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Review Article

PORTULACA OLERACEA LINN: A GLOBAL PANACEA WITH ETHNOMEDICINAL AND PHARMACOLOGICAL POTENTIAL

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ABSTRACT

Portulaca oleracea L. belongs to the family Portulaceae, is a warm-climate annual herb, known as *khurfa* in Arabic and common purslane in English. The plant is succulent, herbaceous, erect or decumbent growing up to 30 cm height with cylindrical stem of 2-3 mm in diameter. The plant, which is common weed of cultivation, are eaten as a vegetable and used for medicinal purposes. Traditionally, since antiquity this plant has been used for the treatment of various ailments like skin diseases, fever, dysentery, diarrhea, bleeding piles, kidney, liver, spleen diseases etc. The qualitative phytochemical studies of this plant extract showed the presence of alkaloids, coumarins, flavonoids, cardiac glycosides, anthraquinone, saponins, tannins etc. The plant is reported to have versatile biological activities like antipyretic, antitussive, diuretic, hypolipidemic, antiulcerogenic, anti-inflammatory, anticonvulsant, antimicrobial properties etc. The present review is an endeavour to summarize the recent knowledge of significant traditional uses, pharmacognosy and pharmacological activities of the plant *P. oleracea.*

Keywords: *Portulaca oleracea* L; *Khurfa*; Purslane; Phytochemical constituents; Pharmacological activities; Saponins

INTRODUCTION

Portulaceae is a family of annual or perennial herbs and rarely shrubs. It contains about 19 genera and 500 species. *Portulaca* is an important genus of this family includes 150 species and *P. oleracea* Linn is one of the leading species in this genus. The origin of the plant is uncertain; however archeobotanical findings are very common at many prehistoric sites. Seeds were found in archaeological sites in the Emilia Romagna Region (Northern Italy), since the Bronze Age [1]. In historical perspective, seeds have been recovered from a protogeometric layer in Kastanas and from the Samian Heraion dating back to seventh century B.C. Theophrastus (fourth century B.C) names purslane, *andrákhne* (ἀνδράχνη), as one of the several summer pot herbs that must be sown in April. Pliny advised wearing the plant as an amulet to expel all evil in antiquity because of its healing properties which were thought to be so reliable [2]. Its use as medicinal herb dates back at least 2000 years but it was used as food well before this period. Ancient Romes used it to treat dysentery, intestinal worms, head ache and stomach ache [3]. It has an extensive old world distribution, extending from North Africa through Middle East and the Indian subcontinent to Malaysia and Australia [4]. According to Duke (2002), the purslane plant has very important effects in the medicinal field (approximately 30 different biological activities and over 60 medicinal indications concerning the plant), and he considers it a "medicinal food" to consume like spinach [5]. *P. oleracea* is currently considered so much interesting from a food point of view [6] that it is included in the list of "World Economic Plants" [7]. It is frequently mentioned in alternative system of medicine. All the parts of this plant have medicinal properties: from the roots to the stem, from the leaves to the seeds [8, 9].

The etymology, *Portulaca* word is derived from the Latin, portula means little door, possibly from the type of dehiscence of the fruit [8]. Olera means vegetable, points toward its widespread use as food of this species in the Classical World. The common Italian name, "porcellana", is derived from the Latin term used by Pliny (1st cent. A.D.), porcilaca, meaning, an herb liked by pigs, with the root, lac = milk, which seems underline the mucilaginous content found in the plant [1].

Scientific Classification

Kingdom: Plantae

Division: Magnoliophyta

Order: Caryophyllales

Family: Portulacaceae

Genus: Portulaca

Species:*oleracea* [4]

Vernacular name

Arabic: *Baqlatul humqa* [9,10], *khurfa* [10], *baqlatul mubarika*, *rijala* [11]; **Bengali**: *Baraloniya* [12], *chotaluniya, kulfi, munya* [10]; **Chinese:** *Ma chin Hsien* [14]; **English:** *Common purslane, garden purslane, purslane* [10] **Greek:** *Andrachni, andrakala, antrakala* [10]; **Hindi:** *Baralunia, chhotalunia, lonia, lunia, lunuk, muncha, nonkha, khurfa*, [12] *khursa* [12]; **Kannada:** *Doddagonisoppu,* [12] *gonisoppu;* **Persian:** *Cholza, khurfah, kurfah, lonika* [10]; **Sanskrit:** *Brihalloni, lonika, lonamla*, [12] *gholika, lunia;* **Tamil:** *Karikkirai, parapukkiray, pullikirai* [10, 12]; *pasalakkirai;* **Urdu:** *Khurfah* [10]

Botanical description: *P. oleracea* is a succulent annual herb. Stems sometimes flushed red or purple, not articulated, prostrate or decumbent, less often erect, diffuse, much branched; leaf axils with a few inconspicuous stiff bristles. The leaves are alternate or occasionally subopposite, petiole short, leaf blade flat, obovate, 10-30 × 5-15 mm, base cuneate, apex obtuse, rounded, and truncated. The flowers are in clusters of 3-5, 0.4-0.5 cm in diameter, surrounded by involucre of 2-6 bracts. Sepals are green, helmeted, ca. 4 mm, apex acute, and keeled. Petals 5, yellow, obovate, 3-5 mm, slightly connate at base, apex retuse. Stamens 7-12, ca. 12 mm; anthers are yellow. Ovary is glabrous. Stigma is 4-6-lobed. Capsule ovoid, ca. 5 mm. Seeds glossy black when mature, never iridescent, obliquely globose-reniform, 0.6-1.2 mm; testa cells stellate, usually with central peg like tubercle, sometimes without and then surface granular [13]. Seed production of these plants is very high (one plant can introduce up to 10,000 seeds to the environment. It has a slightly sour and salty taste. The stems, leaves and flower buds are all edible [4].

Habitat: Purslane is found in all over India and up to 5,000 ft in the Himalaya and all warm countries [10].

