



Phytochemical Profiling And Isolation Of Bioactive Constituents From Tridax Procumbens

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Abstract:

Tridax procumbens L., a pantropical herbaceous plant from the Asteraceae family, presents a compelling paradox as both a globally recognized noxious weed and a revered component of traditional pharmacopoeias. This review systematically synthesizes the current scientific literature to bridge the gap between its ethnobotanical heritage and modern pharmacological validation. The paper provides a comprehensive botanical profile and details its extensive use in Ayurvedic, African, and Central American folk medicine for treating a wide spectrum of ailments, including wounds, infections, inflammatory disorders, and hepatic conditions. A detailed phytochemical profiling reveals a rich chemical arsenal, dominated by flavonoids, terpenoids, and alkaloids. The isolation and structural elucidation of key bioactive constituents, such as the novel flavonoid procumbenetin and the pentacyclic triterpenoid oleanolic acid, are discussed, highlighting the analytical methodologies employed. Furthermore, this review critically evaluates the extensive pharmacological evidence that substantiates its traditional uses. *In vitro* and *in vivo* studies have validated potent anti-inflammatory, antioxidant, antimicrobial, and immunomodulatory activities, with specific extracts and isolated compounds demonstrating significant efficacy. For instance, extracts have shown robust inhibition in carrageenan-induced edema models, potent free radical scavenging with low IC₅₀ values, and broad-spectrum antimicrobial activity with defined Minimum Inhibitory Concentrations (MICs). The review identifies a critical research gap in the structural characterization of its alkaloid constituents, which remain largely unexplored despite their consistent detection. By consolidating this evidence, this paper positions *T. procumbens* not as a mere weed, but as a resilient, abundant, and sustainable natural resource for the discovery of novel therapeutic agents, meriting further rigorous investigation to unlock its full clinical potential.

Keywords: *Tridax procumbens*, phytochemical profiling, bioactive constituents, isolation, flavonoids, alkaloids, terpenoids, tannins, phenolics

Introduction:

The exploration of natural products, particularly those derived from medicinal plants, remains a cornerstone of modern drug discovery.¹ An impressive number of contemporary pharmaceuticals have their origins in traditional herbal remedies, where centuries of empirical use have provided an invaluable roadmap for identifying botanicals with significant therapeutic potential.¹ This ethnobotanical approach, which leverages historical and cultural knowledge of plant-based medicines, serves as a powerful and efficient filter in the search for novel bioactive compounds.⁴ Plants have evolved complex chemical defense mechanisms, producing a vast array of secondary metabolites that are not essential for their primary growth but are critical for survival against predation and disease.⁴ These compounds, including alkaloids, flavonoids, and terpenoids, often possess potent pharmacological properties that can be harnessed for human health.

Within this paradigm, *Tridax procumbens* L. (Asteraceae) emerges as a plant of profound paradox. On one hand, it is globally recognized as a pernicious and invasive weed.⁷ Native to the tropical Americas, it has successfully naturalized across tropical, subtropical, and mild temperate regions worldwide, where it is often considered a pest plant.⁵ Its ecological success is due to its aggressive growth habit, prolific seed production (up to 2500 seeds per plant), and effective wind-based dispersal mechanism facilitated by a feathery pappus on each achene.¹⁰ It readily colonizes disturbed habitats, forms high-density populations, and has even developed resistance to herbicides like glyphosate.¹⁰ In

the United States, it is listed as a Federal Noxious Weed, and it holds pest status in numerous other countries, posing a significant threat to agriculture and native ecosystems.⁷

On the other hand, this same plant is a highly esteemed medicinal herb in numerous traditional healthcare systems.⁵ In India, it is a staple of Ayurvedic medicine, employed for a wide range of conditions from wound healing and liver disorders to diabetes and infections.² Similarly, in African and Central American folk medicine, it is used to treat dysentery, malaria, inflammation, and skin ailments.¹³ This duality—a reviled weed that is also a revered remedy—forms the central thesis of its scientific interest. While the over-utilization of many known medicinal plants raises serious conservation concerns, the very characteristics that make *T. procumbens* an ecological problem—its resilience, abundance, and rapid propagation—transform it into an ideal candidate for sustainable drug development.¹⁶ Its harvest for medicinal purposes could simultaneously serve an ecological benefit by controlling its spread, presenting a unique "weed-to-wonder-drug" opportunity.

