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Review Article

ETHNOMEDICINAL, PHYTOCHEMICAL CONSTITUENTS AND PHARMACOLOGICAL ACTIVITIES OF *TRIDAX PROCUMBENS:* A REVIEW

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ABSTRACT

Tridax procumbens is a plant used majorly in Indian traditional medicine. This is rich in alkaloids, steroids, carotenoids, flavonoids (such as catechins, centaurein and bergenins), fatty acids, phytosterols, tannins and minerals. Concoctions of extracts from *T. procumbens* leaves, stem, flower, and roots are used to treat patients suffering from diabetes, arthritis, inflammatory reactions and even applied to open wounds. The medicinal value of extracts has been evident by *in vitro*/*in vivo* assay of antioxidant, anti-bacterial, anti-inflammatory, anti-microbial, vasorelaxant, anti-leishmanial and mosquitocidal activities. Still, there is derth in the studies on isolation, characterization and evaluation of active principles from the extracts. This current review article gives comprehensive information about the *T. procumbens* taxonomy, morphology, geographical distribution, phytoconstituents and pharmacological activities.

Keywords: *Tridax procumbens*, Antioxidant, Anti-hepatic, Anti-inflammatory, Anti-arthritic, Anti-microbial, Anti-diabetic, Anti-cancer, Anti-hypertensive, Immunomodulatory, Wound healing, Mosquitocidal, Nanoparticles, Waste water treatment.

INTRODUCTION

Tridax procumbens is a widely spread hispid, procumbent herb, usually found as a weed. *T. procumbens* is perennial in nature with flowering-fruiting throughout the year [1-4]. *T. procumbens* is commonly called as 'Jayanti-veda' in Sanskrit, Tikki-kasa/'Ghamra' in Hindi and 'Wild daisy', 'Mexican daisy' and 'Coat buttons' in English based on the appearance of the flower. The scientific name is '*Tridax procumbens*' [3-7]. The generic name is derived from the Greek, meaning 'summer eating', implying that it was a summer vegetable [8].

T. procumbens belongs to the kingdom: Plantae, sub-kingdom: Tracheobionta, division: Magnoliophyta–Dicotyledons, class: Magnoliopsida, sub-class: Asteridae, order: Asterales, family: Asteraceae, genus: Tridax L. and species: procumbens [4].

T. procumbens is widely distributed in India up to 2400 m above sea level [6, 9]. The leaves of the plant are used as raw feed to cattle and food additive by humans as well [6]. The leaves have medicinal value and used to treat catarrh, dysentery and diarrhea. The different leaf extracts are used as antiseptic to treat fresh cuts, wounds, burns and in anemia [10]. It also contains hair growth enhancing ability [11, 12].

Plant morphology and cytology

T. procumbens is a semi prostate, annual, creeper herb with stem ascending to 30-50 cm in height, branched, sparsely hairy and rooted at nodes. Leaves are simple, opposite, serrate or dentate, acute, fleshy, pubescent, exstipulate, lanceolate to ovate in shape with 3-7 cm long, irregularly toothed margin with wedge shaped base, shortly petioled and hairy on both surfaces (fig. 1). The leaves are dorsiventral; epidermis is single layered on both the surfaces and covered with a thick cuticle. Upper epidermis shows single layered, multicellular covering trichome and lower epidermis is single layered, elongated cell and closely arranged [13]. Xylem vessel shows the presence of calcium oxalate crystals. Vascular bundles are concentric in shape. Meristeel consists of single, centrally located collateral vascular bundle surrounded by some parenchymatous cells [13].

Flowers are tubular in nature, yellow in color with hairs having a capitulum inflorescence [4, 13, 14]. This has two types of flowers: ray florets and disc florets with basal placentation [13].

Fig. 1: *Tridax procumbens* plant
Courtesy: tools.sugarresearch.com.au

Fruit is a hard achene covered with stiff hairs and having a feathery, plume-like white pappus at one end, which assists in aerial dispersal [4, 13]. The heads are heterogeneous, having long peduncles which may reach up to a height of 2 ft. The ray florets are female with ligulate corolla, trifid and invariably pale-yellow in color [8] (fig. 2).

