Innovare Academic Sciences

International Journal of Pharmacy and Pharmaceutical Sciences

ISSN- 0975-1491 Vol 6, Issue 3, 2014

Review Article

PHYTOCHEMISTRY, PHARMACOLOGY AND THERAPEUTIC APPLICATION OF *OXALIS CORNICULATA* LINN. - A REVIEW

RAM AVATAR SHARMA, ARUNA KUMARI*

Plant physiology and biochemistry lab, lab no. 14, Department of Botany, University of Rajasthan, Jaipur, India.
Email: apayal88@gmail.com; Sharma_ra2007@rediffmail.com

Received: 21 Jan 2014, Revised and Accepted: 10 Apr 2014

ABSTRACT

Oxalis corniculata Linn. commonly known as creeping woodsorrel belonging to the family Oxalidaceae, is one of the most recent focus plant species in India. It is a medicinally important plant indigenous to tropical and subtropical regions of the world. The plant *Oxalis corniculata* Linn. has been used in different system of traditional medication for the treatment of diseases and ailments of human beings. The review reveals that wide ranges of phytochemical constituents have been isolated from the plant like flavonoids, tannins, phytosterols, phenol, glycosides, fatty acids, galacto-glycerolipid and volatile oil. The leaves contain flavonoids, iso vitexine and vitexine-2"-O-beta-D-glucopyrunoside. It is rich source of essential fatty acids like palmitic acid, oleic, linoleic, linolenic and stearic acids. It has been reported that the plant contains anti-inflammatory, anxiolytic, anticonvulsant, antifungal, antiulcer, antinociceptive, anticancer, antidiabetic, hepatoprotective, hypolipidemic, abortifacient, antioxidant, diuretic, antimicrobial and wound healing properties. This article briefly reviews the botany, pharmacology, biochemistry and therapeutic application of the plant. This is an attempt to compile and document information on different aspects of *Oxalis corniculta* Linn. and highlight the need for research and development.

Keywords: *Oxalis corniculata* Linn. creeping woodsorrel, Phytochemicals, Pharmacology, Traditional medication.

INTRODUCTION

Nature has been a source of medicinal agents for thousands of years and an impressive number of modern drugs have been isolated from natural sources. Many of these isolations were based on the uses of the agents in traditional medicines [1]. The plant-based traditional medicine system continues to play an essential role in health care with about 80% of the world's inhabitants relying mainly on traditional medicines for their primary healthcare [2].

There exists a plethora of knowledge and information and benefits of herbal drugs in our ancient literature of Ayurvedic and Unani medicine. One of the earliest treatises of Indian medicine, the Charaka Samhita (1000 B.C.) mentions the use of over 2000 herbs for medicinal purpose [3].

A large proportions of world's population depend on traditional medicine because of scarcity, high cost of orthodox medicine and unpleasant side effects [4]. In addition, herbs have provided us some of the very important lifesaving drugs used in the armamentarium of modern medicine [5]. There is a worldwide belief that herbal remedies are safer and less damaging to the human body than synthetic drugs. Therefore laboratories around the world are engaged in screening of plants for biological activities with therapeutics potential. One major criterion for the selection of plant for such a study is traditional healer's claim for its therapeutics usefulness. The traditional Indian medicinal system mentions herbal remedies for the treatment of variety of diseases. Exploration of the chemical constituents of the plants and pharmacological screening may provide us the basis for developing the leads for development of novel agents. Ayurveda has emphasized importance of food in the management of diseases. Even practitioner of modern system has realized the significance of dietary items, in the form of nutraceutical elements, in the treatment of chronic diseases [6].

The genus *Oxalis* belongs to the family Oxalidaceae with about 500 species, distributed in America, Africa, Europe and Asia [7, 8].

Oxalis corniculata Linn, Oxalidaceae, a sub-tropical plant being native of India, are commonly known as creeping woodsorrel. It is a delicate-appearing, low growing, herbaceous plant and abundantly distributed in damp shady places, roadsides, plantations, lawns, nearly all regions throughout the warmer parts of India, especially in the Himalayas up to 8,000 ft- cosmopolitan [9].

Oxalis corniculata Linn. (Family: Oxalidaceae) is a well-known plant in India and is one of the most versatile medicinal plants having a wide spectrum of biological activity. It is commonly known as creeping wood sorrel, an excellent plant in the nature having composition of all the essential constituents that are required for normal and good health of humans [10]. Herb is a good appetizer, removes kapha, vata, and piles; astringent cures dysentery and diarrhoeas, skin diseases and quarten fevers. An infusion of the small leaves is externally used to remove warts and opacities of cornea. The leaves are anti-inflammatory, refrigerant and antiscorbutic [11].

Oxalis corniculata Linn. is locally used in various ailments. It is rich in niacin, vitamin C and β-carotene [12]. The juice of the plant is given in jaundice and in stomach troubles [13]. The juice of the plant, mixed with butter, is applied to muscular swellings, boils and pimples [12]. *Oxalis corniculata* Linn. is also used as antiseptic, refrigerant, diaphoretic, diuretic and anti diabetic [13]. It is used as complementary medicine in wound healing, anemia, dyspepsia, cancer, piles, dementia and convulsions [14, 15]. Other alternative uses are; anti-helminthic, anti-inflammatory, astringent, depurative, diuretic, emmenagogue, febrifuge, lithontriptic, stomachic and styptic. It is also used in the treatment of influenza, fever, urinary tract infections, enteritis, diarrhoea, traumatic injuries and sprains [16]. It was also reported that *Oxalis Corniculata* Linn. have hypoglycemic, antihypertensive, antipsychotic, nervous system stimulant and have chronotropic and inotropic effect [17, 18]. Chemical characterization of *Oxalis corniculata* Linn. showed the presence of glyoxylic acid, oxalic acid, pyruvic acid, vitexin and isovitexin, vitexin-2-O-beta-D-glucopyranoside, neutral lipids, glycolipids; vitamin C; phospholipids; fatty acids, 18:2, 18:3, 16:0; saturated (C10-C14) acids; alpha and beta tocopherols [18].