Pharmacological actions in traditional and ethnomedicine: The important actions in alternative system of medicine and ethnomedicine show the precision of the data. Its comparison provides a concise summary that the alternative system of medicines itself has tremendous evidences not a mere of chance.

Action mentioned in Unani medicine: *Dafe humma* (antipyretic); *habis dam* (styptic); *mudir baul* (diuretic); *dafe ishal* (antidysentric);

dafe sua'l (antitussive) [14]; antidiabetic; *qatile karim shikam* (antihelmintic) [11, 14]; *musakkin safra* [15]

Action mentioned in ethnomedicine: Anaphrodisiac; emollient; calmative [16]; diuretic [12, 16, 17, 18, 19]; antiscorbutic [12, 16, 18, 19]; vermifuge [16]; refreshing agent [16, 17, 18]; alterative [17]; aperients [12, 19]. The diuretic action is probably due to the presence of high percentage of potassium salts [12, 18, 19].

Therapeutic Uses mentioned in Unani classical literature: Whole plant and seeds of the plant is used for same purpose, but seeds are considered weak in action. Juice of the plant (30g) with sugar is administered orally is beneficial in intestinal worm infestation [14]. Whole plant cooked with ghee and onion is beneficial for bilious dysentery [11, 14]. It is refrigerant and useful in excessive thirst [9]. Paste of whole plant made with rose oil relieves headache. This paste is also used on burn wound, inflammed area, orchitis and pleurisy. Juice with rose oil is effective to cure boils on scalp and headache [11, 14]. It is aphrodisiac for the person with hot temperament while in cold temperament person it may reduce libido [14]. Juice of leaves and branches (60g) is commonly useful in dysuria. Orally, macerated leaves are given in high fever [14, 15]. Whole plant or its juice is useful in gastritis [21, 22]. It is hemostatic thus used in polymenorrhagia, bleeding piles, hemoptysis [11, 15, 20, 21, 22]. It helps in thickening of blood [11, 22]. It helps in cleansing the teeth [22]. Leaves rubbed on the warts remove it. Juice alone or incorporated in powder and applied in eyes is beneficial in conjunctivitis [21] and intestinal ulcers [11]. It is useful in hot inflammation, gastric burning, fever and pain in bladder [11, 15]. It is useful in burning micturition [11].

Seeds: Roasted seeds given internally cause constipation, whereas unroasted seeds are laxative [11, 14]. Seeds with honey are used as aphrodisiac [14]. Its seeds with *sheera* of leaves of khas are beneficial in enhancing sleep [14]. Locally, paste is applied in all types of skin diseases, burn wounds, scalds and boil [14, 21]. Seeds are useful in children suffering from stomatitis and piles [11, 15]. Enema of seed's water, stops bile to fall on intestine and beneficial in bilious diarrhea [11]. It is used as diuretic and remove stones from the kidney [11].

Dosage: Whole plant juice 36 to 72 g; 6-7 g (seed) [14].

Formulations mentioned in Unani Medicine:

Dawa ul misk; mufarreh barid; ban'duqul bazoor; qurs sartaan [15]

Therapeutic uses mentioned in ethnomedicine:

Since antiquity this herb is use as vegetable, spice and medicinal plant in Egypt and England.

Its earliest recorded use dates back to around 500 AD in China in the Ben Cao Jing Ji Zhu. Traditionally, it is considered sour tasting and cold with heat relieving and detoxicant properties. It is considered to have blood cooling and hemostatic properties hence useful internally in bleeding bacillary dysentery, hematochezia (bloody stool), bleeding haemorrhoids and metrorrhagia. Externally, it is useful in bleeding condition. The whole plant and leaves are used in China as sour, diuretic, cooling herb that lowers fever and clears toxins. The leaves are used for poulticing tumors, bed wounds, ulcers and edematous swellings, also for hemorrhage and leucorrhea. The seeds decoction is considered as excellent diuretic. In Africa whole plant is considered as antiphlogestic and bactericidal in bacillary dysentery, diarrhea, hemorrhoids, enterorhagia and used as antidiabetic. It is used externally as cataplasm for maturing of the abscesses. The seeds are considered calmative and useful in polydypsia. The herb is generally used for heart trouble in Ghana. The plant is used in the treatment of hemoptysis and pulmonary diseases and decoction of leaf (macerated leaf in cold water) is useful in palpitation. The American Indians, for the treatment of colds used purslane and decoction of the herb is also useful in gout and headache. In inflammation of male genitalia the juice of the plant is beneficial. The leaves are infused in linseed oil as a liniment for stiff neck. The Indians use this plant for treating excessive menstrual flow, stomachache, hemoptysis [16], and inflammation of stomach [17]. The mixture of plant juice with honey is used for cough.

The herb is also prescribed in the treatment of cardiovascular diseases, dysuria, hematuria, gonorrhea, dysentery, sore nipples and ulcers of the mouth. The juice of plant is sometimes used in earache and toothache [12].

Leaves: The fresh leaves bruised are applied to the temples to allay excessive heat and pain. It is also used as a cooling external application in erysipelas and an infusion is given as a diuretic [12, 17, 18]. Herb is useful in scurvy, liver [10, 12, 17], spleen [12] and kidney and bladder diseases [18, 19]. The leaves and tops are employed in anti-hemorrhagic poultices [12].

Stem: Juice of the stem is useful in cases of prickly heat and in burning sensation of hands and feet. It has soothing effect [10, 17].

Seeds: Plant and seeds are useful in hematuria, gonorrhea, dysuria, strangury and diseases of kidney, bladder and lungs [17]. The bruised and boiled seeds are used as vermifuge and the decoction is useful in gonorrhea [16]. The seeds are considered diuretic and antidysenteric [12, 18, 19].

In Srilanka, it is useful in catarrhal and urogenital ailments [16].

In Nigeria the leaves are used as a local application to swellings [10].