T. procumbens seeds germinate at higher temperatures (35/25 and 30/20 °C) in the presence of 58 to 78 % light. These are very sensitive to salt concentration and water stress [15]. The chromosome numbers are 36 (diploid) and 18 (haploid) in gametes [8]. The propagation is through spreading stems and seed production [4].

Fig. 2: *Tridax procumbens* leaf and flower
Courtesy: chalk.richmond.edu

Chemical composition

T. procumbens has high moisture content of 88.30 % in the stem and 90.05 % in leaf. It is rich in protein with 37.44 % dry weight (4.38 % wet weight) in the stem and 34.57 % dry weight (3.44% wet weight) in leaf. The total lipid and carbohydrate content in the stem is 0.85 % dry weight (0.1 % wet weight) and 41.03 % dry weight (4.80 % wet weight) respectively, and that in leaf is 6.03 % dry weight (0.6 % wet weight) and 51.26 % dry weight (5.10 % wet weight) respectively. The crude fiber content is 16.41 % dry weight (1.92 % wet weight) in stem and 6.13 % dry weight (0.61 % wet weight) in leaf. The metabolizable energy per 100 g of *T. procumbens* is about 321.54 Kcal in dry weight (37.62 Kcal in wet weight) for stem and 397.59 Kcal in dry weight (39.56 Kcal in wet weight) for leaf [16].

The plant is rich in minerals such as iron, copper, manganese, sodium and zinc and other trace minerals such as magnesium, phosphorous, potassium, selenium and calcium [16-19]. The aqueous extract contains phytochemicals such as alkaloids, steroids, carotenoids, flavonoids (catechins and flavones), saponins and tannins [7, 16, 19-21]. While organic solvent extraction with ethyl acetate has flavonoids (centaureidin and centaurein) and bergenin [1]. Some of the 2° metabolites present are fatty acid derivatives, sterols, lipid constituents, luteolin, glucoluteolin, quercetin, isoquercetin and fumaric acid [2, 19, 22, 23].

Antioxidant activity

The oxygen free radicals generated from phagocytes activates transcription factor NF-κB inducing the formation of inflammatory cytokines and activation of cyclooxygenase-2 (COX-2). This initiates tissue damage cascade mechanism which needs to be neutralized. *T. procumbens* shows anti-oxidant activity. This was validated by DPPH (2, 2-diphenyl-picrylhydrazyl hydrate) and ABTS [2, 2'-azino-bis (3-ethyl benzothiazoline-6-sulphonic acid)] methods. Chloroform and ethyl acetate fractions of ethanol extract showed maximum activity in DPPH method with IC_{50} values of 37.39 µg/ml. In addition, methanol extract also showed antioxidant activity in DPPH method [1]. Flavonoids and alkaloids of the extracts are mainly responsible for the activity [17].

Hepatoprotective property

The liver is the major detoxifying organ in the body. Liver contains enzymes involved in detoxification mechanism. Any injury to the hepatic cells releases the enzymes into the blood stream. The serum marker enzyme estimation gives the extent and type of hepatocellular damage [24]. *T. procumbens* showed hepatoprotective activity. Lipopolysaccharide and D-galactosamine-induced hepatitis in rat model were significantly decreased by chloroform extract of aerial parts of *T. procumbens* as evident by the decrease in enzyme markers such as aspartate transaminase (AST), alanine transaminase (ALT), lactate dehydrogenase, gamma glutamyl transferase and bilirubin in the serum of the animal model. Thus, the extract ameliorates the hepatocellular injury and initiated parenchymal cell regeneration in the liver [4, 17, 19, 24, 25]. Similar results were also observed with aqueous extract of *T. procumbens* coupled with chloroquine [20].