In Nepal village, *Oxalis corniculata*. Linn (Jujur saang) is used as medicinal herb [19]. The plant is mixed in equal amount with the leaf bud of *Justicia adathoda* L. and *Maesa macrophylla* is pounded and the juice about 6 tea spoons 3 times a day is given in gastric troubles [20]. The leaf decoction is used in fever and dysentery in some areas of Madhya Pradesh [21]. Maceration of the whole plant with leaves of Sida acuta is taken orally to treat gonorrhoea in Cameroon [22]. The herb juice is used as eye drop in conjunctivitis by Boro Tribals of Assam [23]. The local inhabitants of Tehsil Chakwal (Pakistan) uses Plant sap to cure skin diseases, Leaves as

cooling agent and refrigerant in stomach disorders, fever and acute headache and also in snake bite. Plant pounded with cumin seeds are taken with water thrice a day for dysentery. It is also used for sensitive teeth [24].

The present review is dealing with medicinal importance of the *Oxalis corniculata*. Linn with reference to its Pharmacognosy, Phytochemistry and pharmacological activities.

Plant profile

Taxonomic Classification [25]

Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Order : Oxalidales
Family : Oxalidaceae
Genus : *Oxalis*
Species : *corniculata*

Vernacular Names [25]

Sanskrit: Ambashta, Amlalonika, Amlapatrika, Amlika,
Hindi: Seh-patti, Tinpatiya, Anboti, Chuka tripati, Bhilmori, Khatari
English: Indian sorrel
Urdu: Khatti-buti
Assamese: Changeritenga, Saru tengesi
Bengali: Amrul-sak, Amrul shak, Amrul, Tandi chatom arak, Amrool
Kannada: Huli-huniche, Hulihunice, Pullam-purachi-sappu, Teltuppi
Tamil: Palaikiri, Puliyarail
Telugu: Ambotikura, Pulichintha, Pallachintha
Marathi: Ambali, Chicha
Malayalam: Poliyarala, Puliyaral, Puliyarala, Puliyarila, Pullampurachi
Marathi: Umbuti, Ambuti, Bhinsarpati, Aambotee, Ambata chukaa
Oriya: Sialthur, Siakthur, Ambo chingari
Arabic: Hememdab, Hemda, Homadmad

Distribution

It is a somewhat delicate-appearing, low-growing, herbaceous plant abundantly distributed in damp shady places, roadsides, plantations, lawns, nearly all regions throughout the warmer parts of India, especially in the Himalayas up to 8,000 ft –cosmopolitan [25]. It is also distributed in ballast about the eastern seaport town of the United States and becomes quite abundant in Texas and Ontario. These weeds are found throughout Florida. They are common in the southeastern United States; from Newfoundland to North Dakota; and southward to Mexico. *Oxalis corniculata* Linn. is a cosmopolitan weed occurring in the Old World and in temperate and tropical regions of North, Central and South America and the West Indies [26].

Botanical description

They are tap rooted herbs, bushy or mat forming, and 0.1-0.5 m tall (Figure 1). Branching from the base and often rooted at the nodes, the upper portions are ascending or weakly erect smooth or hairy [26].

Stem

The stem is slender, terete and pubescent, 0.4 to 1.5 cm long. The internodes vary from 4.5 to 8.5 cm in length. Acidic odour, taste sour when fresh [26].

Leaves

The trifoliate leaves are alternate, with thin, heart-shaped, leaflet blades having a distinct apical indention. Leaflets 0.5 to 1 cm long with reticulate venation. The blades are smooth on the upper surface, slightly folded upward lengthwise along the major vein, and have a few appressed hairs along the veins on the lower surface and along the lower portion of the margins. The leaves are arranged alternately along the stems. A single long stalk arises from the axils of the leaf, from which extend three flower stalks, each with a single flower.

Flowers

The flowers are 7-11 mm wide and have 5 yellow petals [26].

Fruit

The fruit is a capsule, 1-1.5 cm long, cylindrical, pointed apically, and 5-ridged in cross section [26].

Seeds

The seeds are oval in outline, apically rounded, basally pointed, flattened in cross section, light brown, and have a surface distinctly transversely ridged. *Oxalis corniculata* Linn. will have stolons [26].

Fig. 1: **Leaves and flowers of *Oxalis corniculata* Linn.**

Phytochemistry

Phytochemical investigations of *Oxalis corniculata* Linn. have revealed the presence of tannins, palmitic acid, a mixture of 8 oleic, linoleic, linolenic and stearic acids. Methanolic and ethanolic extracts of this plant show the presence of carbohydrate, glycosides, phytosterols, phenolic compounds, flavonoids, proteins (12.5%), amino acids and volatile oil.

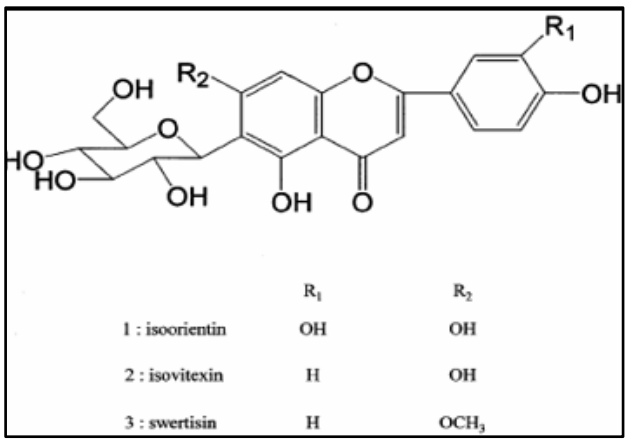

Fig. 2: The structures of flavonoids [I: Luteolin 6 -C-Glucoside (Isoorientin), 2: Apigenin 6 -C- Glucoside (Isovitexin), 3: Isovitexin 7- Methylether (Swertisin)] Isolated from the shoots of *Oxalis corniculata* Linn.

It also showed the presence of calcium, fiber and tannin. Leaves contain tartaric acid and citric acids, calcium oxalate, flavones (acacetin and 7,4'-diOMe apigenin), glycoflavones (4'-OMe vitexin, 4'-O Meiso-vitexin and 3',4'-diOMe orientin), flavonols (3', 4'-diOMe quercetin) and phenolic acids such as p-hydroxybenzoic, vanillic and syringic acids. This herb is well known to have an acid taste due to the high content of oxalate in its leaves and stems. Study revealed

the presence of three glycosylflavones in the leaves namely 6-C-glucosyl luteolin (isoorientin), 6-C-glucosylapigenin (isovitexin) and isovitexin 7-methylether (sertisin) (Figure 2).