In North America the seeds at one time were thought to be anthelmintic, though not known to be inert [10].

In Jamaica it is used in fevers. Bruised, it is applied to the temples to allay excessive heat and pain. The juice is also useful in spitting of blood [10].

In Vietnam the entire plant except roots is used as an anti-inflammatory, antihelmintic and antibacterial. Macerated fresh plant (100g) juice diluted with water is used against oxyuriasis and ascariasis. It is administered in the morning for 3-5 days. Fresh leaves poultice is useful to treat boils, impetigo and mastitis [16].

Pharmcognostical and phytochemical standardization

In transverse section of the leaves, the whole mesophyll consists almost solely of aqueous tissue; the vascular bundles are surrounded by sheath of green palisade cells. The ergastic substance occurs in the form of prismatic and rosettes of calcium oxalate crystals of different sizes. The leaf is amphistomatic; the number of stomata on adaxial surface is higher than that of the abaxial ones. The types of stomata are paracytic and are accompanied on both sides by subsidiary cell placed parallel to the pore. Transverse section of petiole reveals that lower surface is comparatively very much bulged while the upper one slightly depressed. It is protected by a thick, striated cuticle all around. The uniseriate epidermis is made up of tangentially elongated tubular parenchymatous cells. The anticlinal wall of lower epidermal cell is curved and these cells contain some dark pigment. Next to epidermis is brown tissue, comprised of 4-6 layers of thin walled rounded parenchymatous cells having distinct intercellular spaces. The outer larger parenchyma cells having distinct intercellular spaces, and are rich in calcium deposition which is in the form of druses while smaller parenchymal cells are rich in chloroplast. The endodermis is present but not clearly distinguishable and they contain starch grains. The vascular bundles are about 2-4 in numbers are collateral, closed, placed more or less centrally and arranged in an arch which opens towards adaxial side. In each bundle, xylem is on the adaxial side and the phloem on abaxial. The protoxylem facing the adaxial side of the petiole radiates towards the lower side with distinct metaxylem.

Transverse section of the stem is almost circular in outline; the epidermal cells are polygonal in shape and are surrounded externally by thick striated cuticle. Epidermis is followed by 2-3 layers of collenchymas cells. Next to which are the isodimetric parenchymatous cells densely filled with starch grains, simple as well as compound. Druses, prismatic acicular crystals and colorless mucilage cells are frequently found. The endodermis is not well defined. A large number of collateral vascular bundles are found arranged in a ring enclosing big pith which is made up of thin walled isodimetric cells, some of which contain calcium oxalate crystals. The vessels having helical scaliform thickenings show simple perforations. Fibers often grow intrusively [12].

Analysis of edible leaves and stems (51% of herb) showed moisture 90.5%, protein 2.4%, carbohydrates 2.9%, mineral matter 2.3%, Calcium 111 mg, magnesium 120 mg, oxalic acid 1697 mg, total phosphorus 45 mg, phytin phosphorus 4 mg, total iron 408 mg, ionisable iron 1mg; sodium 67.2 mg, potassium 716 mg, copper 0.19 mg, sulphur 63 mg, chlorine 73 mg, chlorine 73 mg thiamine 0.10mg, riboflavin 0.22 mg, nicotinic acid 0.7 mg and vit C 29mg per 100g and Carotene 3.82 IU/100g [12]. It also contains various other constituents including iron, manganese, urea and fatty acids (especially omega-3-acids whose concentration in *P. oleracea* is the highest found in leafy vegetables [23, 24, 25, 26, 27].

Phytochemical constituents: Some of the reported biologically active compounds include alkaloids, coumarins, flavonoids, cardiac glycosides, anthraquinone glycosides, alanine, catechol, saponins, tannins and organic acids like oxalic acid, cinnamic acids, caffeic acid, malic acids and citric acids. Furthermore, the occurrence of glutathione, glutamic acid and aspartic acid has been published by Simopoulos *et al*. [27].

Moreover, the whole plant contains large amounts of l-norepinephrine (0.25% in fresh herb), soluble carbohydrates, fructose/fructane, vitamins, A, B1, B2, B6 and it is rich in ascorbic acid [28]. The seeds contain 17.4% of a fixed oil containing β-sitosterol [29].

The leaves contain 0.42% mucilage, which is composed of an acidic and a neutral fraction. The acidic fraction consists of galacturonic acid residues joined by α-(1→4) linkages. The neutral fraction is composed of 41% of arabinose and 43% of galactose residues, besides traces of rhamnose residue [26, 29].

Imperato (1975) studied the acylated betacyanins of *P. oleracea* and isolated two red-violet pigments (Olecacin I and II). He found that Olecacin I converted upon treatment with aqueous citric acid to Olecacin II. Upon alkali treatment, this mixture yielded ferulic acid and two new diastereoisomeric pigments (DO1 and DO2), which were separated by chromatography on polyamide. DO1 was identified as betanidin 5-0-cellobioside and DO2 was isobetanidin 5-0-cellobioside [30]. Sakai *et al*. (1996) isolated a i.e. Portuloside A from the methanolic extract of *P. oleracea* [31].

The fatty acid content in *P. oleracea* ranged from 1.5 to 2.5 mg/g of fresh mass in leaves, 0.6 to 0.9 mg/g in stems and 80 to 170 mg/g in seeds. The β-carotene content ranged from 22 to 30 mg/g fresh mass in leaves. Longer-chain omega-3 fatty acids were not detected [32]. α-Linolenic acid accounted for around 60% and 40% of the total fatty acid content in leaves and seeds, respectively. It is the uniqueness of purslane as the "richest vegetable source" of omega-3 fatty acids and protein compared to other vegetables has been concluded [23]. A water-soluble an ionic, low molecular weight polysaccharide (gum) with surface, interfacial, and emulsification properties was extracted from leaves of *P. oleracea* and named *P. oleracea* gum which probably considered as a new good food emulsifier [24, 29].

