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Review Article

Traditional Uses and Pharmacology of Plant *Tridax procumbens*: A Review

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ABSTRACT

From the time immemorial plants have been a rich source of inspiration for novel drug compounds and have highly contributed in the treatment of various ailments. *Tridax procumbens* is an annual or perennial herb, mostly found as a weed of cultivation, grown on waste ground, or as an invader of bare soil used majorly in Indian traditional medicine. The great variety of secondary metabolites present in the plant are tannins, alkaloids, saponins, flavonoids, phenols steroids, anthocyanins, proteins, amino acids and carbohydrates have been a great source of important pharmaceutical compounds. This present study aims to document the scientific literature regarding the medicinal properties, bioactive constituents and pharmacological importance of the plant *T. procumbens*, of the Asteraceae family. The various scientific literatures have been collected from different scientific search engines like PubMed, Elsevier, Google Scholar, Science Direct and Research gate for all the relevant date regarding the pharmacological activities of *Tridax procumbens*. The CABI, Invasive Species Compendium database was used to provide the scientific names, subspecies of plants. This species has a vast diversity of traditional use by different communities. Amongst the biological activities of various phytochemicals present in the plant, acting as free radical scavenger, actions against inflammation, allergies, platelet aggregation, microbes, tumours, hepatotoxins. Antibacterial, anti-inflammatory, anti-oxidant, anti-diabetic and hypotensive activities have been documented. This review shows the importance of more studies to understand the potential of *T. procumbens* secondary metabolites for medicinal or preventive treatment, making it a propitious ethnobotanical resource. This review can also be useful for providing important information of this species and indicates that this species could be an effective, safe and affordable treatment for some ailments, especially in tropical areas where this plant is native and abundantly available.

Keywords: *Tridax procumbens*, Phytochemicals, Secondary metabolites, Anthocyanin's, Hepatotoxic, Perennial

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INTRODUCTION

Nature has inspired human beings since time immemorial and every member of human race, irrespective of origin and religion, keeps nature at an esteemed place. The nature has also bounteously given us a rich repository of medicinal plants for thousands of years and an impressive number of modern drugs have been already isolated from these natural resources particularly of plant origin. According to the World Health Organization (WHO), almost 65% of the world's population have incorporated herbal medicines into their primary modality of health care (Farnsworth NR, *et al*., 1985). Herbal treatment or folklore medicines are widely used for the treatment of many diseases in both developed and developing countries. But with the passage of time and advancement in the field of technology and development, synthetic medicines have started replacing natural medicines irrespective of the fact that former have certain side effects as well. According to the reports about 8% of hospital admissions in the United States of America are due to adverse side effects of synthetic drugs and about 100,000 people each year die due to these toxicities (Karimi A, *et al*., 2015).

Herbal medicines usually act gently to support or uplift the body systems and processes that have become deficient or attempt to help remove excesses that have become preeminent. They usually tend to have several broad complementary or synergistic actions on physiological systems, which are usually in the same general therapeutic direction. Therefore instead of using synthetic drugs for the cure of any disease, natural drugs which can reduce the side effect, toxicities of synthetic counterparts and also maximize therapeutic potential with effective and dynamic healing effects should be used. Even it is documented that most of the world's population has taken plant derived drug for their primary health care need.

Tridax procumbens L. also known as "coat buttons" is a perennial plant from the Asteraceae family originated in Central America but now can be found throughout the tropics and subtropics. It is a highly valuable plant with maximum number of pharmacological activity and is one of the essential ingredients in the most of the compound preparations of Ayurvedic literature (Kethamakka SR and Deogade MS, 2014). Traditionally, it is used for the treatment of bronchial catarrh dysentery, malaria, high blood pressure and to check haemorrhage from cuts, bruises and wounds (Udupa SL, *et al*., 1991) staunching bleeding backache and treatment of diarrhoea. Extracts of this weed are also reported to inhibit the growth of *Culex quinquefasciatus* larvae and to prevent falling of hair. It possesses anti diabetic (Bhagwat DA, *et al*., 2008), anti-bacterial (Pai C, *et al*., 2011), anti-plasmodial (Appiah-Opong R, *et al*., 2011), anti-hepatotoxic, anti-oxidant (Hemalatha R, 2008) and antimicrobial (Mundada S and Shivhare R, 2010) properties. This review is attempted to present a systematic correlation between ethno pharmacological relevance and scientific evidence to provide proof of the importance of the plant to indigenous people as well as pharmaceutical industries. Furthermore, the information for its taxonomy, chemical constituents, and cultural practices by people with specific approaches for better conservation has also been included.