Ferritin was detected in the integumentary cells of the *Oxalis corniculata* Linn. ovule that was confirmed by an electron microscope x-ray microanalysis; it occurs in immature plastids & in amyloplasts in the form of paracrystalline aggregates which have round profiles or which may be intended by the surrounding starch grains. Integumentary ferritin aggregates are regarded as an iron source for the embryo. The leaves contain about 86% water, 0.8% fat, 8.2% carbohydrate, 150mg calcium, 78 mg phosphorus, 8mg iron, 0.6mg niacin, 78mg vitamin C, 6050 microgram beta carotene and between 7-12% oxalate [10].

During photosynthesis, an oxalic acid is produced by carbon dioxide fixation both in light and in darkness but the rate of its photosynthetic formation is much higher in darkness. Identified several compounds that were characterized by nuclear magnetic resonance, infrared, and mass spectrometry as (i) Oc-1, a mixture of saturated fatty acids C_{24} to C_{28}; (ii) Oc-2, a mixture of long-chain alcohols C_{18} to C_{28}; and (iii) Oc-3, a single compound that was a galacto-glycerolipid [27].

β-sitosterol (1), betulin (2), 4-hydroxybenzoic acid (3), ethyl gallate (4), 5-hydroxy-7,8-dimethoxyflavone (5), 5-hydroxy-3', 4', 6, 7, 8-pentamethoxyflavone (6), 7, 5′-dimethoxy-3, 5, 2′-trihydroxyflavone (7), 5-hydroxy-3, 6, 7, 4′-tetramethoxyflavone (8), 4′, 5-hydroxy-3, 6, 7-trimethoxyflavone (9), 5-hydroxy-3, 6, 7, 4′-tetra-methoxyflavone (10), apigenin 7-O-β-Dglucoside (11) and 3, 3′, 5, 7-trihydroxy-4′-methoxyflavone 7-O-β-D-glucopyranoside (12), has been isolated from the *Oxalis corniculata* Linn.[28]. (Figure 3).

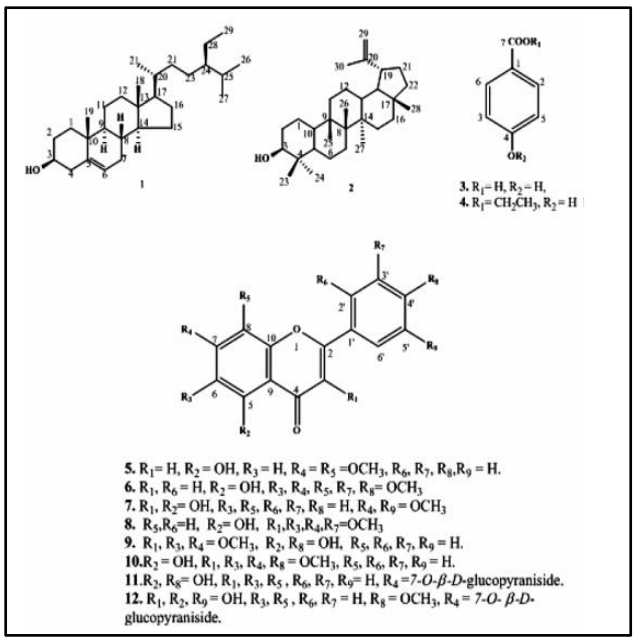

Fig. 3: Structures of compounds 1-12 isolated from *Oxalis corniculata* Linn.

Corniculatin A, a new flavonoid glucoside, was isolated from the ethyl acetate soluble fraction of the whole plant along with luteolin, luteolin-7-*O*-β-D-glucoside and β-sitosterol-3-*O*-β-D-glucoside, this is the first report of these compounds from this species. Their structures were elucidated on the basis of spectral data including mass and 2D NMR experiments [29].

Nutritional Value of *Oxalis corniculata* Linn.

The leaves have been found to be rich in moisture, total carbohydrate, crude protein, crude lipid hence it can be alternative vegetable during emergency. The leaves of *Oxalis corniculata* Linn. exhibit rich in mineral contents like Sodium (1.12+0.02%), Potassium (2.17+0.31%), Calcium (2.510.08%), Nitrogen (3.5610.70%) and Magnesium (0.25+0.03%), these mineral components are vital in regulating various metabolic pathways in human body [30].

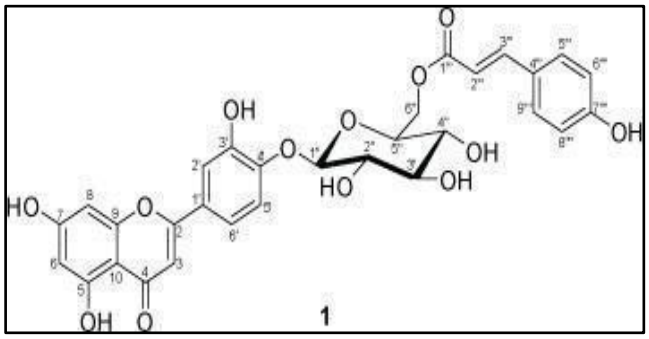

Fig. 4: Structure of corniculatin A

Antibacterial activity

Methanolic and ethanolic extracts of *Oxalis corniculata* Linn. plant showed significant antibacterial activity against *Xanthomonas* and fourteen human pathogenic bacteria. Interestingly, among the extracts, Methanol extract showed highly significant activity as compared to K-cycline and Bact-805 against plant pathogenic bacteria. In case of human pathogenic bacteria methanol extract showed moderately significant antibacterial activity when compared with standard streptomycin [31].

Antifungal activity

The aqueous extract of four various plants were evaluated for antifungal activity against various pathogens. All the four plants showed different activities against all the pathogenic fungi. Among them, *Oxalis corniculata* Linn. showed the significant antifungal activity against *A. niger* by suppressing the fungal mycelial growth by 71 to 86% and moderately against *P. these*, *R. solani* after three days of incubation [32].

Pharmacological activities of *oxalis corniculata* linn.

Anti-helminthic activity

This study aimed at the in vitro comparative study of anti-helminthic activity of petroleum ether, ethyl acetate and methanol extracts of whole plant of *Oxalis corniculata* Linn. using *Eisenia foetida* at three different concentrations (100, 200 and 400 mg/ml) respectively. The study involved the determination of time of paralysis (P) and time of death (D) of the worms. At the concentration of 400 mg/ml all the extracts showed very significant activities as compared to the standard drug levamisole (0.55 mg/ml). Each extract with the dose 100, 200 and 400 mg/ml produced dose dependent paralysis ranging from loss of motility to loss of response to external stimuli which gradually progressed to death. In case of methanol extract which was found to be most potent, the time of paralysis and death time was observed as 11.33 and 41.33, respectively [33].