Rashed and co-workers identified allantoin, N, N'-dicyclohexylurea and β-sitosterol-glucoside in fresh aerial parts of *P. oleracea* [33].

Pharmacological activities

1. **Anticonvulsant activity:** The aqueous extract of *P. oleracea* leaves was trailed for anti convulsant activity in healthy albino mice. Extract significantly reduced the duration of tonic hind limb extension in Maximal Electroshock. It also delayed the onset and decrease the duration of clonic convulsion induced by pentylene tetrazole in a dose dependent manner [34].

2. **Antimicrobial effect:** Antimicrobial effect of *P. oleracea* extracts on food borne pathogens was assessed by Bae JH. He found ethyl acetate extract was having highest anti microbial activity against *Staphylococcus aureus* and *Shigella dysentrica* in comparison to petroleum ether, chloroform and methanol extracts. The ethyl acetate extract of *P. oleracea* showed strong antimicrobial activity against *Staphylococcus aureus* at 4000 ppm concentration. This concentration retarded the growth of *S. aureus* by more than 24 hours and *S. dysentrica* up to 12 hours at 37 ^{o}C [35].

Dhole *et al.* screened the aqueous and ethanolic extracts of root and leaves of *P. oleracea* for antimicrobial activity against two gram-positive bacteria (*Bacillus subtilis*, *Staphylococus aureus*), one gram-negative bacterium (*Pseudomonas aeruginosa)* and a mould *Aspergillus niger* by agar diffusion method. The highest antibacterial and anti fungal activity was observed at the concentration of 750 µg/ml. Ethanolic root extract was more potent to inhibit growth of *Pseudomonas aeruginosa,* while aqueous extract was comparatively more potent for other three microbes [36].

The antifungal activity of *P. oleracea* extracts on dynamic hyphal growth response curves of various fungi was evaluated in real time using an automatic single-cell bioassay system against *Aspergillus*, *Trichophyton* and the yeast *Candida*. A crude sample obtained by Ethyl acetate extract showed a specific and marked activity against dermatophytes of the genera *Trichophyto*n [37].

3. **Antitussive effect:** Boroushaki *et al.* evaluated the antitussive effect of aerosols of two different concentrations (2.5% and 5%) of boiled extract of *P. oleracea* plant in citric acid aerosol induced coughs in guinea pigs and compare it with codeine (0.03 g/ml) and saline. Both concentrations of boiled extract and codeine caused significant reduction in number of citric acid induced coughs compared to saline ($p<0.001$). However, the antitussive effect of 5% concentration of boiled extract was significantly different with that of codeine ($p<0.01$), and 2.5% extract showed no significant difference from codeine. There was also significant difference between antitussive effect of both boiled extracts ($p<0.001$). EC50 of the plant extract was 4.5% [38].

4. **Broncho dilator effect:** Boskabady *et al.* reported that boiled and aqueous extract of *P. oleracea* showed a relatively potent relaxant (bronchodilatory) effect in concentration–dependent manner on guinea pig's tracheal chain, which was comparable with that of theophylline. These results were comparable to or even greater than theophylline at different concentration [39].

5. **Antioxidant activity:** Sanja *et al*. investigated the in-vitro anti-oxidant activity of the methanolic extract of *Portulaca oleracea* by 1,1-diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging activity, reducing power by FeCl, nitric oxide free radical scavenging activity and super oxide scavenging activity by alkaline DMSO method. The methanolic extract shows significant in vitro antioxidant activity in a higher dose than standard antioxidant [40].

Arda and co-workers examined the ability of *P. oleracea* to reduce oxidative stress induced by vitamin A deficiency in male Wistar rats. The thiobarbituric acid-reactive substances (TBARS), reduced (GSH) and oxidized (GSSG) glutathione, and antioxidant enzyme activities were determined in the heart and liver. The rats fed pure beta-carotene diet and diet supplemented *P. oleracea* leaves, showed liver and heart TBARS concentrations lower than vitamin A-deficient diet rats. The liver GSH concentration of beta-carotene and *P. oleracea* leaves fed rats was lower compared to vitamin A-deficient diet rats. The heart GSSG concentration of the purslane group was significantly lower than in vitamin A deficient rats. Liver and heart catalase activities were not significantly different among the groups, nor was heart glutathione peroxidase (GPX) activity; however the beta-carotene fed rats showed the highest liver GPX activity. There was no difference in liver glutathione-S-transferase level among the groups, while heart activity was higher in rats fed the vegetable leaves. This study evidences that the ingestion of purslane leaves may have a protective effect against oxidative stress caused by vitamin A deficiency [41].

Yang *et al.* also established the anti oxidant properties of phenolic alkaloids, i.e., oleracein A (OA), oleracein B (OB) and oleracein E (OE), isolated from *P. oleracea* against 1,1-diphenyl-2-picryl-hydrazyl (DPPH) radical and inhibitory effect on hydrogen peroxide-induced lipid peroxidation in rat brain homogenates [42].

6. **Hepatoprotective activity:** The suspensions of methanol and petroleum ether extracts of entire plant of *P. oleracea* in carboxy methyl cellulose were evaluated for hepatoprotective activity in Wister albino rats by inducing hepatic injury with D-galactosamine

(400 mg/kg). Altered biochemical parameters were significantly restored at the dose levels of 200 and 400 mg/kg when compared to d-galactosamine and Silymarin treated groups. Histology of the liver sections of albino rats also showed to significantly prevent the d-galactosamine toxicity as revealed by the hepatic cells with well-preserved cellular architecture. Biochemical and histological data confirmed significant hepatoprotective activity of these extracts [43].