LITERATURE REVIEW

Distribution

T. procumbens mainly originated in Central America but now can be found throughout the tropical and subtropical areas of the world growing with annual crops, along roadsides, pastures, fallow land, dikes, railroads, riverbanks, meadows, dunes and waste

areas. It was introduced in Nigeria as an ornamental plant but later it has spread to other tropical countries. It is classified as a noxious weed in Alabama, Florida, Minnesota, North and South California and Vermont. In Guatemala *T. procumbens* is a weed that grows over a wide range and can be found in both dry and damp soil (Poll E, 2003).

Taxonomy

Tridax procumbens belongs to the Domain of Eukaryota, kingdom: Plantae, sub-kingdom: Tracheobionta, Phylum: Spermatophyta, Subphylum: Angiospermae, Class: Dicotyledons, Sub-class: Asteridae, Order: Asterales, Family of Asteraceae or compositae. Genus: *Tridax* and Species: *Tridax procumbens*. The other species of this genus include *T. balbisioides* and *T. trilobata*. The plant is known to possess remarkable medicinal properties. The name *Tridax* refers to the three lobes of the ray flowers while procumbens refers to the prostrate, trailing habit of the stems.

Botany

It is a perennial herb with a firm taproot. The species has a diploid number 36 (Raghavan TS and Vinkatasubban KR, 1941). It has herbaceous, semi-prostrate habit, and can grow anywhere from 15-40 cm in height. The branches are ascending from a creeping base, cylindrical stem, often purplish, sparsely and patently long- and white-pubescent. The leaves are elongated, opposite, ovate with serrated margins, hirsute on the abaxial and adaxial sides (Powell AM, 1965). The inflorescence is a capitulum with three-toothed white ligulate female 5-6 ray florets and yellow disc inner flowers, tubular and bisexual; the seedling hypocotyl is 1-7 mm long. The two cotyledons are glandular-hairy, green or purplish and have petioles 2-5 mm long. The first two true leaves are glandular-hairy with petioles 2-7 mm long and ovate to lanceolate blades 6-14 by 6-7.5 mm. The mid nerve is distinctly prominent on the lower leaf surface. It is usually considered to be as a weed, due to its spreading stems and abundant seed production. Flowering plants of *T. procumbens* are found all round the year in Sri Lanka but shorter flowering periods are observed in West Africa. In East Africa, flowering occurs 35 to 55 days after emergence, and seeds ripen within 3 weeks of flowering. *T. procumbens* can be both cross- or self-pollinated. Insect pollinators of *Tridax procumbens* can be thrips, beetles, bees (Ananthakrishnan TN, *et al*., 1981) and butterflies. Single plants can produce 500 to 2500 seeds *(Table 1)*.

Table 1: Common names of *Tridax procumbens* throughout the world

Country/region	Common names	References
Chinese	Kotobukigiku	
English	Coat buttons, *tridax* daisy	(Chauhan BS and Johnson DE, 2008; Ravikumar V, *et al*., 2005; Bhagwat DA, *et al*., 2008)
French	Herbe cailli	
Latin	*Tridax procumbens* Linn.	
Kannada	Jayanthi	
Spanish	Cadillo chisaca	
Sanskrit	Kumminnippacha	
Telugu	Gaddi chemanthi	
Tamil	Thata poodu	
Assamese	Bikhalyakarani	
Hindi	Ghamra	
Bengali	Tridhara	
Oriya	Bishalya karani	
Malayalam	Chiravanak	
Marathi	Kambarmodi, jakhamjudi and tantani	
Gujarati	Ghaburi	(Saxena VK and Albert S, 2005)
Japanese	Kotobukigiku	
Thai	Tīn túkkæ	
Nigeria	Igbalobe, muwagun, muriyam pachila, jayanti, vettukkaaya-thala	(Sureshkumar J, *et al*., 2017)
United States	*Tridax* daisy	
Guatemala	Bull grass, bull's herb	(Gamboa-Leon R, *et al*., 2014)