Nematocidal activity

Chitwood (2002) [34] and Silamar and Leandro (2004) [35] have reviewed the ethanolic extract of *Oxalis corniculata* Linn. plant that having nematotoxic activity against phytoparasitic nematodes. In another research has revealed ethanolic extract of *Oxalis corniculata* Linn. having the same activity detected on *Meloidogyne incognita*. After 7 days of incubation period the immobility of the nematode was observed under the light microscope and that conform the nematocidal activity of this plant [36].

Other activities

Wound healing activity

The alcoholic and petroleum ether extract of whole plant of *Oxalis corniculata* Linn. has been evaluated for its wound healing activity

by using excision, resutured incision and dead space wound models in rats. Both the extracts at the dose of 300 and 500 mg per kg p.o.showed significant wound healing activity by producing an increase in wound contraction rate, wound breaking and significant decreases in epithelization period. In this study both the extracts significantly increased the granuloma tissue breaking strength and hydroxyl proline content as compared to control [37].

Anti-implantation and abortifacient activity

Petroleum ether and ethanol extracts of the whole plant of *Oxalis corniculata* Linn. were administered orally at the dose level of 100 and 200 mg/kg body weight from day 1 to 7 of pregnancy to evaluate the anti-implantation activity. Though all the treated groups showed significant anti-implantation activity when laparotomised on day 10, it was maximum (76.42%) with the high dose of petroleum ether extract. Upon withdrawal of the treatments the rats which retained the implantation continued pregnancy. The pregnant rats which received the treatment from day 8 to 14 of pregnancy showed abortifacient activity and it was maximum (78.55%) with high dose of petroleum ether extract [38].

Gastroprotective activity

The objective of this study was to investigate the antiulcer activity of methanol extract of *Oxalis corniculata* Linn. (whole plant) using pylorus ligation and indomethacin-induced gastric ulceration in Wistar rats. The extract was preliminary evaluated for acute oral toxicity test using Organisation for Economic Co-operation and Development guidelines 423. Further, it was studied for antiulcer potential at the dose levels of 125, 250 and 500 mg/kg. Ranitidine was used as a standard drug (100 mg/kg). Acid secretory parameters like gastric volume, pH, total acidity and free acidity were measured in pylorus ligation model, whereas numbers of ulcers, ulcers score and ulcer index was measured in pylorus ligated and indomethacin treated rats. Pretreatment of test extract significantly ($p<0.05$) decreased the gastric volume, total acidity, free acidity and increase in the pH of the gastric fluid in pylorus-ligated rats. It also showed significant ($p<0.05$) decrease in number of ulcers, ulcers score and ulcer index in pylorus ligated and indomethacin treated rats. Results of the study suggest that, the methanol extract of *Oxalis corniculata* Linn. possesses significant antisecretory and antiulcer effects and justify the traditional usage of this herb to treat peptic ulcers [39].

Anti-diabetic activity

The aqueous extract of the *Oxalis corniculata*. Linn plant has been tested for the inhibitory potential against procaine pancreatic amylase. At a concentration of 100µg/ml exhibited a maximum inhibition of 89.27% (IC 50 value 68.08±0.06). The organic extracts did not show any significant inhibition in this study which might suggest that the active principle possessing amylase inhibitory potential is extracted only in the aqueous extract [40].

Anti-amoebic Activity

Oxalis corniculata Linn. identified several compounds that showed anti-amoebic activity in axenic cultures of *E. histolytica*. These were characterized by nuclear magnetic resonance, infrared, and mass spectrometry as (i) Oc-1, a mixture of saturated fatty acids C_{24} to C_{28}; (ii) Oc-2, a mixture of long-chain alcohols C_{18} to C_{28}; and (iii) Oc-3, a single compound that was a galacto-glycerolipid (GGL). Of the different compounds that were obtained, the strongest anti-amoebic activity was found in GGL [27].

Anti-cancer Activity

Ethanolic extract of *Oxalis corniculata* Linn. evaluated for its anticancer activity in Ehrlich acsites carcinoma (EAC) induced in Swiss albino mice. Results conclude that the ethanolic extract of *Oxalis corniculata* Linn. was effective in inhibiting the tumor growth in ascitic and solid tumor models [41].

Anti-nociceptive Activity

Ethanolic extract of *Oxalis corniculata* Linn. at doses of 200 and 400mg/kg body weight evaluated for its anti-nociceptive activity in diabetic neuropathy rats. Diabetic rats were showed significant reduction in tail flick latency by 49% in hot water tail immersion test and decreased paw withdrawal by 40% in hot plate test by the end of 5th week [42].

Anti-diarrhoeal activity

The anti-diarrhoeal activity of aqueous and methanolic extracts of *Oxalis corniculata* Linn. was evaluated on castor oil induced diarrhoea in rats and on small muscle intestinal transit. At orally administered doses of 160,320 and 640 mg/kg of body weight. The two plant extracts significantly ($p<0.05$) prolonged the time of onset of diarrhoea and inhibited the frequency of defecation. These extracts also reduced the wetness of faecal droppings in castor oil induced diarrhoea and decreased the propulsion of charcoal meal through the small intestine. At all doses the aqueous extract appeared to be more effective than the methanolic extract [43].

Anti-epileptic activity

Methanolic extract of *Oxalis corniculata* Linn. leaves at doses of 200 and 400mg/kg body weight were screened for antiepileptic activity on Maximal Electroshock (MES) and Pentylenetetrazole (PTZ) induced seizures models in Albino Wistar rats. In MES model, MEOC showed significant reduction in duration of hind leg extension with 200 mg/kg dose and effect was dramatically reduced with 400mg/kg. Similar dose dependent results were obtained in PTZ model by delayed the onset of clonic convulsions. The complete protective effect against mortality was reported in both the tests. In conclusion, our present results indicate that *Oxalis corniculata* Linn. has anti-epileptic effects on MES and PTZ induced convulsions and its mechanisms might relate to potentiation of the activity of GABA receptors and their signal transduction process [44].

A study was conducted to investigate the effect of methanolic extract of *Oxalis corniculata* Linn. on antioxidant enzymes in rat brain after induction of seizures by MES and PTZ. The levels of antioxidant enzymes Superoxide dismutase, glutathione peroxidase, glutathione reductase and catalase was decreased in rat brain due to seizure and it was restored significantly by administration of ethanol extract of *Oxalis corniculata* Linn. treated rats. Similar dose dependent results were obtained in PTZ model also, Whereas MEOC significantly decreased lipid peroxidation in both models. The anticonvulsant activity of MEOC might be presents of antioxidant properties and it delays the generation of free radical in MES & PTZ induced epilepsy [45].

