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Review Article

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Bioactivity and pharmacological potential of *Trianthema portulacastrum* L. (Angiosperms: Aizoaceae): An overview

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Abstract

Trianthema portulacastrum L. (Biskhapra/ Horse purslane) is widely found in tropical and sub-tropical countries of the world. This weed automatically spread in cultivated fields. From the ancient time it is used for curative purposes. The plant pertains wide range of applicability and henceforth used as an Ayurvedic herb. The decoction of this herb is utilized as a vermifuge, antidote prepared from that helps in treating alcohol poisoning and leaves cure the wound. In the era of phytomedicines lot of work has been done related to its morphology, ethno-pharmacology, medicinal uses, phyto-chemistry and pharmacological properties. Various pharmacological properties like antimicrobial properties, analgesic, anti-inflammatory, anti-diabetic, anti-hyperglycemic, hepato-protective activity makes this plant very renowned amongst researchers as they utilized it somewhat like a panacea. Different parts of plants are utilized for the therapeutic purposes and extract prepared in different solvents used in the treatment of various disorders. In this review, an attempt has been made to provide all inclusive information of this plant about its bioactive compounds and their pharmacologoical importance.

Keywords: Aizoceae; Ethnopharmacology; Morphology; Phytochemistry; Trianthema.

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Introduction

Trianthema portulacastrum L. (TP) is one of the most important members of Aizoaceae family (1). Other than this, 20 more species are reported from the similar genus *Trianthema*, which is an annual or perennial plant and various researches reported about the therapeutic potential of this species. Various parts of this plant are used for the isolation of drugs and bioactive compounds (2). *T. portulacastrum* is a flowering plant commonly known as Horse purslane, Biskhapra and Giant pigweed (3). It is broadly distributed in tropical countries and is native to continents Africa, South and North America Southeast Asia. This review shows the evaluation of occurrence, morphology, ethnopharmocology, ecological, biodiversity, phytochemistry, medicinal uses, toxicity and pharmacological activities about *T. portulacastrum*. The Broad classification is tabulated in Table 1 (4).

Table 1. Taxonomical Classification (3, 23)

Domain	: Eukaryota
Kingdom	: Plantae (Plants)
Sub-kingdom	: Tracheobionta (Vascular plants)
Division	: Magnoliophyta (Flowering plants)
Superdivision	: Spermatophyta (Seed plants)
Class	: Magnoliopsida (Dicotyledons)
Subclass	: Caryophyllidae
Order	: Caryophyllales (Herbaceous and fleshy)
Family	: Aizoaceae (Fig-marigold family)
Genus	*: Trianthema* L.
Species	*: Trianthema portulacastrum* L.

Distribution and occurrence

T. portulacastrum is an exotic weed, native to tropical America but geographically occurring at most of the tropical, subtropical habitats, generally distributed in Saudi Arabia, Bangladesh, Sri Lanka, Africa China, Egypt, Uganda, Ghana, Mali, Congo, New Jersey, Nevada, Utah, Virginia, Costa Rica, Peru, Chile as shown in Fig. 1 (5, 6). In India Biskhapra is naturalized throughout the cultivated fields, river beds, waste ground especially in the states of central and northern zone in which areas of Delhi, Rajasthan, Punjab and Uttar Pradesh. It thrives better in saline soil than that of alkaline soil (7). It is very common and easily visible in agricultural and vegetable crops such as pigeon pea, mung bean, cotton, pearl millete, sugarcane, soybean, onion, potato, maize, mustard, direct-seeded rice, tomato, oilseed, pulses and horticulture crops in India, Pakistan and Sri Lanka (8). This weed is reported to be strong competitor and reducing the yield by negative allelopathy in mung bean up to 60% and significant losses in soybean, maize and peanut (9).

Vernacular names of the plant

T. portulacastrum L., commonly known as black pigweed, gaint pigweed, itcit, gudbur, hogweed, desert purslane, horse purslane and lowland purslane. Apart from these common names, TP is globally utilized for its broad range of applications. It is known to people of distinct area by different regional names which is mentioned in Table 2 (10, 11).

Morphology

T. portulacastrum is the prostrate herb (Fig. 2) grows up to an average height of 40 cm, it is pubescent, diffuse, prostrate, profusely branched species developed in mats or clump with stems and propagation occurs very rapidly on cutting (12). Leaves are of 1.5 - 2.5 cm, stem is green in color, ascended, hispid, cylindrical, rounded, hairy and fleshy. Mature stem comprises of five successive

Fig. 1. Map showing distribution of TP all across the world.