Al-Howiriny evaluated the hepatoprotective effect of freeze dried juice extract of Purslane in carbon tetrachloride (CCl4) induced acute hepatotoxicity in rat. Purslane treatment (at 150 and 300 mg/kg, p.o) for 10 consecutive days prior to CCl4 administration significantly prevented the increase in the serum levels of hepatic enzymes, glutamate oxaloacetate transaminase, glutamate pyruvate transaminase, gamma glutamyl transferase, alkaline phosphatase and bilirubin. The purslane extract, also exhibited the capacity to replenish CCl4 induced decreased level of non protein sulfhydryl concentration and decreased the elevated malondialdehyde level in the liver tissue. Moreover, purslane extract significantly prevented the CCl4-induced prolongation in pentobarbitone sleeping time in mice. These findings suggest that purslane prevents acute liver damage through its intrinsic antioxidative chemical components which act as a powerful antioxidant [44].

Ahmida *et al.* investigated the effect of fresh juice of *P. oleracea* on the oxidative stress in paracetamol induced hepatic toxicity in male rats. Study included biomarkers of hepatic toxicity such as histopathological study and serum activity of AST, ALT, ALP and γ-GT. Oxidative stress and antioxidants of liver were studied by determination of reduced glutathione (GSH), Superoxide Dismutase (SOD) and catalase (CAT) enzyme activities and lipid peroxidation. Administration of *P. oleracea* juice with paracetamol significantly ameliorated the indices of hepatotoxicity induced by paracetamol. In addition, juice alleviated paracetamol induced oxidative changes in liver. Study demonstrated that plant juice inhibits paracetamol induced hepatotoxicity and might serve as a protective agent with paracetamol to limit its free radical induced liver injury [45].

7. **Nephroprotective effect**: Aqueous and ethanolic extract of *P. oleracea* against cisplatin induced acute renal toxicity was studied in rats. Treatment with aqueous and ethanolic extracts in the highest dose (0.8 and 2 g/ kg), 6 and 12 hour before cisplatin injection reduced blood urea nitrogen and serum creatinine. Tubular necrotic damage was also not observed. In another group rats treated with aqueous and ethanolic extract, 6 and 12 hr after cisplatin injection also had blood urea nitrogen and serum creatinine levels significantly lower than those receiving cisplatin alone but mild to moderate cell injury was observed [46].

8. **Neuroprotective effects:** Li-Wei and co-worker evaluated the effects of flavones extracted from *P. oleracea* on ability of hypoxia tolerance in mice. They found survival time of mice in hypoxic conditions in flavones-treated group was significantly longer than that in the untreated group. The RBC, Hb concentration, HCT, plasma EPO level and the relative values of EPO mRNA in renal tissue and pallium of mice were significantly higher in the flavones-treated group than those in the untreated group [47].

Wang *et al.* investigated the hypoxic neuroprotective effects of *P. oleracea* extracts in mice. After oral administration with the extracts or distilled water for seven days, mice were kept in a normobaric low oxygen environment (10% oxygen and 90% nitrogen) for different time and then were sacrificed. The mouse cortices were used for histological analysis. The activities of pyruvate kinase (PK), phosphofructokinase (PFK), lactic acid and the level of lactate dehydrogenase (LDH) and ATP were detected, and the mRNA and protein levels of EPO in the cortices were analyzed. PC-12 cells and primarily cultured nerve cells were used for 3-(4, 5-Dimethylthiazol-2-yl) 2,5-diphenyltetrazolium bromide assay. Their results showed that the *P. oleracea* extracts enhanced the EPO mRNA and protein expression in the mouse cortices. Compared to the control group, the mouse in the group treated with the PO extracts by 1 g/d had significantly higher activities of PF, PFK, LDH and higher levels of ATP in the cortices, especially under the hypoxic environment for 24 hours. Histological analysis indicated that the extracts lessened the inflammation damage of the mouse brain. MTT assay results showed the extracts or the herb-containing serum raised the viability of the cells under the tested hypoxic conditions and decreased the degree of LDH in the culture medium in a dose-dependent manner. These results showed that PO extracts had protective effects on hypoxic nerve tissue [48].

Hongxing and co-workers assessed neuroprotective effects and mechanisms of natural plant purslane herb aqueous extracts at doses of 2.5, 5 and 10 mg/(kg day) on SD mice injected daily with d-gal (50 mg/(kg day)) by behavioral tests. Extract fed mice showed higher activity upon induction by new environmental stimuli, lower anxiety and higher novelty-seeking behaviour in the open field tasks, and significantly improved learning and memory ability in step-through compared with d-gal-treated mice. Researchers further examined the mechanisms involved in neuroprotective effects of the extract on mouse brain. Extract significantly increased superoxide dismutase activity and decreased the malondialdehyde level. They found that p21 waf1 was down regulated by this extract without changing the expression of p53. They conclude that the effects of extract might be carried out through a p21 waf1 -dependent and p53-independent pathway [49].

In another study, Moneim *et al*. demonstrated that purslane aqueous juice administration significantly increased the different monoamines, acetylcholinesterase activity in rats due its content of melatonin, omega-3 fatty acid, phenolic and flavonoids compounds and other active ingredients, suggesting the potential role of purslane for neurotransmitters which is an integral part of many neurodegenerative disorders [50].

9. **Skeletal muscle relaxant activity:** Parry *et al*. evaluated the skeletal muscle relaxant activity of aqueous extract of the stems and leaves of *P. oleracea.* They found that extract abolishes the twitch contraction of the directly stimulated rat hemidiaphragm preparation. They further note that the effects of the extract mimic qualitatively the action of potassium oxalate, (a known constituent of *P. oleracea*) on the diaphragm. Removal of K+ ions from the methanol extract by passing it through a cation exchange resin reduced the inhibitory effect of the extract. There was a positive correlation between the concentration of K+ ions in the extract and the effects of potassium chloride of similar molarity. It is concluded that the K+ ion content of *P. oleracea* is at least partly responsible for the relaxant effect observed on the isolated rat diaphragm [51].