Anti-ulcer activity

The aqueous and ethanolic extract of *Oxalis corniculata* Linn. leaves at a doses of 200 and 400mg/kg body weight were screened for anti-ulcer activity by using ethanol induced gastric mucosal ulcers and pylorus ligated ulcers. There was a decrease in gastric volume and reduction in free and total acidity treated with both extracts and the catalase and SOD levels was increased and lipid peroxide was decreased in both extracts [46].

Anti-inflammatory activity

Methanol extract of whole plant of *Oxalis corniculata* Linn. (Family: Oxalidaceae) was assessed for its antioxidant and anti-inflammatory activity by in-vitro methods. In-vitro anti-inflammatory activity was evaluated using albumin denaturation assay, membrane stabilization assay and proteinase inhibitory activity at different concentrations. Aspirin was used as a standard drug for the study of anti-inflammatory activity. Linear regression analysis was used to calculate IC_{50} value. Results showed that, the extract exhibited significant DPPH and nitric oxide radical scavenging activity with IC_{50}. value of 302.93±4.17 and 73.07±8.28µg/ml respectively. Lipid peroxidation induced by the Fe^{2+}, was inhibited by the extract with IC_{50} value 58.71±2.55µg/ml. Total phenol content was estimated as 25.62±0.10mg of gallic acid equivalents of dry extract. Total flavonoids and flavonols were found to be 150.88±12.61 and 150.16±2.16 mg of rutin equivalents per gram of dry extract respectively. Extract also showed in-vitro anti-inflammatory activity by inhibiting the heat induced albumin denaturation and Red Blood Cells membrane stabilization with the IC50 values of 288.04±2.78 and 467.14±9.56µg/ml respectively. Proteinase activity was also

significantly inhibited by the extract (IC50=435.28±5.82µg/ml). From the results, it is concluded that flavonoids and related polyphenol s present in the O*xalis corniculata* Linn. extract may be responsible for the activity [47].

Anxiolytic activity

The anxiolytic effect of Ethanolic extract of *Oxalis corniculata* Linn. (100 and 300 mg/kg) produced a significant increase in the number of squares crossed (controls= 24.33±3.48), but significantly decreased both the immobility (controls = 47.17±4.29 sec) and fecal pellets (controls = 13.50±0.96 fecal pellets) when compared with control mice in the open-field test; they significantly increased the number of entries (controls = 53.00±2.67 sec) in the open arms, but decreased both the number of entries (controls = 29.33±1.05 entries) and time spent (controls = 166.7 ± 4.30 sec) when compared with the control mice in the closed arms of the elevated plus-maze test. Furthermore, ethanol extract of *Oxalis corniculata* Linn. (100 and 300 mg/kg) decreased the fighting episodes significantly (controls = 9.50±0.62 fighting episodes) when compared with control mice. In addition these results were found to be consistent with anxiolytic effect produced by diazepam [48].

The study is to evaluate anxiolytic effect of Ethanolic extract of *Oxalis corniculata* Linn. (200mg/kg and 400mg/kg P.O) on male mice using various paradigms of anxiety. In elevated plus maze, extract (200mg/kg and 400mg/kg) had shown a dose dependent increase in time spent and number of entries into open arm compared to control group. The number of central squares, peripheral squares crossed and rearings were stepped up significantly in open field paradigm. The treated groups had shown accession in time spent in light compartment, number of crossings, latency compared to control group in light dark exploration test. In Hole board model, number of head dips were minified in mice that received Ethanolic extract of *Oxalis corniculata* Linn. (200mg/kg and 400mg/kg) [49].

Hepatoprotective activity

The hepatoprotective activity of aqueous and ethanolic leaves extracts of *Oxalis corniculata* Linn. (200 and 400 mg/kg) were evaluated against thioacetamide-induced hepatotoxicity. Oral administration of *Oxalis corniculata* Linn. aqueous and ethanolic leaves extract at 400 mg/kg resulted in a significant reduction in SGOT (146.42±2.54 and 136.75±1.37 IU/L respectively), SGPT (81.96±3.15 and 72.05±2.33 IU/L respectively), GGTP (16.6±0.49 and 15.02±0.68 IU/L respectively), ALP (241.86±3.94 and 202.42±5.37 IU/L respectively) and total bilirubin (0.226±0.00 mg/dL 0.288±0.01 mg/dL respectively) content that were lesser than positive control, thioacetamide damaged rats. Histology of the liver sections of the animals treated with the extract also showed dose dependent reduction of necrosis [50].

Hypolipedemic activity

The hypolipidemic and antioxidant activities of leaves of *Phlogacanthus thyrsiflorus*, *Oxalis corniculata* Linn. and *Fragaria vesca* were evaluated in the study. Hyperlipidemia was induced in rats by giving high fat diet consisting of coconut oil and vanaspati ghee, in a ratio of 2: 3 v/v at a dose of 10 ml/Kg body weight. The extracts showed a significant decrease in total cholesterol, triglycerides, LDL and MDA in blood. On the other hand, HDL, CAT and SOD were increased significantly [51].

Steroidogenic activity

The study proved that the *Oxalis corniculata* Linn. has steroidogenic activity and this natural chemical can be safely used as it does not alters the functioning of organs which is proved by its action on one of the endocrine organ-adrenal gland, which functions normally in the extract treated female albino rats [52].

Cardio protective effect

The present study evaluated the protective potential of aqueous extract of (*Oxalis corniculata* Linn. OCE) against isoproterenol (ISO) induced myocardial infarction in rats. Myocardial infarction in rats was induced by isoproterenol (200 mg/kg) at an interval of 24 h for 2 days. OCE was given to rats as pretreatment for 30 days orally using an intragastric tube. Isoproterenol caused a significant increase in the activity of cardiac injury marker enzymes like creatine phosphokinase (CPK) and lactate dehydrogenase (LDH) and increased the concentration of serum lipids. OCE pretreatment significantly reduced the concentration of CPK, LDH, serum total cholesterol, LDL cholesterol and triglycerides. OCE also reduced the activity of lipogenic enzyme, glucose-6-phosphate dehydrogenase in ISO administered rats. Oxidative stress produced by isoproterenol was significantly lowered by the administration of OCE which was evident from increased activities of antioxidant enzymes (catalase and superoxide dismutase) and reduced concentration of lipid peroxidation products (TBARS and conjugated dienes). Concentration of vitamin C, protein sulfhydryl groups and reduced glutathione (GSH) was also high in OCE pretreated rats. Histopathology of heart of ISO administered rat pretreated with OCE showed normal myocardium with very little evidence of inflammatory infiltration. Results of our in vitro findings also confirmed that OCE exhibits significant antioxidant and radical scavenging activity against DPPH, superoxide and nitric oxide radicals [53].