Fig. 2. *T. potulacastrum* L. (A. Root, B. Leaf, C. Seed, D. Stem).

rings of cambium having fusiform cells, devoid of xylem rays and only consist of tracheids, vessels and fibers which help in transportation of water (13). Leaves are simple, fleshy, entire, broad, opposite, uneven, ovate-ovate, petiole dilated enclosing the stem, single mid-rib, dorsiventral, having two-layered palisade tissue, pinnately veined, green in colour and 2 cm long, 3 cm wide attached to the plant via 1 cm short petioles (14). It bears pink or purple and rarely whitish bisexual flowers and 1-3 in number. Flowering season of *T. portulacastrum* is approximately for five months which is from June to October, they bloom generally in morning hours and they are small in size with horn-like appendages with stipules and have green bracts generally fused with leaf bases with white sepals. Root is greenish-yellow from outside and is white in color from inside (15).

Table 2. Vernacular Names (3, 57)

Language	Local name
Arabic	Zaleya Pentandra, Hamd Qooqi
Bengali	Godabani, Sabuni, Kulphasag, Swet punarnova
Chinese	Jia Hai Machi
English	Giant pigweed, Desert Horse purslane, Carpetweed
Indonesia	Subang- subang
Kannada	Muchchugoni, Pasalaesoppu, Sihi Punarnava
Hindi	Sabuni, Svetsabuni, Salsabuni,Vishakhapara, Saphed Punamava
Malayalam	Tavilama, Talutama, Sharunnau, Pasalikeera, Thazhuthama, Jamizhama
Marathi	Pundhari-ghentuli, Pundharighetntuli
Nepali	Setopunarnava
Oriya	Dewasapt
Punjabi	Biskhapra, Itsit, Sanaya
Sanskrit	Dhanapatra, Chiratika, Upothaki, Vishakha Shvetamula, Dirghapatrika
Sindhu	Sweta puruni, Luduru sas
Spanish	Verdolaga
Tamil	Sharunnai, Charu velai, Shavalai, Shaaranaj, Mukuruttai
Telugu	Ghelijeru, Ambatimadu, Galijenu, Atikamamidi
Thai	Phak biahin
Urdu	Narma, Biskhapra
Unani	Lotoos Aghryoos
Vietnamese	Sam bien, Cotam khoi, Rau sam gia

Ethnopharmacology

T. portulacastrum is popularly used throughout the globe due to its pharmacological activities against many disorders or diseases. Leaf extract of plant possesses antioxidant properties and act as poultice which is useful in the healing of wound (16), curing the chronic pain of osteoarthritis disease and its diuretic action help in curing edema (17), jaundice, strangury and also used to treat ascites and beriberi (18). Asthma and alcohol poisoning are cured by using decoction of leaves which carry antihelminthic properties, help in curing heart diseases, piles and also used as a vermifuge (19). Dried leaves used in treatment of Gonorrhea. Roots are abortifacient in high concentration whereas in optimum concentration its decoction used as an emmenagogue, it also cure liver obstruction, eye inflammation, asthma and relieve from constipation. Leaves of plant are used with soups and vegetables in African countries like Tanzania and Ghana (21).

Phytochemistry

Screening method help in determination of number of remarkable phytochemicals like alkaloid, carbohydrates, flavonoid, phenolic compounds, steroid and terpenoid (22), Photoecydosone in different parts of plant *T. portulacastrum* L. which is used for various therapeutic and medicinal purposes (2). This plant is also a rich source of organic and inorganic components such as calcium (Ca), magnesium (Mg), nitrogen (N), Iron (Fe), Zinc(Zn), phosphorus(P), ascorbic acid (Vitamin C) and nicotinic acid (Vitamin B) (24) and this species comprised of excellent amount of fiber along with other nutrients which make it useful for animals as a food in the form of fodder while other species of genus *Trianthema* are rich in fats. Most of these species phosphorus and iron present in abundance whereas calcium is present in low percentage. The mineral profile of TP is tabulated in Table 3.

Table 3. Mineral profile of *T. portulacastrum* L.

