically significant ($p > 0.05$).	[141]
	Leaves	Chloroform, ethyl acetate, acetone and methanolic extract	500 µg/ml	MCF 7, Hep G2 and K562 cells	The IC50 results indicated that all extracts, with the exception of those derived using acetone and chloroform, displayed minimal cytotoxic effects across the three cell lines tested. Among them, the acetone extract demonstrated the most potent anti-proliferative effect, with IC50 values between 16 and 37 µg/mL for K562 cells over exposure periods ranging from 24 to 72 hours. This extract was found to trigger cell death in both K562 and HepG2 cells in a dose and time dependent fashion, while no significant effect was observed in MCF-7 cells.	[142]
	Leaves	Methanolic extract	50, 100, 150, 200 and 250 mg/ml	Human lung cancer cells-(A549) and breast cancer cell lines-(MCF-7)	The leaf extract exhibited stronger cytotoxic effects against human lung cancer cells compared to the breast cancer cell lines. At a concentration of 250 mg/mL, the extract caused $84 \pm 2.8\%$ cell death in lung cancer cells, whereas the same dose resulted in only $68 \pm 3.1\%$ cytotoxicity in breast cancer cell lines. The cytotoxic activity was found to be concentration-dependent, with increased cell death observed at higher concentrations of extract.	[143]
	Leaves	Acetone and Chloroform Extracts	18.75, 37.5, 75, 150, and 300 µg/mL	Breast Cancer Cell Line MCF-7	The leaf-derived aqueous extract of *T. procumbens* exhibited minimal anticancer activity, causing only 6.6% cell death at a concentration of 250 µg/mL. In contrast, the acetone extract demonstrated strong cytotoxic potential, inducing 93% cell death at the same concentration. The chloroform extract showed significant growth inhibition at higher doses (150–300 µg/mL), reaching up to 99.5% suppression of cell growth. At lower concentrations, the extract exhibited a dose-dependent effect, with 8.14% inhibition at 18.75 µg/mL, 12.9% at 37.5 µg/mL, and 24.7% at 75 µg/mL. The IC50 for the *T. procumbens* leaf extract was determined to be 47.5 µg/mL, with a regression coefficient of 0.974 µg/mL.	[144]
	Leaves	Dichloromethane: methanol extract	10, 20, 40 & 80 (µg/ml)	HaCat (Skin cancer) cell lines	This study revealed that the Tridax extract has significant inhibitory effects on HaCaT (skin cancer) cell lines, as confirmed through both MTT and SRB assays. Analytical techniques like HPTLC and GC-MS identified various bioactive compounds, including butyl ester of hexadecanoic acid, tetradecene, squalene, and cyclic octaatomic sulfur. These constituents are likely to suppress cell growth by elevating intracellular ROS, reducing mitochondrial membrane potential, and triggering apoptosis through oxidative damage to cellular DNA.	[145]
	Leaves	Green synthesized	100, 200, 400, 600, and 800	Human non-small-	The findings indicated a dose-responsive effect, with cytotoxicity increasing alongside rising concentrations.	[146]

		silver nanoparticles (AgNPs), aqueous extract, Biogenic Silver Nanoparticles (TNP)	μg/ml of aqueous extract	lung cancer cell line (A549)	Among the samples tested, TNP exhibited the most potent anticancer effect, with an IC50 of 42.70 µg/mL, significantly outperforming the leaf aqueous extract (IC50: 40,676.7 µg/mL) and AgNPs (IC50: 1,159,668.0 µg/mL). This suggests that TNP has a markedly higher efficacy in suppressing cancer cell growth as compared to the other formulations.	
	Flowers and leaves	Ethanol and hexane extract	6.25 to 200µg/ml	Human breast cancer cell lines (MCF-7 and MDA-MB-231)	The MTT assay confirmed that all tested extracts exerted cytotoxic effects on human breast cancer cell lines MCF-7 and MDA-MB-231, with the hexane extract derived from the flowers of *T. procumbens* (HTPF) demonstrating the most pronounced activity. Additionally, this hexane flower extract significantly suppressed colony formation in MDA-MB-231 cells and exhibited clear apoptotic features, including elevated levels of cleaved caspase-3 and cleaved PARP. Notably, results from the wound healing assay indicated that the hexane flower extract also possesses anti-metastatic properties against breast cancer cells.	[147]
	Whole plant	hydroalcoholic extract	1000, 500, 250, 125, 62.5, 31.25 µg/ml	Colon cancer cells (HT-29)	The extract demonstrated notable anti-proliferative effects on colon cancer cells, with an IC50 of 74.10 µg/mL, while exhibiting minimal toxicity toward normal intestinal epithelial cells (IEC-6). These findings suggest that *T. procumbens* possesses strong anti-cancer potential.	[148]
	Aerial parts	Methanolic extract	12.5, 31.5, 62.5, 125, 250, and 500 µg/mL	MDA-MB-249 and MCF-7 cells	The treated cells displayed a concentration-dependent reduction in viability, with increasing doses (6.25, 12.5, 25.0, and 50 µg/mL) resulting in progressively lower survival rates. The polysaccharide exhibited strong anti-cancer activity, showing a low IC50 of 5.06 µg/mL against MCF-7 cells and 15.68 µg/mL against MDA-MB-231 cells. These findings highlight the significant cytotoxic potential of the polysaccharide, particularly against the MCF-7 breast cancer cell line.	[149]
	Leaves, stems, and flowers	Hexane, chloroform, n-butanol, and methanol	2, 10, 50 and 100 µg/mL	Human cancer cell lines (PC-3, COLO-205, A549, A431, MDA-MB-231, MDA-MB-468, and K562)	Most of the extracts demonstrated inhibitory effects on the growth of human cancer cell lines, with IC50 values ranging between 23.41 and 90.76 µg/mL. Notably, the chloroform fraction from the stem (7) exhibited potent activity against A431 and MDA-MB-231 cells, showing IC50 values of 23.41 µg/mL and 29.45 µg/mL, respectively.	[150]

Abbreviations

ALX; Alloxan, **STZ;** Streptozotocin**, FBG;** Fasting blood glucose **TBARS;** Thiobarbituric Acid Reactive Substances, **ZOI;** Zone of inhibition**, AST;** Aspartate Aminotransferase**, ALT;** Alanine Aminotransferase**, ALP;** Alkaline Phosphatase.

CONCLUSION

The widely recognized medicinal plant *Tridax procumbens* exhibits considerable pharmacological potential, attributed to its diverse array of bioactive compounds. The plant is rich in as flavonoids, alkaloids, tannins, carotenoids, and saponins, which contribute to its broad spectrum of therapeutic effects. Extensive studies have highlighted its beneficial properties in improving reproductive health, regulating lipid metabolism, and demonstrating analgesic, antidiabetic, antioxidant, anti-urothelic, cardioprotective, larvicidal, wound healing, anthelmintic, anti-ulcer, hepatoprotective, antimicrobial, anticancer, anti-inflammatory effects. These findings underscore the medicinal significance of *T. procumbens*, positioning it as a promising candidate for the development of herbal remedies and pharmaceutical interventions. Future research is essential to fully elucidate its mechanisms of action and enhance its clinical applications.

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Conflict of interest

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