Nephrotoxicity

CCl_4 induces oxidative stress in various tissues by altering antioxidant enzymes defense system. In this study we investigated the chemical composition and protective role of *Oxalis corniculata* Linn. methanol extract (OCME) on CCl_4-induced nephrotoxicity in rat. Presence of flavonoids, alkaloids, terpenoids, saponins, cardiac glycosides, phlobatannins and steroids was determined in OCME while tannins were absent. Total phenolic contents estimated were 7.76 ± 0.36 (mg gallic acid equivalents/g extract) while total flavonoid contents recorded were 6.92 ± 0.52 (mg rutin equivalents/g extract). Intraperitoneal injection of CCl_4 (1 ml/kg b.w., 20% in olive oil) once a day for seven days caused nephrotoxicity as evident by elevated levels of urinary specific gravity, RBCs, WBCs, level of creatinine, urea and blood urea nitrogen were significantly increased while protein and creatinine clearance was decreased by CCl_4 treatment in kidney samples. Activity of antioxidant enzymes; catalase, peroxidase, superoxide dismutase, glutathione peroxidase, glutathione-S-transferase, glutathione reductase and glutathione concentration was decreased whereas lipid peroxidation and protein contents were increased along with histopathological injuries. Treatment with OCME caused significant recovery in changed parameters. It could be concluded that OCME has a protective role against CCl_4-induced oxidative stress in rat, due to antioxidant effects of phenolics [54].

Diuretic activity

This study was under taken to investigate diuretic effect of methanolic extract of whole plant of *Oxalis corniculata* Linn. in albino wistar rats. The methanolic extract of *Oxalis corniculata* Linn. was administered to experimental rats overall at doses of 200 mg/kg, and 400mg/kg, p.o. furosemide (20mg/kg) was used as standard control in thi s study. The diuretic effect of the extracts was evaluated by measuring urine volume, sodium, and potassium content using flame photometry. Urine volume was significantly increased by the two doses of MEOC is comparison to control group. Excretion of electrolytes Na^+, K^+, increased by both doses. The diuretic effect of the extracts was comparable to that of standard furosemide. We can conclude the MEOC produced notable diuretic effect which appeared to comparable to that produced by the reference diuretic furosemide. The present study provides a quantitative basis for explaining the folkloric use of *Oxalis corniculata* Linn. as a diuretic agent [55].

Antioxidant and hepatoprotective activity

The study revealed that ethanolic extract of *Oxalis corniculata* Linn. at different doses level showed significant antioxidant activity in mice [40]. Methanolic extract of *Oxalis corniculata* Linn. showed potent antioxidant activity compare to reference standard ascorbic acid. The concentration of plant extract required for 50% inhibition of DPPH radical scavenging effect (IC_{50}) were recorded as 30 mg/ml and 37 mg/ml for MEOC and standard ascorbic acid. These results suggest that the MEOC possess antioxidant activity compared to ascorbic acid [56]. The whole plant of *Oxalis corniculata* Linn. in

three different solvent systems was tested for antioxidant capacity by phosphomolybdate method. The radical scavenging activity of plant extracts was studied by different standard in vitro methods. The quantitative estimation of major antioxidant constituents was carried out by standard method and contained total crude phenolics content (6.424 mg gallic acid eqvt. /gm dry wt. of sample), phenolic acid (0.738 mg gallic acid eqvt. /gm drywt.), total flavonoids (0.814 mg rutin eqvt. /gm dry wt.) and glutathione (948.143 µM/gm fresh wt.). The antioxidant vitamins of the plant were also estimated. The vitamin C content was found to be 0.414 mg/gm fresh wt. and vitamin E was found to be 137.36 mg/gm fresh wt. [57]

Many human diseases are caused due to oxidative stress involving excessive production of free radicals that can be ameliorated by the antioxidant activities of plant extracts. Present study was designed to characterize the chemical composition of *Oxalis corniculata* Linn. methanol extract (OCME) and its various fractions; *Oxalis corniculata* n-hexane (OCHE), *O. corniculata* ethyl acetate (OCEE), *O. corniculata* chloroform (OCCE) and *O. corniculata* aqueous (OCAE); and to determine the antioxidant potential by different in vitro assays. OCME was also evaluated for its antioxidant capacity against hepatotoxicity induced with carbon tetrachloride (CCl_4: 1 ml/kg b.w., 20% in olive oil, seven doses) in rat. The results showed the presence of flavonoids, alkaloids, terpenoids, saponins, cardiac glycosides, phlobatannins and steroids in OCME while tannins were absent.

Total amount of phenolic and flavonoids was affected by the solvents and the sequence of solvents for phenolic contents was OCME > OCAE > OCCE > OCEE > OCHE while for flavonoids was OCME > OCCE > OCAE > OCEE > OCHE. Free radicals were scavenged by the extract/fraction in a dose response curve in all models. Biochemical parameters of serum; aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), gamma-glutamyl transpeptidase (γ-GT), total bilirubin, cholesterol and triglycerides were significantly increased while total protein and albumin were decreased by CCl_4. Treatment of CCl_4 significantly decreased the liver contents of reduced glutathione (GSH) and activities of antioxidant enzymes; catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), glutathione-S-transferase (GST), glutathione reductase (GSR) and quinone reductase (QR) whereas elevated the thiobarbituric acid reactive substances (TBARS) contents, and hepatic lesions. All the parameters were brought back to control levels by the supplement of OCME. The results of the study suggest the antioxidant potential of OCME and its fractions as evidenced by scavenging of free radicals and hepatoprotective capacity [58].

CONCLUSION

From the above review, it can be concluded that *Oxalis corniculata* Linn. is used traditionally since many years as reported in various literature. However, after detected of various newer compounds from the plant, several new activities were reported by the researchers and hence the plant is now gaining importance to develop some more new search for the future development by understanding the gene level study. Therefore, considering its versatile medicinal uses, there is an ample scope for future research on *Oxalis corniculata* Linn. and hence further pharmacological investigations are warranted.