Content	Quantity present	References
Protein	21.50%	(52, 53)
Neutral Lipid	95. 2%	(54)
Polar Lipid	4.80%	(54)
Crude Fibre	43%	(54)
Carbohydrate	30.20%	(52)
Hydrocarbons	0.30%	(54)
Vitamin A	0.081 mg/100gm	(54)
Vitamin C	0.202 mg/100gm	(54)
Carotene	2.3 mg/100gm	(53)
Calcium	52 mg	(55)
Chromium	0.200 mg	(56)
Copper	8ppm	(52)
Iron	6.44mg/kg	(55)
Magnesium	153mg	(56)
Manganese	40 mg/kg	(55)
Nickel	0.03 mg/gm	(54)
Phosphorus	22 mg	(56)
Potassium	51.6 mg /gm	(54)
Sodium	44 mg /gm	(54)
Zinc	30 ppm	(54)

Phytochemical screening by using the methanol, chloroform and water extract helped in the determination of photochemicals which are acetylaleuritolic acid (25), dimethoxycinnamic acid, 5,7-dihydroxy-6-8-dimethylchromone (Leptorumol), dihydroxy-7-methoxy-6-8-dimethyl flavones, 5-hydroxy-2-methoxybenzaldehyde, p-methoxybenzoic acid, Quercetin and plays a major role in drug development (Fig. 3).

T. portulacastrum flower consists of alkaloid punarnavine (26). These phytochemicals are reported in the aerial parts of the plant (27). Presence of dichloromethane in the extract of