T. procumbens aqueous, ethanolic and chloroform extracts showed hepatoprotective activity against hepatitis induced by d-Gal N/LPS, carbon tetrachloride, drug (paracetamol) and oxidative stress. The rat model with hepatotoxicity induced by d-Gal N/LPS, showed increased levels of TBARS (thiobarbituric acid reactive substance) leading to decreased concentration of superoxide dismutase (SOD), catalase, glutathione peroxidase (GPX), glutathione-s-transferase (GST), glutathione, vitamin C and vitamin E. The decreased components are non-enzymatic, detoxifying and anti-oxidant defense systems in the body. This imbalance was normalized upon treatment orally with *T. procumbens* chloroform extracts for a period of ten days [17, 26]. This was further confirmed by histopathological studies as shown by the absence of cellular necrosis and inflammatory infiltrate central zone of the perivenular region [24]. Chloroquine-induced hepatotoxicity was neutralized by *T. procumbens* aqueous extract by preserving the structural integrity of hepatocellular membrane. The methanolic extract prevents the bile duct ligation-induced liver fibrosis by reducing hepatotoxicity marker enzymes and maintaining total bilirubin count, direct bilirubin count, hydroxyproline, infiltration of lymphocytes and proliferation of bile duct in a rat model [27]. The hepatoprotective activity may be attributed to saponins and flavonoids present in the extract. In addition, *T. procumbens* extract inhibits enhancement of glycoprotein biosynthesis, stabilization of cell membrane and inhibition of fatty acid accumulation [24].

Anti-inflammatory activity

The aqueous, ethyl acetate, methanol and ethanol extracts showed significant anti-inflammatory activity by inhibiting the actions of inflammatory mediators such as histamine, serotonin, bradykinin and prostaglandins [28, 29]. The identified active components Bergenin, Centaureidin and Centaurein from solvent extracts inhibited COX-1 and COX-2 enzymes. The flavonoid compound 'Quercetin' is responsible for analgesic and anti-inflammatory activity. This might also be responsible for the inhibition of inflammatory pain and anti-allodynic effect on chronic constriction injury (CCI) induced neuropathic pain model [30, 31].

Anti-arthritic activity

Arthritis is an inflammatory disorder involving damage to one or more joints. The ethanolic extract of the *T. procumbens* displayed a significant role in the anti-arthritic activity in Freund's Complete Adjuvant (FCA) induced rat model compared with that of the standard drug, indomethacin. An evaluation was done by an increase in the body weight, RBC count, Hb level and a decrease in ESR level, WBC count, pannus formation and bone destruction. The rheumatoid arthritis is characterized by loss of articular cartilage leading to diminished joint spaces due to severe swelling of soft tissues through a variety of pathological mechanisms and bone resorption which was normalized by the administration of ethanolic extract of the *T. procumbens* confirming the anti-arthritic activity of the extract [32].

Immunomodulatory activity

The ethanolic extract of *T. procumbens* has immunostimulatory property as it enhanced the uptake of particulate matter by phagocytes [33]. This also stimulates a cell-mediated immune response by increasing the number of leukocytes, plasma cells and splenic leukocytes in turn increasing the phagocytic index. The active component 'sesquiterpene lactone', majorly present in the ethanolic extract, is known to induce delayed type hypersensitivity reaction. The extract prevents BSA sensitized anaphylactic reaction by producing IgG antibodies blocking the BSA-IgE interaction, thereby inhibiting mast cell degranulation [4, 19, 25, 33]. This was also observed in *Pseudomonas aeruginosa* infections [34].

Wound healing

The leaf extract is commonly used in Indian traditional medicine and topically applied on open wound to stop bleeding and enhance the healing process. The plant extract showed wound healing activity in a rat model with increased lysyl oxidase and hexosamine levels that are reported to stabilize the collagen fibres by increasing the cross-linking of collagen during the healing process. The extract also

increases mRNA content and protein synthesis of glycosamine glycan (GAGs) content which are the main components of ECMs in the granulation tissue [4, 19, 22, 25, 35-37].

T. procumbens enhances wound healing by interacting with epidermal cells, dermal cells, ECM, soluble proteins and angiogenesis processes co-ordinated by an array of cytokines and growth factors [38]. The ethanolic extract showed significant wound healing activity in gel based formulation [39]. In excision wound healing process, *T. procumbens* extract shows indirect corticotropic effects. This increases the tensile strength of collagen fibers and rate of epithelialization [12, 19, 36, 40]. The leaf extract is also reported to stop bleeding when applied topically [41].

Anticancer activity

The aqueous extract of *T. procumbens* leaves containing essential oils showed anti-metastatic activity on lung cancer development in C57BL/6 (B16 F-10 melanoma cell line) mice evidenced by neutralizing the increase in body weight, WBC and hemoglobin count. The active compounds are α-pinene (C10H16), β-pinene (C10H16), phellandrene (C10H16) and sabinene (C10H16), all belonging to monoterpene family. This is characterized by the increased expression of caspase-3 and p53 as analyzed by Terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL) assay [42].