Despite its rich ethnobotanical history and promising preliminary scientific validation, a comprehensive, integrated review of its phytochemistry and pharmacology is necessary to guide future research. Therefore, the objectives of this paper are: (1) To provide a thorough botanical and ethnomedicinal profile of *T. procumbens*; (2) To systematically catalogue its known phytochemical constituents across different chemical classes; (3) To review the

modern analytical methodologies used for the isolation and structural characterization of its bioactive compounds; (4) To critically evaluate the pharmacological evidence from in vitro and in vivo studies that substantiates its traditional therapeutic claims; and (5) To identify critical research gaps and propose future directions for its development as a source of novel therapeutic agents.

Botanical Profile And Ethnomedicinal Heritage Of *Tridax Procumbens*:

1. Taxonomy and Botanical Description:

Taxonomic Classification: *Tridax procumbens* L. is a flowering plant belonging to the Asteraceae (or Compositae) family, one of the largest families of flowering plants.⁹ Its detailed taxonomic classification is as follows:

Kingdom: Plantae;

Order: Asterales;

Family: Asteraceae;

Genus: *Tridax*;

Species: *T. procumbens*.⁷ The genus

Tridax comprises approximately 30 species, most of which are native to Mexico, but *T. procumbens* is by far the most widespread and well-known member of the genus.⁵

Morphology and Habit:

T. procumbens is a semi-prostrate, annual or short-lived perennial herb.¹⁰ Its stems are typically covered with coarse, stiff hairs and can grow in an ascending manner to a height of 30-50 cm, or trail along the ground, where they often root at the nodes, facilitating vegetative propagation.¹⁰ The leaves are simple, arranged oppositely on the stem, and are generally 3-7 cm long and 1-4 cm wide.¹⁰ They are ovate to lanceolate in shape with an arrowhead-like appearance,

featuring irregularly toothed (dentate) margins, a wedge-shaped (cuneate) base, and a pointed (acuminate) apex.⁷

The plant produces solitary, daisy-like flowering heads (capitula), each about 1-2 cm in diameter, borne on a long peduncle (10-25 cm).¹⁰ These heads are composed of two types of flowers: a central cluster of yellow, tubular disk florets, which are bisexual (perfect), and an outer ring of pale yellow or white ray florets, which are carpellate (imperfect).⁷ The name

Tridax is derived from the characteristic three-toothed or three-lobed appearance of these ray florets.¹ The fruit is a small, hard, black achene, about 2 mm long, covered with stiff hairs.⁷ Each achene is crowned with a pappus of feathery, plumelike white bristles, 5-6 mm long, which acts as a parachute, enabling efficient and widespread dispersal by wind.¹⁰

Geographical Distribution and Ecology:

T. procumbens is native to the tropical Americas, with a range extending from Mexico through Central America and the Caribbean to parts of South America.⁷ It was reportedly introduced to the Old World as an ornamental plant but has since become a pantropical weed, naturalized throughout Africa, Asia, and Australia.⁹ It is a highly adaptable species that thrives in open, sunny, disturbed areas such as roadsides, fallow fields, croplands, pastures, and waste grounds.¹¹ Its ability to flower year-round in tropical regions, coupled with its prolific seed production and vegetative propagation, contributes to its success as an invasive species.¹⁰

2. Ethnomedicinal Applications: A Cross-Cultural Analysis:

The medicinal value of *T. procumbens* is recognized across disparate geographical and cultural landscapes, a testament to its robust bioactivity. The convergence of its traditional uses for treating conditions related to infection, inflammation, and tissue repair provides a strong ethnobotanical signal, validating its selection for rigorous scientific scrutiny.