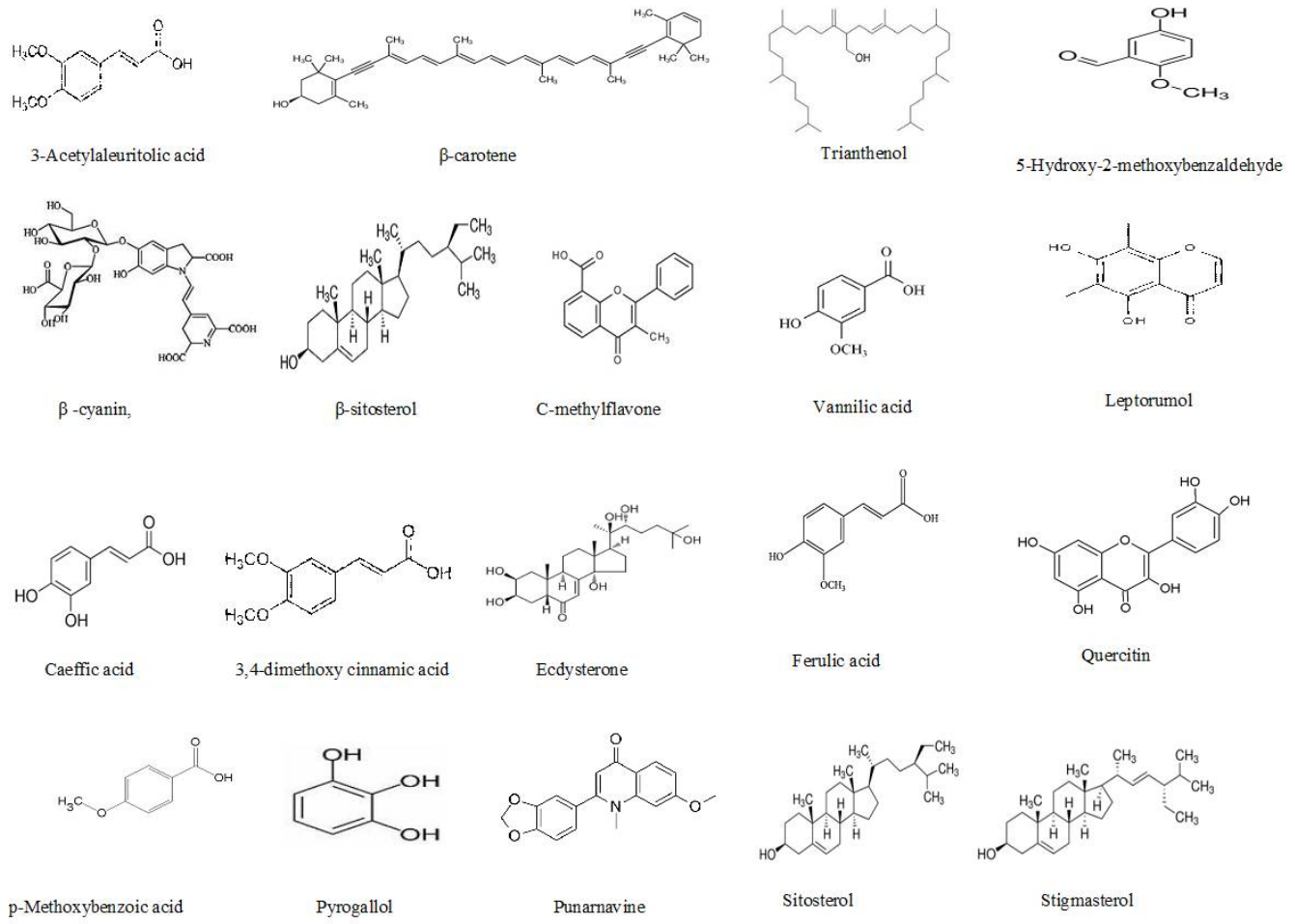

Fig. 3. Structures of various phytochemicals present in *T. portulacastrum* L.

dried leaf reported new flavonoids, 5,2'-dihydroxy-7-methoxy-6,8-dimethyl flavones (C-methylflavone), 5,7-dihydroxy-6,8-dimethylchromone (leptorumol) and its structure is been reported by X-ray analysis. Red color pigment β-Cyanin is one of the prominent flavanoid of *T. portulacastrum*. Qualitative analysis by chromatographic separation of plant extract gave mixtures of sterols which are stigma sterol, β-sitosterol and their β-glucopyranosides. An important tetraterpeniod named trianthenol with antifungal properties reported in chloroform extract (28).

Pharmacological activities

T. portulacastrum is a medicinal weed which shows many recognizable pharmacological activities like antimicrobial, antiparasitic, anti-inflammatory, antioxidant, diuretic, antihyperglycemic, antipyretic and cancer-preventive therapeutic properties that are been depicted in (Fig. 4). It is also reported for combating other disorders such as gastrointestinal, jaundice, edema, hormonal, cardiovascular and skin-related diseases (29).

Analgesic activity

Evaluation of ethanolic extract of plant *T. portulacastrum* was done and outcome it showed its antinociceptive activity in mice. The effect of analgesic activity was checked by introducing the doses for central and peripheral analgesic like morphine, aspirin and streptomycin. Which was found to be inactivate of pain relief, the effect of plant extract showed close value to that of aspirin which seems to help in blocking of writhing response gave value of P less than 0.005 ($P<0.005$) (30).

Antifungal activity

It was reported that horse purslane extract against *F. chlamydosporum* found to be very effective which causes leaf-spot disease in the plants. Besides, many reports admitted that the both chloroform extract of plant and well known phytochemical trianthenol (Tetraterpenoid) shows the antifungal activity (31).

Anticarcinogenic activity

The chloroform extract and ethanolic extracts of the plant showed reliable result in chemoprotective activity as clearly manifested in (Table 4). When in mice a potent carcinogen named, DENA (diethylnitrosoamine) was introduced that induced hepatocancer in a mice model and this chemical reduces the nodules size of rat's liver. The dose of plant extract which is been prepared in ethanol reviled the best result

than that of chloroform, inhibiting cell proliferation and also suppressed the effect chemical DENA. It was effective in reducing carcinogenic activity up to 25% and acted as most active in inhibition of hepatic cancer (32).