The acetone extract of flower showed an apoptotic effect within 24 h of treatment [43-46]. Lupeol, a triterpenoid isolated from dried leaves of *T. procumbens* plant, gave positive results for *in vitro* anticancer activity in MTT assay. It showed more than 90% of cytotoxic potential against human lung cancer cell line A-549 by colony formation inhibition assay. The mode of action is through inhibiting COX activity and increasing the DNA fragmentation by activation of endogenous endonucleases causing apoptosis.

Antihypertensive activity

Increased pulse pressure predicts cardiovascular and coronary artery disease, myocardial infarction (MI) and congestive heart failure, which is independent of diastolic blood pressure and systolic blood pressure. Whereas, the high heart rate (tachycardia) is associated with an increased risk of death from cardiovascular and non-cardiovascular causes [47]. The aqueous extract of the *T. procumbens* leaves lowered the mean arterial blood pressure and heart rate in the Sprague–Dawley rat models [25, 48].

Vasorelaxant activity

Smooth muscle contraction is involved in many physiological activities such as blood circulation, organ maintenance and peristalsis of biological tracts. The aqueous extract of *T. procumbens* leaves induced relaxation of isolated aortic rings from rat by decreasing the calcium supply from the extracellular fluid. The extract also neutralized the phenylephrine/high potassium induced smooth muscle contraction by NO synthase pathway (either by increasing endothelial production of NO or premature activation of NO production) [50, 51].

Antimicrobial activity

The extracts of *T. procumbens* showed anti-microbial activity against gram+ve and –ve bacterial strains. The anti-microbial activity of different extracts is as shown in the table. 1. This explains the reason for using the plant in traditional folk medicine to treat dysentery, diarrhea and gastrointestinal disorders of bacterial infections. The active components such as tannins, flavonoids (apigenin, quercetin and kaempferol), ethyl esters (9, 12-octadecadienoic acid ethyl ester, 5 α-cholestane, hexadecanoic acid ethyl ester and 9-octadecenoic acid ethyl ester), unsaturated fatty acids, phenols, saponins and sterols are responsible for antimicrobial activity observed.

Table 1: Antimicrobial activity of different part and extracts of *T. procumbens*

Plant part	Extraction solvent	Microorganism		Reference
Bacteria				
		Gram-positive	**Gram-negative**	
Aerial	n-hexane	-	*Escherichia coli*	2, 25
Flower	n-hexane	*Mycobacterium smegmatis*	*Escherichia coli Klebsiella sp. Salmonella group C Salmonella paratyphi*	2, 25
Aerial	Ethyl acetate	*Mycobacterium smegmatis Staphylococcus aureus*	-	2, 25
Flower	Ethyl acetate	*Bacillus cereus*	*Klebsiella sp.*	2, 25
Leaf	Ethyl acetate	*Staphylococcus aureus Bacillus cereus*	*Klebsiella pneumonia Salmonella typhi Escherichia coli*	52
Flower (Flavonoids)	Ethyl acetate	*S. aureus*	*E. coli P. mirabilis*	53
Stem Flavonoids Root Calli	Ethyl ether, Ethyl acetate	*S. aureus*	-	53, 54
Leaf	Chloroform	*Bacillus subtilis Bacillus faecalis*	*Escherichia coli Pseudomonas aeruginosa*	7
Whole plant	Ethanol Methanol Aqueous	*Staphylococcus aureus*	*Escherchia coli Klebsiella pneumonia Proteus vulgaris Pseudomonas aeruginosa*	25, 55, 56
Fungi				
Flower Flavonoids Stem Root Calli	Ethyl ether, Ethyl acetate	*C. albicans*		53, 54
Aerial	Methanol	*C. albicans Microsporumfulvum Microsporum gypseum Trichophyton mentagrophytes Trichophyton rubrum Trichosporon beigelii*		57

Anti-leishmanial activity

T. procumbens showed significant anti-leishmanial activity against promastigotes of *Leishmania mexicana*, the causative agent of cutaneous leishmaniasis, also known as 'chicleros ulcer' [58, 59]. The active principle was found to be an oxylipin namely (3*S*)-16, 17-Didehydrofalcarinol. This compound also inhibited amastigote, which is an intracellular stage of the protozoa, and the efficiency was increased when used in addition with aqueous extract of *Allium sativum* [59].