Common folk medicinal practices of the plant

Long before the existence of medical facilities, plant extracts were being used for human well-being to prevent themselves from various chronic and infectious diseases (Diallo D, *et al*., 1999). The plant *Tridax procumbens* had its paradoxical use against malaria, hemorrhage, diarrhea, stomach ache, parasitic infection, liver disorder and inflammation. The tribal inhabitants of Udaipur district in Rajasthan (India) used the leaf powder (along with other herb) orally to treat diabetes. It is also used as potent anti-bacterial, anti-fungal and anti-trypanosomal agent (Cáceres A, *et al*., 1998) used in aquaculture as a fish growth enhancer (Adeshina I, *et al*., 2021) aqueous leaves extract possess cardiovascular effect and reduces heart rate and blood pressure (Agrawal S, *et al*., 2010) acts as a wound healing agent (Udupa AL, *et al*., 1995) hepatoprotective activity (Ravikumar V, *et al*., 2005). Along with that, the leaf juice of the plant is used as potent antiseptic, insecticidal and parasiticidal agent and is used also to check haemorrhages from cuts, bruises and wounds. The leaf of this plant is also known to be used for bronchial catarrh, dysentery, diarrhoea and to prevent falling of hair and also promotes hair growth. The plant is also found to possess insect repellent activity, hypotensive effect and potent immune-modulating property. In the certain parts of the world, traditional medical practitioners and the native peoples of those areas also use the leaves of this plant as a remedy against conjunctivitis (Nia R, *et al*., 2003). It is also used as bio-adsorbent for chromium (VI), which is one of the highly toxic ions released into the environment through leather processing and chrome plating industries (Mundada S and Shivhare R, 2010). This herb plays an important role in defluoridation of water, where, it serves as an inexpensive way to defluoridate water in regions where the natural level of fluoride mineral is high in ground water (Ingle NA, *et al*., 2014).

Extraction of plants

For therapeutic application plants can be used either directly or indirectly for various purposes. Indirectly, a medicinally active constituent of plant can be extracted using selective solvents through standard procedures to attain the therapeutically important portions and to eliminate unwanted material. The amount of product extracted depends upon time of extraction, temperature, nature of solvent, solvent concentration, polarity and quantity of plant material to be extracted. The different types of solvent that are generally used for extraction include water, acetone, alcohol, chloroform, ether, dichloromethanol and hexane.

Chemical constituents of Tridax procumbens

The goals of using plants as sources of therapeutic agents depends on many forms such as, bioactive compounds that can be isolated for direct use as drugs, or to produce bioactive compounds as pharmacological tools or to use the whole plant or part of it as a herbal remedy (Fabricant DS and Farnsworth NR, 2001). *Tridax procumbens* has high moisture content of 88.30% and 90.05% in the stem and leaf respectively and total ash content is 11.8%. It is rich in crude protein (37.44% in stem and 34.57% in leaves), crude lipid (0.85% in stem and 6.03% in leaves), total carbohydrate content (41.03% in stem and 51.26% in leaf), crude fibre content (16.41% in stem and 6.13% in leaf) and the total metabolizable energy is 321.54 kcal/100 g in stem and 397.59 kcal/100 g in leaves). The plant is a high source of minerals like as iron, copper, manganese, sodium (50.44 mg/kg) and zinc and other trace minerals such as magnesium (3.56 mg/kg), phosphorous, potassium (31.92 mg/kg), selenium (0.20 mg/kg) and calcium (20.96 mg/kg) (Jude CI, *et al*., 2009). The aqueous extract of the plant contains phytochemicals such as alkaloids, steroids, carotenoids, flavonoids (catechins and flavones), saponins and tannins .The organic solvent extraction with ethyl acetate has flavonoids (centaureidin and centaurein) and bergenin. Some of the secondary metabolites present in the plant are fatty acid derivatives, sterols, lipid constituents, luteolin, glucoluteolin, quercetin, isoquercetin and fumaric acid (*Tables 2 and 3*).