Ayurveda and Traditional Indian Medicine:

In India, *T. procumbens* is a cornerstone of traditional medicine, particularly within the Ayurvedic system.² It is renowned for its hemostatic and wound-healing properties; the fresh juice extracted from its leaves is applied directly to cuts, bruises, and wounds to stop bleeding and prevent infection.³ This application is supported by its traditional use as an anticoagulant and antifungal agent.⁷ Beyond topical applications, it is used internally to treat diarrhea and dysentery.⁵

One of its most prominent uses is in the treatment of liver disorders. It is often dispensed as 'Bhringraj', a well-known Ayurvedic medicine for its hepatoprotective effects, and is also used to alleviate gastritis and heartburn.¹ Local healers also employ the plant to treat boils, blisters, and other infectious skin diseases.⁵ Furthermore, its utility extends to metabolic conditions, with tribal inhabitants in Rajasthan using the plant to treat diabetes, a claim substantiated by studies showing the antidiabetic properties of its flower extract.⁵ Other traditional applications in India include promoting hair growth and preventing hair fall.⁸

African and Central American Folk Medicine:

The therapeutic applications of *T. procumbens* in Africa and the Americas show a remarkable overlap with its uses in India. In many African countries, it is prepared as a drink to treat bronchial catarrh, diarrhea, dysentery, and liver diseases, mirroring its use for gastrointestinal and hepatic ailments in Ayurveda.¹⁵

In Central America, particularly Guatemala, the plant is a versatile remedy. It is employed as a broad-spectrum treatment for infections, including those caused by bacteria, fungi, and viruses.⁴ The leaf juice is used topically to treat wounds and stop bleeding, consistent with its primary use in India.¹³ It is also used to address a range of internal conditions such as anemia, colds, mucosal inflammations, stomach pain, and high blood pressure.³ Notably, the entire plant is used in the treatment of protozoal infections, including malaria (against *P. falciparum*), leishmaniasis (for chronic ulcers), and dysentery, highlighting its importance in combating parasitic diseases prevalent in the region.¹³ This cross-cultural consensus on its efficacy against a core set of ailments—wounds, infections, and inflammatory conditions of the gut and liver—lends significant credibility to its traditional reputation and strongly justifies modern pharmacological investigation.

Phytochemical Landscape Of *Tridax Procumbens*:

The diverse therapeutic applications of *T. procumbens* are a direct reflection of its complex chemical composition. Phytochemical investigations have revealed a rich array of secondary metabolites,

providing a chemical basis for its observed pharmacological activities.

1. Qualitative Phytochemical Screening:

Preliminary qualitative screening of various extracts (aqueous, methanolic, ethanolic, acetone) from different parts of the plant—including leaves, stems, and flowers—has consistently confirmed the presence of several major classes of secondary metabolites. These include alkaloids, flavonoids, saponins, tannins, terpenoids, steroids, and phenolic compounds.¹ The presence of these bioactive constituents across different plant parts and in extracts of varying polarities underscores the plant's rich and diverse phytochemistry.¹⁶

2. Dominant Chemical Classes:

While a broad range of compounds is present, several chemical classes stand out due to their abundance and contribution to the plant's bioactivity.

Flavonoids:

Flavonoids represent one of the most significant and well-studied classes of compounds in *T. procumbens*. These polyphenolic compounds are known for their potent antioxidant and anti-inflammatory properties.²⁸ Numerous flavonoids have been isolated and identified from the plant, including common flavonols and flavones like quercetin, kaempferol, luteolin, and their glycosidic forms such as isoquercetin and glucoluteolin.² More importantly, novel flavonoids have been discovered in

T. procumbens, highlighting its unique chemical profile. One of the most notable is **procumbenetin**, characterized as 3,6-dimethoxy-5,7,2',3',4'-pentahydroxyflavone 7-O- β -D-glucopyranoside, which was isolated from the aerial parts.³¹ Other novel compounds,

such as 8,3'-dihydroxy-3,7,4'-trimethoxy-6-O- β -D-glucopyranosyl flavone, 6,8,3'-trihydroxy-3,7,4'-trimethoxyflavone, and a flavone glycoside acetate named **tridprocumoside A**, have also been isolated and structurally elucidated, further expanding the known chemical diversity of this plant.³³