REFERENCES

1. Saini S, Kaur H, Verma B, Ripudaman, Singh SK. *Kigellia Africana* (Lin) Benth – An Overview. Natural Product Radiance 2009; 8: 190-197.
2. Fainsworth NR, Akerele O, Bingel AS. Medicinal plants in therapy. Bull WHO. 1985; 63: 965-981.
3. Kubde MS, Khadabadi SS, Farooqui IA, Deore SL. Report and Opinion. 2010; 2(12): 24-31.
4. Agrawal B, Das S, Pandey A. *Boerhaavia diffusa* Linn; a review on its phytochemical and its pharmacological profile. Asian Journal of Applied Sciences 2011; 4(7): 663-684.
5. Goyal BR, Goyal RK, Mehta AA. Phyto-pharmacology of *Achyranthes aspera*: A review. Pharmacognosy Reviews 2007; 1(1): 143-150.
6. Williamson EM, Okpako DT, Evans FJ. Selection, Preparation and Pharmacological Evaluation of Plant Material. John Wiley and Sons, England. 1996; 1: 1-5.
7. Lourteig A *Oxalis* L., subgenera Monoxalis(Small) Lourt., Oxalis y TrifidusLourt. Bradea. 2000; 7: 201-629.
8. Mabberley DJ. The Plant-Book. A portable dictionary of higher plants. Cambridge: University press; 2008.
9. Kirtikar and Basu. Indian Medicinal Plants. 3rd ed. New Delhi : MS periodical experts; 1975. P. 1: 437.
10. Anil Kumar K. Kuntal Das, Joshipura M, Mandal N. *Oxalis corniculata* Linn. -The Plant of Indian subtropics. Herbal Tech Industry 2010; 7-11.
11. Kirtikar KR, Basu BD. Indian Medicinal Plants, 1st ed. Allahabad: The Indian Press; 1988. p. 437-438.
12. Manandhar NP. Plants and People of Nepal. Portland, Oregon: Timber Press; 2002. p. 599.
13. Hussain K, Shahazad A, Hussnain ZU. An ethnobotanical survey of important wild medicinal plants of Hattar, District Haripur, Pakistan. Ethnobotanical Leaflets 2008: 12: 29-35.
14. 14.Taranalli AD, Tipare SV, Kumar S, Torgal SS. Wound healing activity of *Oxalis corniculata* whole plant extract in rats. Ind. J. Pharma. Sci 2004; 66(4): 444-446.
15. Madhavachetty K, Sivaj JK, Tulasi RK. Flowering plants of Chittoor district, Andhra Pradesh, India, 1st ed. Student offset printers, Tirupati. 2008, pp. 54-55.
16. Chopra RN, Nayar SL, Chopra IC. Glossary of Indian medicinal plants (Including the Supplement). Council of Scientific and Industrial Research, New Delhi. 1986.
17. Achola KJ, Mwangi JW, Munenge RW. Pharmacological activity of *Oxalis corniculata*. Pharm. Biol. 1995; 33: 247-249.
18. Raghavendra MP, Satish S, Raveesha A. Phytochemical analysis and antibacterial activity of *Oxalis corniculata*, a known medicinal plant. My. Sci 2006; 1: 72-78.
19. Mary Z, Vasantha kumar KG, Saraswathy, Bikshapathi T. Pharmacognostical studies on changeri *Oxalis corniculata* Linn. (oxalidaceae). Ancient Science of Life 2001; 21(2); 1-8.
20. Taba S. A study in ethnobotany and village economy. khaling plant names.147-169.
21. Manandhar NP. Ethnobotanical note on folk-lore remedies of baglung district Nepal. CNAS journal 1993; 20(2): 184-196.
22. Focho DA, Nkeng EAP, Lucha CF, Ndam WT, Afegenui A. Ethnobotanical survey of plants used to treat diseases of the reproductive system and preliminary phytochemical screening of some species of malvaceae in Central Sub-division. Cameroon. Journal of Medicinal Plants Research 2009; 3(4): 301-314.
23. Achuta AS, Srivatsava S, Rawat AKS. An ethnobotanical study on medicinal plants of Rewa district, Madhya Pradesh. Indian Journal of Madhya Pradesh 2010; 9(1): 191-202.
24. Basumatary SK, Mahmed, Deka SP. Some medicinal plant leaves used by boro (tribal) people of Goalpara district, Assam. Natural product radiance 2004; 3(2): 88-90.
25. Hemant B, Singh MK, Thakur D, Giri TK, Tripathi DK. The Botany, Chemistry, Pharmacological and Therapeutic Application of *Oxalis corniculata* Linn– A Review. International Journal of Phytomedicine 2011; 3: 01-08.
26. Hall DW, Vandiver VV, Sellers BA. Creeping Wood Sorrel, *Oxalis corniculata* L. Southern Yellow Wood Sorrel, Oxalis florida Salisb. SP 37, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.1996, 01-02.
27. Qureshi R, Waheed A, Arshad M, Umbreen T. Medico-ethnobotanical inventory of tehsil Chakwal, Pakistan. Pak. J. Bot. 2009; 41(2): 529-538.
28. Manna D, Dutta PK, Achari B, Lohia AA. Novel Galacto-Glycerolipid from *Oxalis corniculata* Kills Entamoeba histolytica and Giardia lamblia. Antimicrobial Agents Chemother. 2010; 54: 4825-4832.
29. Ibrahim M, Hussain I, Imran M, Hussain N, Hussain A, Mahboob T. Corniculatin A, a new flavonoidal glucoside from Oxalis corniculata. Revista Brasileria de Farmacognosia Brazilian Journal of Pharmacognosy 2013; 23(4): 630-634.
30. Ibrahim M, Imran M, Aali B, Malik A, Afza N, Aslam M, Ullah Z, Rehmani FS. Phytochemical Studies on *Oxalis corniculata*. 2012; 1-627.