Table 2: Phytochemicals present in different parts of *Tridax procumbens*

Extraction	Plant part	Compounds	References
Chloroform extract and Chloroform water extract	Leaves	Steroid, saponin, coumarins, alkaloids, amino acids, diterpenes, phenol and flavonoids, amino acids, phlobatannin	
Acetone-water extract and acetone extract	Leaves	Steroid, tannin, saponin, anthocyanin, coumarins, alkaloids, diterpenes, phenol and flavonoids, , proteins, carbohydrate, antioxidant property	
Methanol extract	Leaves	Alkaloids, tannin, anthocyanins, proteins saponin, steroid, phlobatannin, terpenoids, flavonoids, amino acids, phenols and cardiac glycosides, antibacterial activity, antioxidant properties	(Dhanabalan R, 2008)
Ethanol extract	whole plant	Flavonoid, quercitin, Alkaloids, tannins, flavonoids, saponins, and phenolic compounds	(Petchi RR, *et al*., 2013)
Acetone extracts	Roots, leaves	Antibacterial activity	
Aqueous extract	Leaves	Blood clotting properties	
Petroleum ether and ethanolic extract	Whole plant	Antibacterial activity against *B. faecalis* due to presence of alkaloids, tannins, steroids, purines, carbohydrates, proteins	(Christudas S, *et al*., 2012)
Chloroform extract	Whole plant	Against *B. faecalis* and *E. coli*	(Christudas S, *et al*., 2012)
Aqueous extract	Leaves	DPPH radical scavenging activity (µg/mL)	(Singh P, *et al*., 2017)
Ethanol extract	Leaves	Polyphenol content, flavonoids, antibacterial activity against *Pseudomonas aeruginosa*	(Singh P, *et al*., 2017; Pai C, *et al*., 2011)
Methanol extract fractioned with Dichloromethane (DCM)	Aerial parts of plant	9, 12-octadecadienoic acid ethyl ester (18.04%), 5-cholestane (12.42%), hexadecanoic acid ethyl ester (4.86%) and 9-octadecenoic acid ethyl ester (4.72%). Cholestane glycosides and rhamnosides are known for their potent cytotoxicity against malignant tumor cells	(Policegoudra RS, *et al*., 2014; Liu XT, *et al*., 2008)

Table 3: Pharmacological properties of *Tridax procumbens*

Pharmacological property	Active against	Phytochemicals responsible for the activity	Extraction procedure	Reference
Antifungal activity	*C. albicans*	Phenols, flavonoids, saponins, sterols and fatty acids, puerarin, esculetin, oleanolic acid, betulinic acid, centaurein, bergenin and centaureidin. Bioactive compounds 9, 12-octadecadienoic acid ethyl ester, cholestane, hexadecanoic acid ethyl ester and 9-octadecenoic acid ethyl ester.	Methanol extract, Dilated Cardiomyopathy (DCM) fraction	(Policegoudra RS, *et al*., 2014)
Antioxidant activities	DPPH (1, 1-diphenyl, 2-picryl hydrazyl)	Phenolics, proteins, vitamins, flavonoids, tannins, catechins and pectins	Ethyl acetate and n-Butanol	(Habila JD, *et al*., 2010)
Anti-inflammatory activity	COX-1 and COX-2	Centaurein and bergenin, flavonoids and other polyphenols	Ethyl acetate extract	(Jachak SM, *et al*., 2011)
Antibacterial activity	*Staphylococcus aureus, Klebsiella pneumoniae, Salmonella typhi, Escherichia coli* and *Bacillus cereus*	Alkaloids, flavanoids, glycosides and other aromatic compounds	Methanol and ethyl acetate extracts	
Anti-cancer activity	Potent cytotoxic activity against malignant tumor cells	5α-cholestane, monoterpenes (alpha and beta pinenes)	Crude flower aqueous and acetone extracts,	
Hepatoprotective activity	Reduced levels of aspartate transaminase, alanine transaminase, alkaline phosphatase, lactate dehydrogenase and gamma glutamyl transferase) and bilirubin	Flavonoids, procumbenetin	95% Ethanol extract	(Ravikumar V, *et al*., 2005)
Immunomodulatory activity	Humoral and cell mediated immune system	Triterpenoides and sesquiterpene	*T. procumbens* Ethanol Insoluble Fraction (TPEIF) of the aqueous extract. EFTP (Ethyl Acetate Fraction) and NFTP (N Butanol Fraction)	(Tiwari U, *et al*., 2004)
	Sheep Red Blood Cells (SRBC) induced delayed type hypersensitivity reactions	Flavonoidal fraction and saponin fraction		