Earlier Okwuasaba and co-worker examined the skeletal muscle relaxant properties of an aqueous extract of this plant on the twitch and tetanus tension evoked by electrical stimulation using the rat phrenic nerve hemidiaphragm and frog sciatic nerve-sartorius muscle preparations and on contractures induced by nicotinic agonists using the rat rectus abdominis muscle preparation. Their observations indicate that the aqueous extract possesses unique skeletal muscle relaxant properties which do not appear to involve interference with cholinoceptor mechanism(s). They concluded that the mechanism of action of the extract may involve interference with Ca2+ mobilization in skeletal muscle [52].

10. **Effect on smooth muscle blood pressure:** An aqueous extract of *P. oleracea* leaves and stems produced a dose-dependent relaxation of guinea pig fundus, taenia coli and rabbit jejunum and a dose-dependent contraction of the rabbit aorta. On spontaneously-beating rabbit right atria and electrically-paced left atria, the extract produced a dose-dependent negative inotropic and chronotropic effects. On rat blood pressure, the extract produced dose-dependent pressor responses. Phentolamine reduced the relaxant effect of the extract on gut smooth muscle and abolished the contractile response on the aorta as well as the pressor response on blood pressure. Guanethidine and tetrodotoxin had no effect on extract-induced relaxant or contractile responses. On rat blood pressure atropine and cyproheptadine had no effect on extract-induced pressor response, whereas propranolol slightly reduced the pressor response. An increase in extracellular calcium reversed the inhibitory effect of the extract on the rabbit atria. They conclude that the extract may act in part on postsynaptic alpha-adrenoceptors and by interference with transmembrane calcium influx [53].

11. **Antidiabetic effect:** A study aimed at revealing the effects of polysaccharide from *Portulaca oleracea* on alloxan-induced diabetic rats and its mechanisms. The polysaccharide treatment resulted in significant decreases of fasting blood glucose, total cholesterol and triglycerides. Polysaccharide also showed a tendency of improvement body weight gain on diabetic rats. Furthermore, the diabetic control group had low serum insulin level comparing with that of normal control group, at the same time, the insulin levels were dose-dependently raised in the polysaccharide treated groups than that of diabetic control group. According to single cell gel electrophoresis and LD50 analysis, polysaccharide was proved to be nontoxic to the animals. The results indicate that polysaccharide would alleviate the blood glucose and lipid rising associated with diabetes, and improve the abnormal glucose metabolism and increase insulin secretion by restoring the impaired pancrease cells in alloxan-induced diabetic rats, which suggest that polysaccharide has the hypoglycemic potential and could be useful on the diabetes therapy [54].

Gong *et al.* also assessed the effects of crude polysaccharide from purslane on blood glucose, body weight, total cholesterol, high-density lipoprotein cholesterol, triglyceride and serum insulin levels in diabetes mellitus mice. Treatment with crude polysaccharide from Purslane (200, 400 mg/kg bw) for 28 days resulted in a significant decrease in the concentrations of fasting blood glucose, cholesterol and triglyceride. Furthermore, this polysaccharide significantly increased the concentration of HDL-c, body weight and serum insulin level in the mice. In addition, according to acute toxicity studies it did not produce any physical or behavioural signs of toxicity. Their data demonstrated best effects at the dose of 400 mg/kg bw. These results suggest that crude polysaccharide from purslane can control blood glucose and modulate the metabolism of glucose and blood lipids in diabetes mellitus mice [55, 56].

Sharma *et al.* studied the effect of *P. oleracea* on blood glucose level, tissue lipid peroxidation and antioxidant status in experimental diabetic rats. Antidiabetic treatment with extract of *P. oleracea* leaves (100mg/kg and 250mg/kg body weight) for three weeks showed significant reduction in thiobarbituric acid reactive substances (TBRAS) and increase in glutathione reductase (GSH-R) in both liver and kidney of STZ diabetic rats. The treatment with *P. oleracea* significantly altered the glutathione and GSH-R to be comparable with the control group. *P. oleracea* and tolbutamide treated rats showed decreased lipid peroxidation that is associated with increased activity of superoxide dismutase (SOD) and catalase (CAT). Study showed that though, *P. oleracea* extract possesses moderate antidiabetic activity; it exhibits potent antioxidant potential in diabetic conditions [57].

12. **Toxicity study**: Toxicity studies carried out by Musa *et al.* on methanolic extract of *P. oleracea* on mice given intraperitoneally. The LD 50 with Miller and Tainter method was, 1853.5mg/kg^{-1}, Reed and Muench method 1871mg/kg^{-1} and with Karber method 1875 mg/kg^{-1}. These finding shows that the plant is moderately toxic. Histopathological findings also showed toxic effect on kidney, lung and liver in dose dependent manner, while heart and spleen showed no significant histopathological changes [58].

13. **Anti inflammatory activity**: Chan *et al.* evaluated the *P. oleracea* sub sp. *sativa* for further work due to its abundant availability from reliable sources. The 10% ethanolic extract of the aerial parts showed significant anti-inflammatory activity in the carrageenan-induced hind paw oedema and the cotton pellet-induced granuloma models in rats, and significant analgesic activity in the hot-plate and tail flick models (in mice and rats, respectively) after intraperitoneal administration [59].

14. **Wound healing activity:** The preliminary wound healing activity of *P. oleracea* was studied using *Mus musculus* JVI-1. For this purpose fresh homogenized crude aerial part of *P. oleracea* were applied topically on the excision wound surface as single and two doses in different amounts. The results obtained indicated that *P. oleracea* accelerates the wound healing process by decreasing the surface area of the wound and increasing the tensile strength. The greatest contraction was obtained at a single dose of 50mg and the second greatest by two doses of 25mg. Measurements of tensile strength and healed area were in agreement [60].