Anti-diabetic activity

Extracts of *T. procumbens* (aqueous, methanolic and ethanolic) exhibited anti-diabetic activity. The extracts decreased the alloxan-induced diabetic condition in the Wistar rat animal model by reducing blood glucose level when administered orally for 7 consecutive days [4, 19, 25, 60]. Alloxan causes diabetes by destroying the insulin-producing beta cells of the pancreas. Alloxan is selectively toxic to the beta cells, which induces cell necrosis. The cytotoxic activity of the alloxan is supplemented by the reactive oxygen species and an increase in the cytosolic calcium concentration, leading to the rapid destruction of beta cells [60]. The extracts help in regeneration of pancreatic beta-cells destroyed by alloxan potentiating insulin release and stimulating peripheral glucose utilization or enhancing glycolytic and glycogenic processes by decreasing glycogenolysis and gluconeogenesis [61].

Dihydroxy-olide is an active principle from *T. procumbens* hexane extract responsible for exhibiting the anti-diabetic effect. This causes a reduction in glucose absorption and lowers the postprandial rise in blood glucose level in Type-II diabetes mellitus [62].

Sulphated polysaccharide

Sulfated polysaccharides have been isolated from the leaves of *T. procumbens*. These are responsible for exhibiting antioxidant, anticoagulant, antithrombotic, antiviral and antitumor activities. The presence of high sulfate content (up to 2%) exhibit anticoagulant and antiviral activities [3].

Mosquitocidal

Alpha-Terpinene, α-Terpineol and β-Pinene, being the major chemical constituents in the essential oil extract from the *T. procumbens* plant, significantly showed repellent activity against the malarial fever mosquito *Anopheles stephensi* at 6 % concentration [25, 63].

Toxicity induced by *T. procumbens*

T. procumbens ethyl acetate extract increased the body weight of experimental animal groups. Treatment for 4 w at a concentration of 800 µg/kg body weights increased the weight of the organs such as spleen, liver, lungs and kidney but the heart rate was decreased. In addition, packed cell volume (PCV), lymphocytes and RBC counts were also increased compared to the animal control group. The glucose level and AST enzyme levels decreased, while the ALT, urea, Na^+ and K^+ concentration increased [64].

Ethyl acetate extract, upon administration (50-100 mg/kg body weight), increased the deposition of hemosiderin in various organs. The deposition was observed mainly in the liver with infiltration of inflammatory cells (WBC) and polymorphonuclear leukocytes. The kidney showed mild interstitial hemosiderin deposition and occasional intra-glomeruli bleeding, which increased with increased hemosiderin deposition [64].

In preparation of nanoparticles

T. procumbens leaf extract is used in the preparation of the Ag/Cu_2O nanocomposites. The leaf extract acts as a reducing agent, reducing Ag^+ and Cu^{2+} ions into Ag ° and Cu^+ respectively [65]. The biogenic pure crystalline spherical-shaped silver nanoparticles synthesized from the aqueous extract of *T. procumbens* leaves showed anti-microbial activity, inhibiting gram positive bacteria, gram negative bacteria and fungal strains [21].

Waste water treatment

The activated biocarbon derived from the dry powder of *T. procumbens* leaves are effective in the removal of heavy metal ions [Zn (II) and Cd (II)] from the waste water. The experimental data were in agreement with both Langmuir and Freundlich adsorption isotherm and was much more effective when compared to the standard commercial charcoal extraction method [66]. Similarly, activated carbon from the *T. procumbens* leaves is an efficient bio-adsorbent for removal of hexavalent chromium from synthetic and industrial tannery wastewater [25, 67].

The *T. procumbens* leaves with aluminum ions is used as a biocarbon filter to remove fluoride ions from the water following the ion-exchange process [19, 68]. The *T. procumbens* plant biocarbon is efficient in the removal of mercury (II) ions [69]. The powdered leaves of *T. procumbens* acts as the raw bio-adsorbent which converts Cr (VI) to Cr (III) and removes Cr (III) and Cd (II) from the aqueous solutions [70, 71].