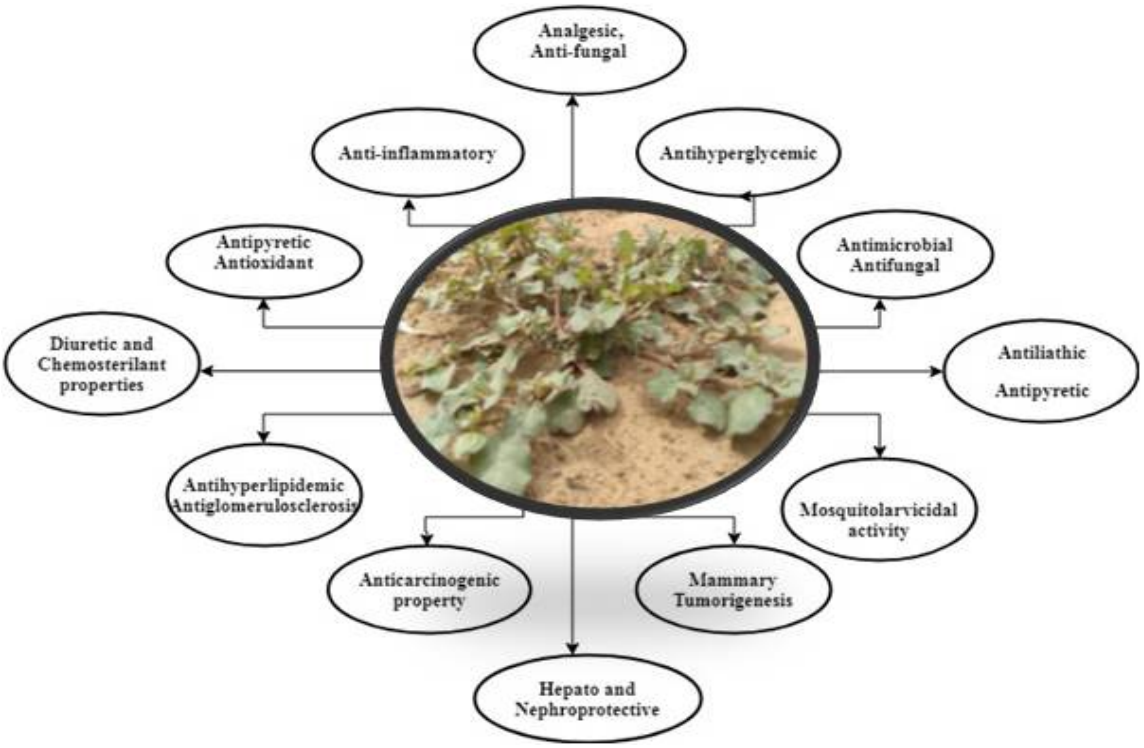

Fig. 4. Overview of pharmacological properties of TP.

Antifertility activity

T. portulacastrum has been well known for its anti-fertility properties because of the presence of phytochemical like steroid and ecdysterone that has been naturally present. Hence, it is employed as a contraceptive and abortifacient by some rural peoples and tribal communities of India. This tendency was studied in aqueous, chloroform and alcoholic extracts of plant, to exhibit antifertility activity. It was found that alcoholic, chloroform and aqueous extract perform 94%, 73% and 64% abortifacient activity. From this, it was clearly depicted that alcoholic extract is most potential as antifertility agent (33).

Antihyperlipidemic property

When there is a rise in concentration of lipids such as phospholipids, cholesterol or triglycerides due to factors like fatty diet, intake of drugs and genetic defects causes hyperlipidemia (34). Against this hyperlipidemia, the methanolic extract of *T. portulacastrum* manifested antihyperlipidemic activity and hence used to develop hypolipidemic drugs from natural sources to prevent the individual from cardiovascular diseases (35).

Plant extract of *T. portulacastrum* significantly used to cure diabetes mellitus. Methanol extract of *T. potulacastrum* (METP) shows antihyperglycemic activity in diabetic rats which is been produced by injecting dose of streptozotocin-induced diabetic rats. Demonstration of antihyperglycemic activity by the extract is done by lowering down the glucose level which is being monitored in diabetic rats (36).

Antimicrobial properties

Some reports depicted that *T. portulacastrum* possessed antimicrobial properties and found to be effective against both gram positive and gram-negative bacteria, fungi and helminthes because of the presence of photochemical available in plant (37). Plant extract prepared from roots showed antimicrobial property against bacteria *Bacillus subtilis*, *Escherichia coli*, *Proteus vulgaris* and *Staphylococcus aureus*. Phytochemical screening confirmed the presence of alkaloid, flavonoid, sterols and phenolic compounds in the plant. Further attribution to the research explored that fraction of flavonoid of plant *T. portulacastrum* performed better antimicrobial and antifungal propertied, based on zone of inhibition than that of phenolic and alkaloid fractions in the methanolic extract (38).

Nephroprotective effects

Nephroprotective effects has been studied in renal damaged mice against whom methanolic extract of *T. portulacastrum* pertained nephroprotective action because of its DPPH-free radical scavenging and antioxidant property. Renal damaged mice developed in an experimental model by Adriamycin in against which the extract improved the histopathological effects that was caused due to disease condition (39).