Phytochemicals present in Tridax procumbens

The GC-MS analysis of the methanolic and ethanolic extracts of *Tridax procumbens* revealed the presence of four phenolic compounds namely thymol (1.78 and 1.52 mg/g), eugenol (49.64 and 49.88 mg/g), gallic acid (0.34 and 0.52 mg/g) and isobutyl gallate (2.88 and 63.32 mg/g). The result also revealed that the ethanolic extract (166.7 mg/g of gallic acid), has more phenolic content compared to the methanolic extract (54.64 mg/g of gallic acid). The *in vitro* antioxidant activity has also demonstrated that ethanol extracts expressed higher antioxidant activity compared to methanol and aqueous extract (Singh P, *et al*., 2017). Eight secondary metabolites from the aqueous and methanolic leaf extract of *Tridax procumbens* Linn. (Dhanabalan R, 2008) showed the presence of eight phytochemicals such as alkaloids, tannin, saponin, steroid, phlobatannin, terpenoids, flavonoids and cardiac glycosides form the methanolic extract of leaves. *Tridax procumbens* leaves have also been found to contain anthraquinones and anthracene derivatives of rhein, emodol, aloe-emodin, sennosides A and B, 4, 5-dihydroxy-1-hydroxymethylanthrone and 4,5-dihydroxy-2-hydroxymethylanthrone. Amongst other secondary metabolites some compounds such as ellagitannin, naphthalene, phenolic acid, purine, and xanthone are also found. Compounds such as kaempferol glycosides and anthraquinones, have already proven to have antimicrobial properties. The *in vitro* antioxidant activity namely DPPH, total polyphenol content, total flavonol content and reducing power assay were analysed.

Medicinal properties of different extracts of Tridax procumbens *recorded in various literatures*

Antimicrobial activity: The methanolic and ethyl acetate extracts of *Tridax procumbens* were tested against various bacterial species using Disc diffusion and Agar well diffusion methods. The ethyl acetate extracts were more effective than the methanolic extracts in both methods. The ethyl acetate extract showed greater zone of inhibition against *Staphylococcus aureus, Salmonella typhi* and *Bacillus cereus* species, whereas, in the methanolic extract of *Tridax procumbens*, only *Escherichia coli* showed significant zone of inhibition, in disc diffusion method. In agar gel diffusion method, methanolic extract of *Tridax procumbens* showed antimicrobial activity for *Staphylococcus aureus, Klebsiella pneumoniae, Salmonella typhi* and *Escherichia coli* and the ethyl acetate extract showed significant zone of inhibition against *Staphylococcus aureus, Klebsiella pneumoniae, Salmonella typhi, Escherichia coli* and *Bacillus cereus*. *Tridax procumbens* leaf, extracted with ethyl alcohol is found to be most effective as an antimicrobial agent against *Pseudomonas vulgaris.* The ethanolic extract showed very good antibacterial activity against gram negative, non-fermenting multidrug resistant *Pseudomonas* isolated from nosocomial infections may be due to the presence of phytoconstituents such as flavonoids and tannins have several mechanisms of action such as inhibition of DNA gyrase, inhibition of cytoplasmic membrane function, and inhibition of energy metabolism (Pai C, *et al*., 2011). The secondary metabolites have great therapeutic potential and also possess lesser side effects that are often associated with synthetic antimicrobial agents. The zone of inhibition tested for various gram negative organism, was well observed highest in *Vibrio cholerae* and lowest for *Escherichia coli*. The extract of *Tridax procumbens* L. was thus found effective against both Gram-positive and Gram-negative bacteria.