15. **Antiulcerogenic effect:** Gastroprotective effect of 50% ethanolic extract (50, 100 and 150 mg/kg body weight BD. po.) of *P. oleracea* was assessed in different gastric ulcer models (i.e. gastric ulcers induced by ethanol, aspirin, cold restraint stress and pyloric ligation) in rats. Study showed dose dependent inhibition of ulcer index with maximum index reduction in ethanol and minimum in aspirin induced ulcer. Extract also prevents the oxidative damage of gastric mucosa by blocking lipid peroxidation and by significant decrease in superoxide dismutase, and increase in catalase activity [61].

Karimi *et al.* also studied the aqueous and ethanolic of whole plant extracts in mice for their ability to inhibit gastric lesions induced by HCl, absolute ethanol and pylorus-ligation, and compare it with sucralfate. In addition, they also measure effects on gastric acid secretion. Both extracts showed a dose-dependent reduction in severity of ulcers. The highest dose of extracts exerted similar activity to sucralfate. The oral and intraperitoneal administration of extracts reduced the gastric acidity in pylorus-ligated mice. These results show that *P. oleracea* possesses significant gastroprotective activity which might be due to gastric defence factors and validate its use in folk medicine for gastrointestinal diseases [62].

16. **Anti-implantation and abortifacient properties:** In a study Albino rats were orally administered with petroleum ether, chloroform and ethanol crude extracts of aerial part of *P. oleracea* at the dose of 500 mg and 250 mg / kg of body weight / day, for 7 days, and effect on anti implantation and abortifacient activity was investigated. The treatment of petroleum ether crude extract has shown 20% and 30% reduction in implantation activity at low (250) and (500) high doses respectively. The chloroform extract has shown 50% and 60% reduction in implantation activity at low and high doses respectively, whereas ethanolic crude extracts have shown 40% and 50% reduction in implantation sites with respect to low and high dose of extract treatment . Ethanolic crude extract treatment has also exhibit abortifacient activity but the petroleum ether and chloroform extract treatment to pregnant rats did not shown any abortifacient activity [63].

Clinical studies

Bronchodilatory effect: Bronchodilatory effect of boiled extract of *P. oleracea* in the dose of 0.25 ml/kg of 5% boiled extract in comparison with 3 mg/kg oral theophylline and 200 microg inhaled salbutamol in asthmatic patients were examined by Malek and co-workers. Results showed that the boiled extract of *P. oleracea* caused significant increases in all measured pulmonary function tests, ($P < 0.05$ to $P < 0.01$). There was no significant difference between PFTs due to the boiled extract and theophylline. However, extract were significantly less potent than those of salbutamol ($P < 0.05$ for both cases). Researchers concluded that *P. oleracea* has a relatively potent but transient bronchdilatory effect on asthmatic air way [64].

Hypolipidimic effect: Besong *et al.* conducted a clinical study to evaluate the efficacy of the freeze-dried supplements of purslane in reducing blood lipids in hypercholesterolemic eleven adult volunteers of either sex. The subjects consumed step I diet during a 2-week acclimation period and switched to step I diet supplemented with freeze-dried purslane leaves (6 g/day) for 4 weeks. Fasting blood samples were analysed at the end of 2-weeks interval for plasma cholesterol, LDL-cholesterol, HDL-cholesterol and triacylglycerol concentrations. Four weeks treatment reduced ($P<0.05$) plasma total cholesterol and LDL-cholesterol. HDL-cholesterol levels were increased ($P<0.05$) and plasma triacylglycerol concentrations were not affected. These results suggest that purslane supplements have the potential to alter blood lipid metabolism in hypercholesterolemic subjects and can lower the risk of heart disease [65].

CONCLUSION

P. oleracea is a unique herb which is richest vegetable source of omega- 3 fatty acids and protein compared to other vegetables. This herb is in use since antiquity in Unani and Ayurvedic medicines for

various ailments such as skin diseases, fever, dysentery, diarrhea, bleeding piles, kidney, liver, spleen diseases etc. The versatile biological activities of this plant have been proven on scientific parameters, which are attributed to its phytochemical constituents like saponin, flavonoids, omega-3 fatty acids, phenolic acid, etc. It mainly possesses antitussive, diuretic, hypolipidemic, antiulcerogenic, anti-inflammatory, anticonvulsant, antimicrobial properties etc.