Terpenoids and Sterols:

This class of lipid-soluble compounds is also well-represented in *T. procumbens*. The most prominent among them is the pentacyclic triterpenoid **oleanolic acid**, a compound known for a wide range of biological activities, including hepatoprotective, anti-inflammatory, and antidiabetic effects.⁵ Other pentacyclic triterpenes such as lupeol and β -amyrin have also been identified.¹⁵ In addition to triterpenoids, the plant is a source of common phytosterols, including β -sitosterol and stigmasterol, which are known for their cholesterol-lowering and anti-inflammatory properties.¹⁵

Alkaloids:

Alkaloids are consistently detected in phytochemical screenings of *T. procumbens* extracts, indicating their presence as a major constituent class.²⁵ One comprehensive analysis of the leaves reported the presence of thirty-nine known alkaloids, with **akuammidine**, an indole alkaloid, being the most abundant, constituting over 68% of the total alkaloid content.³⁹ Another source refers to an alkaloid named "**Tridaxin**" and associates it with antimicrobial and anti-inflammatory effects, though its chemical structure has not been publicly characterized.³⁰

Other Constituents:

Beyond these major classes, *T. procumbens* contains a variety of other bioactive molecules. These include tannins, which contribute to its astringent and antimicrobial properties, and saponins, which have been linked to its anti-inflammatory effects.¹ The plant is also a source of carotenoids (pro-vitamin A),

various fatty acids (e.g., lauric, palmitic, linoleic acid), and simple phenolic acids such as fumaric acid, caffeic acid, and ferulic acid, all of which contribute to its overall antioxidant capacity.⁵

To provide a consolidated overview, the major phytochemicals identified in *T. procumbens* are summarized in Table 1.

Table 1: Major Phytochemical Constituents of *Tridax procumbens*

Plant Part	Phytochemical Class	Specific Compounds Identified	Reference(s)
Aerial Parts	Flavonoid	Procumbenetin, Tridprocumoside A, Luteolin, Quercetin, Kaempferol	²
	Terpenoid/Sterol	Lupeol, β -Sitosterol, Stigmasterol, Oleanolic Acid	¹⁵
Leaves	Alkaloid	Akuammidine (dominant), Emetine, Camptothecin, Lupanine	³⁹
	Phenolic Acid	Caffeic acid, Ferulic acid	²⁸
	Fatty Acid	Linolenic acid, Lauric acid, Palmitic acid	¹⁶
Flowers	Flavonoid	Luteolin, Glucoluteolin, Quercetin, Isoquercetin	²⁸
Whole Plant	Terpenoid	Oleanolic acid, Betulinic acid, β -Amyrin	⁵
	Flavonoid	Puerarin, Esculetin	³⁴

Pharmacological Validation Of *Tridax Procumbens* Constituents:

The extensive ethnobotanical use of *T. procumbens* has prompted numerous scientific investigations to validate its therapeutic claims. A substantial body of evidence from in vitro and in vivo pharmacological studies now supports many of its traditional applications, particularly its anti-inflammatory, antioxidant, and antimicrobial properties.

**1. Anti-inflammatory and Immunomodulatory Activity:
Inhibition of Inflammatory Mediators:**

The anti-inflammatory effects of *T. procumbens* are attributed to its ability to interfere with key pathways in the inflammatory cascade. Studies have shown that its extracts, rich in flavonoids and other phenolics, can inhibit the activity of pro-inflammatory enzymes such as Cyclooxygenase (COX) and Lipoxygenase