Table 4. *In vivo* investigation of anti-carcinogenic property of plant *T. portulacastrum*.

Sl. No.	Plant Extract	Exp. Model	Disease Targeted	Toxic control	Dose	Route	Duration	Investigation	Results	Ref.
1	Ethanolic extract of stem and leaves	Female Sprague-Dawley rat	Mammary carcinogenesis	7, 12-dimethylbenz(a)anthracene	50, 100 and 200 mg/kg	p.o.	18 weeks	Suppressed proliferating cell nuclear antigen and cyclin D1 expression, induced apoptosis	Strong anti-carcinogic compounds	(54)
2	Chloroform extract of stem and leaves	Male rat (Sprague-Dawley)	Hepatocarcinogenesis	DENA-initiated	100 mg/ kg/day	p.o.	4–20 weeks	Decrease in Nodule incidence and multiplicity as well as decrease nodular volume and area. Reduced liver cell foci/cm^2 and focal area	Ppotential of anti-carcinogenic	(53)
3	Ethanolic extract	Wistar albino rats	Breast cancer		50, 100 and 200 mg/kg b.w		16 weeks	TP suppressed proliferating cell nuclear antigen and cyclinD1 expression, induced apoptosis, down regulated antiapoptotic protein Bcl-2 and diminished the expression of nuclear and cytosolic b-catenin in mammary tumors	Exerted chemopreventive effect in the classical DMBA model breast cancer	(50)
4	Ethanolic extract	Wistar albino rats	Mammary carcinogenesis	7,12-Dimethylbenz(a)anthracene (DMBA)	50, 100 and 200 mg/kg		16 weeks	TP down regulated the expression of cyclooxygenase-2 and hsp 90, blocked the degradation of inhibitory kappa B-alpha	Induced breast neoplasia by anti-inflammatory mechanisms	(50)
5	Aqueous ethanol and choloroform extract	Male Sprague Dawley rats	Hepatocarcinogenesis	Diethylnitrosoamine (DENA)	100 mg/ kg	p.o.	Daily for 22 weeks	TP increased glutathione levels and the levels of Phase I (cytochrome P-450 monooxygenase) and Phase II (UDPGT) enzymes. Decrease in lipid peroxidation	TP exerted as strong anticarcinogenic compounds	(52)

Chemosterilants/ molting hormone activity

T. portulacastrum contains well known phytoecdysteroids called Ecdysteroids. Ecdysterone and its analogs tend to stimulate protein synthesis in mammals as well as in arthropods and hence act as a chemosterilants (40). Larva of *Musca domestica* (housefly) selected as a model for the experiment to check molting hormone activity of plant in which abdomen of model is dipped in plant extract and responded by the formation of pupanum just by 0.01 µg ecdysterone dose (41).

Antipyretic activity

The rise in body temperature that is more than 38.3 °C is known as pyrexia or fever, acute infection body respond against this alleviated temperature by releasing cyclo-oxygenase from prostaglandins (42). But this response doesn't go for prolonged or chronic infection recorded the antipyretic activity of *T. portulacastrum*. In his experiment, yeast-stable pyrexia was induced in rats against which antipyretic activity was shown by ethanol extract of *T. portulacastrum* (43).

Antioxidant properties

Plant extract of *T. portulacastrum* is enriched with many antioxidant compounds out of which the major one is Gallic acid which is reported as 50 mg in roots, 75 mg in shoots and 98.09 mg in leaves that is equivalents to per gram dry weight of plant (44). From the above statement it is clear that leaf extract of plant persist highest antioxidant properties over root and shoot. The ethanol extract of leaves was chosen for further investigation for the antioxidant properties and in rats it showed the relation with thioacetanamide, hepatotoxins and paracetamol. Reactive oxygen species, free radical and oxidative stress cause many degenerative diseases in an individual and also damage the body organs as well as genomic material. These oxidant species lowering the concentration of antioxidant enzyme like catalase (CAT), glutathione reductase (GSH-R), glutathione peroxidase (GPX), superoxide dismutase (SOD) and glutathione-S-transferase (GST) but after treatment with plant extract, enzymes attain the normal concentration in the experimental model and prevented from diseased condition (45).