Miscellaneous

A new flavones and flavonoids have been identified and isolated from different parts of the plant like glycoside 5,7,4'-trihydroxy-6,3'-dimethoxy-flavon 5e-O-α-L-rhamnopyranoside from leaves [6], flavonoid procumbenetin from the aerial parts and characterized as 3,6-dimethoxy-5,7,2,'3`,4`-Penta hydroxy flavone 7-*O*-β-D-glucopyranoside [72]. A steroidal saponin is isolated from the ethanolic extract of *T. procumbens* flowers using chloroform and methanol (in 3: 2 ratio) and was identified to be *β*-sitosterol-3-O-*β*-D-xylopyranoside [73]. Many other compounds that are isolated from the ethanolic extract of the aerial parts of *T. procumbens* are two polyacetylenes, 1,2-dihydrodendroarboreol B, dendroarboreol B and dendroarboreol A; an ionone derivative, (3S,5R,6S,7E)-3-tetradecanoate-5,6-epoxy-β-ionone; nine nor isoprenoids, (3S,5R,6S,7E)-5,6-epoxy-3-hydroxy-7-megastigmene-9-one, (6R,7E)-4,7-megastigmadien-3,9-dione, 4-megastigmene-3,9-dione, S-(+)-dehydrovomifoliol, 7,8-dihydro-α-ionol, vomifoliol, byzantionoside B, icariside B_1 and loliolide; one sequiterpene, isopterocarpolone; three diterpenes, phytol, α-tocopherylquinone, and phytene-1,2-diol; four triterpenes, β-amyrin, oleanolic acid, cycloeucalenol, and cycloart-23Z-ene-3β,25-diol; nine steroids, 24-hydroxy-24-vinylcholesterol, exgoster-5α,8α-peroxide, 7-oxositosterol, 7α-hydroxysitosterol, 7β-hydroxysitosterol, 6β-hydroxyenone, and β-daucosterol; one coumarin, (-)-8-methoxyobliquine; three benzenoids, 4-hydroxybenzaldehyde, 2-hydroxybenzaldehyde, and benzyl glucoside; one adenosine, adenosine A; two flavonoid glycosides, quercetagetin-3,6,4`-trimethoxyl-7-*O*-β-D-glucopyranoside and quercetin-3-methoxyl-4-*O*-β-D-glucoside; and a flavonol diglycoside, quercetagetin-3,6,4`-trimethoxy-7-*O*-neohesperidoside [9]. In addition to four known terpenoids–taraxasteryl acetate, β-amyrenone, lupeol and oleanolic acid, a new sulfur containing bis-bithiophene (a dimer) named tri bis bithiophene has been obtained from the soluble hexane part of *T. procumbens* [23].

More compounds have been isolated and characterized as methyl 14-oxooctadecanoate, methyl 14-oxononacosanoate, 3-methyl-nonadecylbenzene, heptacosanyl cyclohexane carboxylate, l(2,2-dimethyl-3-hydroxypropyl)-2-isobutyl phthalate, 12-hydroxy-tetracosan-15-one, 32-methyl-30-oxotetratriacont-31-en-l-ol, 30-methyl-28-oxodotriacont-29-en-l-oic acid, dotria-contanol, β-amyrone, Δ[12]-dehydrolupen-3-one, β-amyrin, lupeol, fucosterol, 9-oxoheptadecane, 10-oxononadecane and sitosterol by spectral data and chemical studies and are the nine known compounds isolated for the first time from the plant. Although 12-dehydrolupen-3-one is reported synthetically, this is the first report of this compound from a natural source [74].

Two water-soluble polysaccharide fractions have been purified from the *T. procumbens* leaves with graded ethanol precipitation followed by milk de lignification namely, WSTP-IA containing L-Ara *f* and D-Gal *p* in ~ 1: 3 molar proportions, and WSTP-IB containing only D-Gal *p* as the major sugar component [75]. Compounds isolated from the *T. procumbens* are listed in the table. 2.