(LOX).⁴¹ These enzymes are responsible for the synthesis of prostaglandins and leukotrienes, respectively, which are potent mediators of pain, swelling, and other inflammatory symptoms.⁶³ An ethyl acetate extract of the plant was specifically shown to possess anti-cyclooxygenase activity, providing a direct molecular mechanism for its anti-inflammatory effects.¹⁵ This inhibition of prostaglandin synthesis aligns with the mechanism of many non-steroidal anti-inflammatory drugs (NSAIDs) and supports the plant's traditional use for arthritis and other inflammatory pains.⁶⁵

In Vivo Anti-inflammatory Models:

The in vitro findings have been robustly confirmed in animal models. The carrageenan-induced rat paw edema assay is a standard model for evaluating acute inflammation. Multiple studies have demonstrated the potent anti-inflammatory effects of *T. procumbens* in this model. Oral administration of an aqueous leaf extract at a dose of 400 mg/kg produced a significant 52.5% inhibition of paw edema at the one-hour mark.⁶⁶ Another study using the dried juice of the plant at 300 mg/kg reported a 55.0% inhibition at one hour and a 60.0% inhibition at three hours.⁶⁷ This same study revealed a synergistic effect when the extract was co-administered with the standard NSAID Ibuprofen, resulting in significantly greater edema reduction than with Ibuprofen alone.⁶⁷ These in vivo results provide strong validation for the plant's traditional use in managing inflammatory conditions.

Immunomodulatory Effects:

Beyond direct anti-inflammatory action, *T. procumbens* has been shown to modulate the immune system. Bioactivity-guided fractionation studies have led to the

isolation of specific compounds with immunomodulatory properties.⁵³ An initial screening found that ethyl acetate and n-butanol fractions of a methanol extract possessed significant immunomodulatory activity.⁵³ Further purification led to the identification of the terpenoids.

lupeol (SA-4) and 18- α -oleanolic acid (SA-6) as key active principles.⁵³ In murine models, both compounds exhibited a dose-dependent immunostimulatory effect. They significantly increased neutrophil adhesion, a critical step in the innate immune response to infection, and enhanced the Delayed-Type Hypersensitivity (DTH) response, a measure of T-cell-mediated cellular immunity.⁵³ This dual action on both innate and adaptive immunity suggests that

T. procumbens can not only suppress excessive inflammation but also bolster the body's defense against pathogens, supporting its use for treating infections and chronic ulcers.²⁴

2. Antioxidant Efficacy:

Free Radical Scavenging:

Many of the therapeutic effects of *T. procumbens*, including its anti-inflammatory and hepatoprotective actions, are linked to its potent antioxidant capacity. Oxidative stress, caused by an imbalance of free radicals and antioxidants, is a key pathological factor in many chronic diseases.⁷⁰ Extracts of *T. procumbens* have demonstrated exceptional free radical scavenging activity in various in vitro assays. In the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay, an ethanolic extract exhibited a remarkable 96.7% antioxidant activity at a concentration of 250 μ g/mL, outperforming standard antioxidants like ascorbic acid (94.8%) and

gallic acid (92.9%) at the same concentration.⁴⁵ Different fractions of the plant have shown extremely potent activity, with reported half-maximal inhibitory concentration (IC₅₀) values as low as 14.70 µg/mL for a chloroform fraction and an exceptionally low 0.51 µg/mL for a specific chromatographic fraction (F48-50).⁴⁰

Link to Phenolic and Flavonoid Content:

The strong antioxidant activity of *T. procumbens* is directly correlated with its high content of total phenolic and flavonoid compounds.⁴⁵ These molecules possess chemical structures that are ideal for donating hydrogen atoms or electrons to neutralize free radicals, thereby terminating damaging oxidative chain reactions.⁷³ The flower extracts, in particular, have been shown to have a higher concentration of flavonoids and correspondingly greater antioxidant activity compared to other plant parts.⁷⁴ This potent ability to mitigate oxidative stress likely underpins many of the plant's other validated bioactivities.