Diuretic Properties

In India *T. portulacastrum* is commonly been used for ethnomedicinal purposes because of its diuretic activity. When diuretic activity of plant extract compared with standard diuretic that is furosamide than it gave 79% result in response to the plant dose of concentration 50 mg/kg and also produces kaliuretic and natiuretic effects (46). A similar investigation was done and reported in further investigations. Researchers are still far from mechanism but certainly it is due to the presence of phytochemicals in plant (43).

Hepatoprotective effects

Hepatotoxicity has been induced in albino rats by introducing familiar hepatotoxins thioacetamide and paracetamol in response to which ethanolic extract showed anti-hepatoprotective activity (47). The intake of higher amount of paracetamol promotes hepatic necrosis and also prescribed as an antipyretic and analgesic agent. Against these hepatotoxins *T. portulacastrum* stimulated regeneration of hepatic cells and also promoted detoxification (48).

Antiglomerulosclerosis

During glomerulosclerosis there is a rise in the level of creatinine and enzymes aspartate, transaminases and alanine. To overcome this, 100 and 200 mg/kg of methanolic extract of plant provided protection in experimental model rats against diet that induced glomeruloscelerosis. It also pertain protective property against hepatic damage, CCT (4% cholesterol, 1% cholic acid and 0.5% thiouracil) and antherosclerotic disease (49).

Mosquito larvicidal activity

Aqueous and acetone extract of plant *T. portulacastrum* persisted best larvicidal activity and 100% mortality rate has been found at third stage of instar larvae at different concentration of on different species of mosquitoes which includes *Culex quinquefaciatus*, *Anopheles culcifacies*, *Anopheles stephensi* and *Aedes aegypti*. On the basis of LD_{50} and LD_{90} values of larvae of different mosquitoes it was concluded that acetone extract pertained better larvicidal activity over crude aqueous extract of experimental plant (20).

Mammary tumor genesis

Breast tumor was developed upon introduction of 40, 50 and 100 mg/kg concentration of 7, 12-dimethylbenz (a) and anthracene (DMBA) in the mice by supplementing with diet. Ethanolic extract of *T. portulacastrum* reported to suppress the activity of DMBA which initiate tumorigenesis. It also helped in proliferating expression of cyclin D1, upregulated propoptotic protein Bax, downregulated antiapoptotic protein Bcl2 and induced apoptosis by regulating or changing the ratio of proteins Bax and Bcl2. It diminished the irregular and abnormal cell proliferation and canonical Wnt signaling pathways which showed oncostatic effects (50).

Anti-inflammatory Properties

Chloroform extract of *T. portulacastrum* induced anti-inflammatory effects and resist 58.36% of inflammation of rat paw edema assay induced on animal by carrageenans which release histamine and 5-hydroxy histamine initially and then kinin and prostaglandin in latter phase. Same as in dextran plant shows resistivity against inflammation which also induce paw edema as that of carrageenans but other than histamine, it is also mediated by serotonin which is inflammation mediators in nature and help to suppress inflammation. The anticancerous properties are also directly or indirectly linked with anti-inflammatory potential of plant. By lowering the inflammatory stress response inhibition of Chemical Dimethylbenzanthracene (DMBA) is done which induces the breast tumorogenesis (51).

Antilithic activity

Antiliathic activity inhibits the formation of kidney stones and help in getting rid its symptoms. When urolithiasis is experimentally induced in model it causes the formation of kidney stone which get cure on treating the animal with ethanolic extract of *T. portulacastrum* made from leaves (45).

Conclusion

Based on this review, it can be concluded that the distinct parts of plant *T. portulacatrum* employed

to perform various functions. Detailed comparative physicochemical and phytochemical studies on different parts of *T. portulacatrum* reported and the data justified the applicability of this plant in traditional systems of medicine. Natural and herbal drugs are recognized as safe but can also lead to adverse reactions, therefore correct identification and adulteration can help to validate it as potential drug candidate. Different polyphnolics isolated from the extract prepared in different solvents which seems to persist number of pharmacological properties such as antimicrobial, analgesic, anti-inflammatory, anti-diabetic, anti-hyperglycemic, hepato-protective activity and help in curing many disorders. This review is an effort to bring all the properties of this plant together that was reported at times. This report explored important therapeutical properties of this herb and its curative nature which converge the interest of researchers towards this plant. This study finally concludes that *T. portulacastrum* L. is an unusual and unbelievable source with so much to offer the world of medicine.

Conflict of interest

All authors declared that they have no conflict of interest in the publication.

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