Table 2: Compounds isolated from different part and extracts of *T. procumbens*

Plant part	Isolated compound	Reference
Leaf	glycoside 5,7,4′-trihydroxy-6,3′-dimethoxy-flavon 5e-O-α-L-rhamnopyranoside	6
Aerial part	3,6-dimethoxy-5,7,2`,3`,4`-pentahydroxyflavone 7-*O*-β-D-glucopyranoside (flavonoid procumbenetin)	70
Flowers (ethanolic extract)	*β*-sitosterol-3-O-*β*-D-xylopyranoside (steroidal saponin)	71
Aerial part (ethanolic extract)	1,2-dihydrodendroarboreol B (polyacetylenes), dendroarboreol B (polyacetylenes), dendroarboreol A (polyacetylenes), (3S,5R,6S,7E)-3-tetradecanoate-5,6-epoxy-β-ionone (ionone derivative), (3S,5R,6S,7E)-5,6-epoxy-3-hydroxy-7-megastigmene-9-one (norisoprenoids), (6R,7E)-4,7-megastigmadien-3,9-dione (norisoprenoids), 4-megastigmene-3,9-dione (norisoprenoids), S-(+)-dehydrovomifoliol (norisoprenoids), 7,8-dihydro-α-ionol (norisoprenoids), Vomifoliol (norisoprenoids), byzantionoside B (norisoprenoids), icariside B_1 (norisoprenoids), loliolide (norisoprenoids), isopterocarpolone (sequiterpene), phytol (diterpenes), α-tocopherylquinone (diterpenes), phytene-1,2-diol (diterpenes), β-amyrin (triterpenes), oleanolic acid (triterpenes), cycloeucalenol (triterpenes), cycloart-23Z-ene-3β,25-diol (triterpenes), 24-hydroxy-24-vinylcholesterol (steroids), exgoster-5α,8α-peroxide (steroids), 7-oxositosterol (steroids), 7α-hydroxysitosterol (steroids), 7β-hydroxysitosterol (steroids), 6β-hydroxyenone (steroids), β-daucosterol (steroids), (-)-8-methoxyobliquine (coumarin), 4-hydroxybenzaldehyde (benzenoids), 2-hydroxybenzaldehyde (benzenoids), benzyl glucoside (benzenoids), adenosine (adenosine), quercetagetin-3,6,4`-trimethoxyl-7-*O*-β-D-glucopyranoside (flavonoid glycosides), quercetin-3-methoxyl-4-*O*-β-D-glucoside (flavonoid glycosides) and quercetagetin-3,6,4`-trimethoxy-7-*O*-neohesperidoside (flavonol diglycoside)	9
Whole plant (hexane soluble part)	taraxasteryl acetate (terpenoids), β-amyrenone (terpenoids), lupeol (terpenoids), oleanolic acid (terpenoids) and tridbisbithiophene [sulfur containing bis-bithiophene (a dimer)]	23
Aerial part	12-dehydrolupen-3-one, methyl 14-oxooctadecanoate, methyl 14-oxononacosanoate, 3-methylnonadecylbenzene, heptacosanyl cyclohexane carboxylate, l(2,2-dimethyl-3-hydroxypropyl)-2-isobutyl phthalate, 12-hydroxytetracosan-15-one, 32-methyl-30-oxotetratriacont-31-en-l-ol, 30-methyl-28-oxodotriacont-29-en-l-oic acid, dotriacontanol, β-amyrone, Δ[12]-dehydrolupen-3-one, β-amyrin, lupeol, fucosterol, 9-oxoheptadecane, 10-oxononadecane and sitosterol	72
Leaf (ethanol precipitation followed by milk delignification)	WSTP-IA and WSTP-IB	73

CONCLUSION

T. procumbens is a major medicinal plant used since before recorded history in both organized (Ayurveda, Unani) and unorganized (folks, tribal, indigenous) traditional medicine practices. The Recent technological invention in identifying, isolating and validating active principles from medicinal plants has gained importance as these may provide an excellent source of lead molecules for the treatment of various disease conditions. In this context, *T. procumbens* appears to be a very promising medicinal plant containing many active molecules evident by its vast medicinal and pharmacological properties. This review provides comprehensive information about the therapeutic, toxicological and clinical value of *T. procumbens*. Though studies have identified the clinical potential of different parts of the plants, there still needs a scientific basis for the medicinal use of this plant.

CONFLICT OF INTERESTS

Declared none

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