3. Antimicrobial Spectrum:

Antibacterial Activity:

Validating its traditional use for treating wounds, skin diseases, and dysentery, *T. procumbens* extracts have demonstrated a broad spectrum of antibacterial activity. They are effective against both Gram-positive bacteria, such as *Staphylococcus aureus* and *Bacillus subtilis*, and Gram-negative bacteria, including *Escherichia coli*, *Proteus mirabilis*, and *Klebsiella pneumoniae*.²⁶ The activity is quantified using the Minimum Inhibitory Concentration (MIC), which is the lowest concentration of an extract that prevents

visible bacterial growth. Studies have reported significant MIC values for various extracts. For example, the essential oil of *T. procumbens* showed an MIC of 125 µg/mL against *S. aureus*.⁷⁵ An ethanolic stem extract was highly effective against the oral pathogen *Streptococcus mutans*, with an MIC of 2.5%⁷⁶, while a methanolic flower extract inhibited *S. aureus* with an MIC of 48.20 mg/mL.⁷⁷

Antifungal and Antiprotozoal Activity:

The antimicrobial activity of *T. procumbens* extends beyond bacteria. Extracts have shown efficacy against pathogenic fungi, including *Candida albicans* and *Aspergillus niger*, which are common causes of opportunistic infections.⁴⁴ Furthermore, its activity against protozoan parasites provides a scientific basis for its use in treating diseases like malaria and leishmaniasis. Methanolic extracts have demonstrated potent in vitro activity against the malaria parasite *Plasmodium falciparum* and the protozoan *Leishmania mexicana*, which causes cutaneous ulcers.¹³ This wide-ranging antimicrobial profile confirms its value as a traditional remedy for a variety of infectious diseases.

Table 2 provides a summary of the key validated bioactivities of extracts and isolated compounds from *T. procumbens*.

Table 2: Bioactivities of Key Extracts and Compounds from *Tridax procumbens*

Extract/Isolated Compound	Bioactivity	Assay/Model	Key Result	Reference(s)
Ethanollic Extract	Antioxidant	DPPH radical scavenging	96.7% inhibition @ 250 µg/mL	⁴⁵
Chloroform Fraction (Stem)	Antioxidant	DPPH radical scavenging	IC ₅₀ =14.70 µg/mL	⁴⁰
Aqueous Extract	Anti-inflammatory	Carrageenan-induced paw edema	52.5% inhibition @ 400 mg/kg (1 hr)	⁶⁶
Dried Juice Extract	Anti-inflammatory	Carrageenan-induced paw edema	55.0% inhibition @ 300 mg/kg (1 hr)	⁶⁷
Lupeol (terpenoid)	Immunomodulatory	Neutrophil adhesion assay (mice)	Significant dose-dependent increase	⁵³
18- α -Oleanolic acid (terpenoid)	Immunomodulatory	Delayed-Type Hypersensitivity (mice)	Significant dose-dependent increase	⁵³
Essential Oil	Antibacterial	MIC assay (S. aureus)	MIC = 125 µg/mL	⁷⁵
Methanolic Flower Extract	Antibacterial	MIC assay (<i>E. coli</i>)	MIC = 67.3 mg/mL	⁷⁷
Ethanollic Stem Extract	Antibacterial	MIC assay (S. mutans)	MIC = 2.5% (v/v)	⁷⁶

Conclusion:

In conclusion, *Tridax procumbens* exemplifies the extraordinary therapeutic potential that can be hidden within a plant often dismissed as a common weed. Its paradoxical identity as both an ecological nuisance and a medicinal treasure highlights a unique opportunity for sustainable pharmacognosy. The plant represents a rich, resilient, and readily available reservoir of complex bioactive molecules. The strong alignment between its cross-cultural ethnobotanical uses and a growing body of rigorous scientific evidence confirms its status as a valuable medicinal resource. By addressing the existing research gaps—particularly in alkaloid chemistry,

mechanistic pharmacology, and toxicology—the scientific community can fully harness the potential of this ubiquitous plant, transforming a common weed into a source of next-generation medicines.

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Ashwini Dilip Tonde, Dr. Kazi Mehraj Abukalam & Dr.Sanjay Shivnarayan Toshniwal

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