31. Raghvendra MP, Satish S., Raveesha KA. Phytochemical analysis and antibacterial activity of *Oxalis Corniculata*, a known medicinal plant. My Science 2006; 1: 72-7825.
32. Iqbal MC, Meiyalaghan S, Wijesekara KB, Abeyrante KP. Antifungal activity from water extracts of some common weeds. Pakistan Journal of Biological Science 2001; 4: 843-845.
33. Dighe S, Kuchekar BS, Wankhede Sagar B. Pharmacological Evaluation of *Oxalis corniculata* Linn. for anthelmintic Activity. Research Journal of Pharmacology and Pharmacodynamics 2012; 4(1): 1-4.
34. Chitwood DJ. Phytochemical based strategies for nematode control. Annual Review of Phytopathology. 2002; 40: 221-249.
35. Silamar F, Leandro GF. Use of antagonistic plants and natural products. In: Chen X, Chen Y, Dickson DW (eds) Nematology advance and perspectives, CAB 33. International, UK. 2005; 2: 931-977.
36. Taba S, Sawada J, Moromizato Z. Nematicidal activity of Okinawa Island plant on the root-knot nematode Meloidogynein cognita (Kofoid and White) Chitwood, Plant Soil. 2008; 303: 207-216.
37. Jain A, Tiwari P, Bashir M. Nutritive Aspects of *Oxalis corniculata* Linn. used by Tribals of Central India During Scarcity of Food. Botany Research International 2010; 3(1): 35-37.
38. Taranalli AD, Tipare SV, Kumar S. Wound healing activity of *Oxalis Corniculata* whole plant extract in rats. Indian Journal of pharmaceutical sciences 2004; 66(4): 444-446.
39. Sakat S,Tupe P, Juveka A. Gastro protective Effect of *Oxalis corniculata* (Whole Plant) on Experimentally Induced Gastric Ulceration in Wistar Rats. Indian J Pharm Sci. 2012; 74(1): 48-53.
40. Sharangouda K, Patil SB. Anti implantation and abortifacient activities of *Oxalis corniculata* in albino rats. Nigerian Journal of Natural Products and Medicine 2007; 11:58-60.
41. Jyothi KSN, Hemadatha P, Schalla S. Evaluation of α-amylase inhibitory potential of three medicinally important traditional wild food plants in india. International Journal of green pharmacy 2011; 95-99.
42. Kathiriya A, Das K, Kumar EP, Mathai KB. Evaluation of antitumor and antioxidant activity of *Oxalis corniculata* Linn. against ehrlich ascites carcinoma on mice. Iranian journal of cancer prevention 2010; 4: 157-165.
43. Watcho P, Nkouathio E, Telesphore B, Nguelefack SIW, Kamanyi A. Anti diarrhoeal activity of aqueous and methanolic extracts of *Oxalis corniculata* klotzch. in rats. Cameroon Journal of experimental Biology 2005; 01: 6-49.
44. Senthil Kumar K.Kand Raj kapoor B. Study on phytochemical profile and anti-epileptic activity of *Oxalis corniculata* Linn. International Journal of Biological & Pharmaceutical Research 2010; 1:34-37.
45. Senthil Kumar K.K and Raj Kapoor B. Effect of *Oxalis corniculata* linn. extracts on antioxidant enzymes levels in rat brain after induction of seizures by MES and PTZ. International Journal of Biopharmaceutics 2010; 1(2): 58-61.
46. Mahadik VJ, Patil SB, Naikwade NS. Evaluation of anti-ulcer activity aqueous and methanolic extract of *Oxalis corniculata* leaf in experimental rats. International Journal of Pharmaceutical Research and Development 2011; 3(10): 98-104.
47. Sakat SS, Juvekar AR, Gamphire MN. In-vitro anti-oxidant and anti- inflammatory activity of methanolic extract of *Oxalis corniculata* linn. International Journal of Pharmacy and Pharmaceutical Sciences 2010; 2 (1): 146-155.
48. Gupta G, Kazmi I, Rahman M, Afzal M, Anwar F. Anxiolytic effect of *Oxalis corniculata* (Oxalidaceae) in mice. Asian pacific journal of tropical disease 2012; 1-6.
49. Sai Sampath T, Santosh P, Mangala Lahkar, Ajaygodwin P, Pavan kumar. S and Lingesh. Anxiolytic effect of ethanolic extract of *Oxalis corniculata* in mice. International Journal of Pharma and Bio Sciences 2011; 2(3); 281-290.
50. Das K, Kathiriya AK, Kumar EP, Benson MK, Einstein JW. Evaluation of hepatoprotective activity of aqueous and ethanolic extract of *Oxalis corniculata* against intoxication of thioacetamide induced rats. Revista Brasileira de Farmacognosia 2012; 22(2): 412-417.
51. Tassa BD, Gogoi G, Das S. A comparative study of the hypolipidaemic and antioxidant activities of ethanolic extracts of leaves of *Phlogacanthus thyrsiflorus*, *Oxalis corniculata* Linn. and *Fragaria vesca* in albino rats. Asian Journal of Pharmaceutical and Biological Research 2012; 2 (1): 12-18.
52. Seraphim ER, Sinha MP. Impact of phyto estrogens on endocrine glands of albino rats II. Adrenal. The Bioscan. 2010; 5(1): 63–66.
53. Abhilash PA, Nilasha, Prathapan A, Suresh V. Nampoothiri, Lizocherian O, Sunitha TK, Raghu KG. Cardio protective effects of aqueous extract of *Oxalis corniculata* in experimental myocardial infarction. Experimental and Toxicological Pathway 2011; 63: 535-540.
54. Rashid M, Zehra H. Amelioration of CCl_4-induced nephrotoxicity by *Oxalis corniculata* in rats. Experimental and toxicological pathology 2013; 65: 327-334.
55. Reddy KY, Lakshmi SM, Kumar AS. Evaluation of diuretic activity of methanolic extract of *Oxalis corniculata* L. in rat. International Journal of Phytopharmacology 2012; 3(1): 61-65.
56. Sampath kumar V, Venumadhav V, Jagadeshwar K, Bhaskar B, Mangala Lankar. Evaluation of antioxidant and antinociceptive activities of *Oxalis corniculata* Linn. In diabetic neuropathy rats. International Journal of Pharmacology 2012; 8(2): 122-127.
57. Borah A, Yadav RNS, Unni BG. Evaluation of antioxidant activity of different solvent extracts of Oxalis *corniculata* L. Journal of Pharmacy Research 2012; 5(1): 93.
58. Khan MR, Marium A, Shabbir M, Saeed N, Bokhari J. Antioxidant and hepatoprotective effects of *Oxalis corniculata* against carbon tetrachloride (CCl_4) induced injuries in rat. African Journal of Pharmacy and Pharmacology 2012; 6(30): 2255-2267.