Anti- hepatotoxic or hepatoprotective activity: *T. procumbens* possibly activates muscarinic cholinergic receptors, which protects the liver *via* ef-

ferent vagus nerve. This plant is also used to prepare the drug "Bhringraj"; which is a reputed medicine in Ayurveda for liver disorders. The alcoholic extract of the plant is useful in liver regeneration; which has hepatoprotective action. The plant extract can improve the activity of liver antioxidant defense system, and it can repair the damage caused by free radicals. Rats pre-treated with chloroform insoluble fraction of ethanolic extract of *Tridax procumbens* has reversed the altered parameters like significant increase in the marker enzymes (aspartate transaminase, alanine transaminase, alkaline phosphatase, lactate dehydrogenase and gamma glutamyl transferase) and bilirubin towards normal due to the hepatitis induced by d-Galactosamine/Lipopolysaccharide (dGalN/LPS) (Ravikumar V, *et al*., 2005). The ethanolic extract of *T. procumbens* has demonstrated its hepatoprotective action against CCl_4 and the liver attained its normal appearance, similar to the liver cells of normal rats (Hemalatha R, 2008). The oral administration of varying doses of ethanolic extract of *Tridax procumbens* L. for the period of 7 days have also reversed the altered parameters to normal levels indicating the antioxidative and hepatoprotective efficacy of *Tridax procumbens* L. against paracetamol induced liver injury. Petroleum ether, methanol, and chloroform water extracts from flowers of *Tridax procumbens* showed protection against hepatotoxicity caused by D-galactosamine in male wister albino rats, with the methanolic extract showing the best effect due to high phenolic contents. Aqueous extract of leaves have shown hepatoprotective activity in rats due to active free radical scavenging and antioxidant activity of the extract (Ugonwanjo H, 2008).

Antifungal activity: The antifungal activity of *T. procumbens* may be due to the presence of many bioactive compounds such as, phenols, flavonoids, saponins, sterols and fatty acids. The essential oils obtained from the flowers of *Tridax procumbens* L. were found to be active against the tested fungi (Joshi RK and Badakar V, 2012). Methanol extract fractionated with dichloromethane have produced zones of inhibition ranging from 17 to 25 mm against various fungal strains including *Microsporum fulvum* (MTCC 8478), *Microsporum gypseum* (MTCC 8469), *Trichophyton mentagrophytes* (MTCC 8476), *Trichophyton rubrum* (MTCC 8477) and *Candida albicans* (MTCC 854). Among all other species *C. albicans* was highly susceptible. The anti-dermatophytic activity of the DCM fraction may be attributed to the presence of unsaturated fatty acids, 5-cholestane and different siloxanes (Policegoudra RS, *et al*., 2014) *Tridax procumbens* also possesses antifungal property against three phytopathogenic fungi i.e. *Helminthosporium oryzae, Rhizoctonia solani* and *Pyricularia oryzae.* The flowers also have excellent inhibitory potential against the tested plant pathogen, *Fusarium oxysporum*. Free flavonoids and sterols of *T. procumbens* (flower) have also completely inhibited the spore germination of the fungi (Sharma B, Kumar P, 2009).

Anti-cancerous activity: The *in vitro* anticancer activity of essential oil obtained from the leaves of *T. procumbens* was evaluated for MCF-7 cell line by MTT assay, where the result revealed that the essential oil has significant anticancer activity which may be attributed to the presence of important terpenes like α-pinene and β-pinene. The flower crude aqueous and acetone extract of the plant *Tridax procumbens* was also tested on prostate epithelial cancerous cells PC3 by measuring cell viability by MTT assay. The assay was based on the capacity of mitochondrial enzymes of viable cells to reduce the yellow soluble salt MTT to purple blue insoluble formazan precipitate which was than quantified spectrophotometrically at 570 nm. The results of the analysis revealed anti-cancer activity of the crude flower extract.

Antidiabetic activity: Alpha amylase and alpha glucosidase are responsible for the hydrolysis of poly and oligosaccharides into monomers or cleavage of bonds between sugars and non-carbohydrate aglycone. These enzymes are involved in the digestion of carbohydrate into glucose or processing of the oligosaccharide moieties of glycoprotein. The methanolic extract of *Tridax procumbens* has the potential to reduce postprandial glucose levels *via* α-amylase inhibitory action. The retardation of membrane bound α-amylase inhibitory reaction or inhibition of passive glucose transport can flatten the postprandial blood glucose excursions or reduce hyperglycaemia. The alpha amylase activity of the methanolic extract of *Tridax procumbens* may be due to the presence of Quercetin. The administration of aqueous and alcoholic extracts from the leaves of *Tridax procumbens* (200 mg/kg) orally for 7 days produced a significant decrease in the blood glucose level in the alloxan-induced diabetic rat model (Bhagwat DA, *et al*., 2008). The ethanolic extract of the whole plant of *T. procumbens* also showed significant anti-diabetic and anti-hyperlipidemic activities against streptozotocin-induced diabetes in rats. Administration of ethanolic extract of the whole plant of *T. procumbens* to diabetic rats also resulted in an increase in their body weight. Flavonoids present in the plant regenerates the damaged beta cells of pancreases, and the polyphenolic compounds and saponin inhibits glucose transport by inhibiting sodium glucose co-transporter-1 (S-GLUT-1) in intestine (Petchi RR, *et al*., 2013). The methanolic extract of *T. procumbens* has shown better results than the strandard drug Glibenclamide, against alloxan-induced diabetic male albino rats. The plant extracts were given to rats in 250 or 500 mg/kg doses, while the Glibenclamide was given at a 10 mg/kg dose. The results showed that both doses of the plant extract lowered the blood glucose levels in the rats better than the conventional drug after 6 hours of treatment. The plants extracts also improved the fasting blood glucose levels of the alloxan-induced diabetic rats (Pareek H, *et al*., 2009).

Repellency Activity: Essential oils extracted from leaves of *Tridax procumbens* Linn. by steam distillation after examination for its topical repellency effects against malarial parasite *Anopheles stephensi* in mosquito cages at three different concentrations (2%, 4% and 6%), exhibited relatively high repellency effect (>300 minutes at 6% concentration) (Rajkumar S and Jebanesan AJ, 2007). The water and ethanol decoctions also reported to have anti-plasmodial properties against chloroquine-resistant *Plasmodium falciparum* (Ghosh P, *et al*., 2019).

Anti-urolithiatic activity: Renal calculi formation is one of the common urological disorders. Hyperoxaluria and hypercalciuria are the major risk factors for renal stone formation. Ethanolic extract of *T. procumbens* was evaluated against 0.75% v/v ethylene glycol and 2% w/v ammonium chloride induced calcium oxalate urolithiasis and hyperoxaluria induced oxidative stress in male albino rats. Treatment with the extract reduced calculogenesis and renal deposition of calcium and oxalate and resultant lipid peroxidation, indicating its antiurolithiatic and antioxidant effects. Thus *T. procumbens* has proven its efficacy to be useful in the treatment of renal stone disease.

Wound healing activity: The whole Plant Extract (WPE) of *Tridax procumbens* demonstrated greatest pro-healing activity as evidenced by the increase in tensile strength and lysyl oxidase activity after being studied on a dead space wound in albino rat. Granuloma tissue harvested from 10 day old wounds was used for estimation of lysyl oxidase activity, tensile strength and other biochemical parameters. The aqueous extract was also seen to be effective in increasing lysyl oxidase activity but to a lesser extrent than WPE. The prohealing action of the plant may be attributed to the presence of fumaric acid (Udupa AL, *et al*., 1995). The aqueous and ethanolic extracts of the whole plant of *Tridax procumbens* Linn. were also evaluated for the wound healing activity. The ethanolic extract was quite more effective in increasing wound contraction compared to the aqueous extract. The topical application of ethanolic extract of the plant showed significantly higher tensile strength than the aqueous extracts, and the standard drug, cipladine control groups also showed much lesser tensile strength than the extracts treated groups. Both the extracts of the plant have not only increased granulation and hexosamine formation but also, showed significant increase in hydroxyproline content of the granulation tissue which indicated rapid collagen formation. *Tridax procumbens* Linn.

may become a useful component for healing the wounds.

Anti-hypertensive activity: Vasodilatation can be facilitated by inhibition of vasoconstriction and secretion of relaxant factors from vascular endothelium. *T. procumbens* leaves have been reported to contain several active compounds such as alkaloids, flavonoids, quercetin, arachidic, and linoleic acid. Quercetin has been known to decrease Blood Pressure (BP) and/or reduced the severity of hypertension in spontaneously hypertensive rats (Carlstrom J, *et al*., 2007). The flavonoid luteolin has also induced NO production and arterial relaxation (Si H, *et al*., 2014). The aqueous extract of the leaves of *T. procumbens* was evaluated for assessing their relaxation effect in the aortic artery that was pre-contracted with Phenylephrine (PE) and KCl by the mechanistic interactions with Nitric Oxide (NO) synthase, cyclic Guanosine Monophosphate (cGMP), and cyclic Adenosine Monophosphate (cAMP). The results showed that the TPE significantly reduced the contraction induced by PE in a concentration-dependent manner. A part of the relaxing effect of *Tridax* is mediated directly by blocking or modulating cGMP and cAMP (Salahdeen HM, *et al*., 2016). The effect of *Tridax procumbens* Aqueous Leaf Extract (TPALE) was also investigated on reproductive function in N nitro-L-arginine-methyl ester (L-NAME) induced hypertensive rats. The results proved that TPALE decreased systolic, diastolic and mean arterial blood pressure in L-NAME+TPALE treated groups compared to only L-NAME treated group (Salami SA, *et al*., 2017).

Anti-inflammatory activity: The most active fraction of *T. procumbens* responsible for anti-inflammatory activity is Ethyl Acetate (ETA) fraction as it was found to contain moderate polar natural products like alkaloids and flavonoids. The alkaloids and flavonoids can counteract Reactive Oxidative Species (ROS) involved in the pathogenesis of inflammation and related ailments in biological systems. *Tridax procumbens* leaves were tested for their contractile activity in response to the potent gastrointestinal constrictors .Oral exposure of Aqueous *Tridax procumbens* Leaf Extract (ATPLE) to the adult male wistar rats potentiated the contraction in duodenal and jejunal small intestinal smooth muscle. Contraction in response to M3 receptor subtype activator (acetylcholine) which couples to Gq and PKC, H_1 receptor subtype activation (histamine) and high conductance Ca^{2+}-activated K^+ channel activator (KCl) was significantly enhanced in ATPLE treated group as compared to control group. Thus, The enhancement in the contraction of ATPLE treated rats may be predicated on *Tridax procumbens* ability to offer protection against inflammation and tissue damage to gastrointestinal smooth muscle.

Hemostatic activity: Various extracts like ethanolic extract, fresh leaf and petroleum extract of the leaves of *Tridax procumbens* were screened for hemostatic activity by studying the clotting time of 10 human volunteers using Lee White's method performed *in vitro*. Among them the ethanolic extract had positive activity by reducing the clotting time uniformly in the blood samples of all the subjects (Kale MA, *et al*., 2008). Aqueous leaf extract have also shown enhanced blood clotting activity, thus it may be used as a potent haemostatic agent.

Anti-diarrheal activity: The aqueous and ethanolic leave extract of *Tridax procumbens* was also evaluated for their antidiarrheal activity on gastrointestinal motility with barium sulphate milk model and the castor oil-induced diarrheal model. Both the aqueous and ethanol leave extracts of *Tridax procumbens* showed significant antidiarrheal activity on gastrointestinal motility with barium sulfate milk model but, the aqueous extract showed no significant reduction in the number of wet faeces for almost 2 hours compared with the standard lomotil drug on the castor oil-induced diarrheal model.

Leishmanicidal activity: *In vitro* activity of methanolic extract of *T. procumbens* inhibited promastigotes growth of *Leishmania mexicana* which is a causative agent of cutaneous leishmaniasis disease with a 50% Inhibitory Concentration (IC_{50}) at 3 µg/ml, showing its anti-leishmanial activity (Martín-Quintal Z, *et al*., 2009).

CONCLUSION

Tridax procumbens is one of the most widely used herbal medicine in India and has stood the test of centuries for the treatment of various ailments. This review therefore puts light on the importance and need to continuously carry out research on this plant that are used against various ailments traditionally and thus makes a way towards the discovery of newer conventional medicines. *Tridax procumbens* has a huge variety of phytochemicals in it, and various extracts have been used experimentally against variety of ailments in several *in vivo* and *in vitro* studies. Based on the reviewed data, many extraction procedures did not work according to the hypothesis and contraindicated with others. Therefore further research needs to be conducted with different extraction methods to see the effect of specific phytochemicals on various ailments. *Tridax procumbens* might have many other pharmacological properties that are yet to be discovered.

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