REFERENCES

1. Bosi G, Guarrera PM, Rinaldi R, Mazzanti MB. Ethnobotany of purslane (*P. oleracea* L.) in Italy and morphobiometric analyses of seeds from archaeological sites in the Emilia Romagna Region (Northern Italy) in Morel JP, Mercuri AM (Eds.),– Plants and Culture: seeds of the cultural heritage of Europe. Centro Europeo per i Beni Culturali Ravello, Edipuglia Bari [serial online] 2009 [cited 2013 Feb 24]: 129-139. Available from: http://www.plants-culture.unimore.it/book/11%20Bosi%20et%20alii.pdf.
2. Megaloudi F. Wild and cultivated vegetables, herbs and spices in Greek antiquity (900 B.C. to 400 B.C.). Environmental Archaeology 2005; 10 (1): 73–82.
3. Chevallier A. The Encyclopaedia of Medicinal plants. New York: DK Publishing; 1996. p.625.
4. *P. oleracea.* Last modified on 21 February 2013 at 21:38. [cited 2013 Feb 24] Available from: http://en.wikipedia.org/wiki/Portulaca_*oleracea*.
5. Duke JA. Handbook of Medicinal Herbs. Boca Raton:CRC Press; 2002.p.599.
6. van Wyk BE. Food Plants of the World. Portland: Timber Press; 2005.p. 24, 28, 303.
7. Wiersema JH, León B. World Economic Plants: a standard reference, Boca Raton: CRC Press;1999.p. 55, 613, 690, 720, 734.
8. Spjut RW. A systematic treatment of fruit types. New York: Memoirs of the New York Botanical Garden; 1994.p.70.
9. Razi Z. Kitabul Mansoori. New Delhi: Central Council for Research in Unani Medicine; 1991.p.115.
10. Kirtikar KR, Basu BD. Indian Medicinal Plants. Vol 2. Dehradun: Oriental Enterprises; 2003.p.330-33.
11. Ibn Baiter. Al Jameul Mufradat Al Advia wal Aghzia. Vol. 1. New Delhi: Central Council for Research in Unani Medicine; Year not mentioned.p.257-8.
12. Anonymous. The Wealth of India. Vol. VIII New Delhi: Council for Scientific and Industrial Research; 2003.p.219-230.
13. Riccieri C, Arrigoni PV. L'aggregato di *P. oleracea* L. (Portulacaceae) in Italia, in Parlatorea IV;2000. p. 91-97.
14. Ghani M. Khazainul Advia. New Delhi: Idara Kitabus Shifa; Year not mentioned.p. 667.
15. Kabiruddin M. Makhzanul Mufredat. New Delhi: Idara Kitabus Shifa; 2007.p.207.
16. Dweck AC. Purslane (*P. oleracea*) - the global panacea. Personal Care Magazine 2001[cited 2013 Feb 24];2 (4): 7-15. Available from: http://www.dweckdata.com/published_papers/portulaca_*oleracea*.pdf.
17. Nadkarni KM, Nadkarni AK. Indian Materia Medica. Vol. I. Bombay: Popular Prakashan; 1999.p. 1005-6.
18. Khare CP. Indian medicinal plants. Delhi: Springer; 2007.p. 513.
19. Ambasta SP. The useful plants of India. New Delhi: Council for Scientific and Industrial Research; 2000.p.485-6.
20. Majoosi AA. Kamilus Sana. (Urdu Trans: Kantoori GH.) Vol. I. New Delhi: Idara Kitabus Shifa; 2010.p.249.
21. Ibn Sina. Al Qanoon Fit Tibb. [Urdu Trans: Kantoori GH]. New Delhi: Central Council for Research in Unani Medicine;2010.p.299.
22. Kabeeruddin M. Ilmul Advia Nafeesi. New Delhi: Aijaz Publication; 2007.p. 93.
23. Ezekwe MO, Omara-Alwala TR, Membrahtu T. Nutritive characterization of purslane accessions as influenced by planting date. Plant Foods Hum Nutr. 1999;54(3):183-191.
24. Garti N, Slavin Y, Aserin A. Surface and emulsification properties of a new gum extracted from *P. oleracea* L. in Food Hydrocolloids. 1999;13:145-155.
25. Hussein FK. Medicinal Plants in Libya. Libya: Arab Encyclopedia House;1985. p.686.
26. Mohamed AI, Hussein AS. Chemical composition of purslane (*P. oleracea*). Plant Foods Hum Nutr 1994;45 (1): 1-9.
27. Simopoulos AP, Norman HA, Gillaspy JE, Duke JA. Common purslane: a source of omega-3-fatty acids and antioxidants. J Am Coll Nutr 1992;11(4): 374-82.
28. Garti N, Aserin A, Slavin Y. Surface and emulsification properties of a new gum extracted from *P. oleracea* L. Food Hydrocolloids. 1999a; 13:145-155.
29. Rizk AM. The Phytochemistry of the flora of Qatar. Scientific and Applied Research Center. Qatar: University of Qatar;1986.p.323-324.
30. Imperato F. Acylated Betacyanins of *P. oleracea*. Phytochemistry. 1975;14: 2091-2092.
31. Sakai N, Inada K, Okamoto M, Shizuri Y, Fukuyama Y. Portuloside A, A monoterpene glucoside from *P. oleracea*. Phytochemistry. 1996;42(6): 1625-1628.
32. Liu L, Howe P, Zhou YF, Xu ZQ, Hocart C, Zhang R. Fatty acids and β-Carotene in Australian Purslane (*P. oleracea*) varieties. J. Chromatography A. 2000; 893(1): 207-213.
33. Rashed AN, Afifi FU, Shaedah M, Taha MO. Investigation of the active constituents of *P. oleracea* L. (Portulacaceae) growing in Jordan. Pakistan Journal of Pharmaceutical Sciences. 2004; 17(1): 37-45.
34. Devi MM, Khomdram KP, Akham S. Anti-convulsant activity of aqueous extract of *P. oleracea* leaves in albino mice. Indian J Pharmacol. 2008 October; 40(Suppl 2): S112–S142.
35. Bae JH. Antimicrobial effect of *P. oleracea* extracts on food borne pathogens. J Food Sci Nutr P. 2004;9: 306
36. Dhole JA, Dhole NA, Lone KD, Bodke SS. Preliminary Phytochemical Analysis and Antimicrobial Activity of Some Weeds collected from Marathwada Region. Journal of research in Biology. 2011;1:19-23.
37. Oh KB, Chang IM, Hwang KJ, Mar W. Detection of antifungal activity in *P. oleracea* by a single-cell bioassay system. Phytother Res. 2000 Aug;14(5):329-32.
38. Boroushaki MT, Boskabady MH, Malek F. Antitussive effect of *P. oleracea* in guinea pigs. Iranian Journal of Pharmaceutical Research. 2004;3:187-190.
39. Boskabady MH, Boroushaki MT, Aslani MR. Relaxant effect of *P. oleracea* on guinea pigs tracheal chain and its possible mechanism of action, Med Hypotheses Res 2004;1: 139-147.
40. Sanja SD, Sheth NR, Patel NK, Patel D, Patel B. Characterization and evaluation of Antioxidant activity of *P. oleracea,* Int J Of Pharmacy and pharmaceutical Sciences.2009;1(1):74- 84.
41. Arruda SF, Siqueira EM, Souza EM. Malanga (Xanthosoma sagittifolium) and purslane (*P. oleracea*) leaves reduce oxidative stress in vitamin A-deficient rats. Ann Nutr Metab. 2004; 48(4):288-95.
42. Yang Z, Liu C, Xiang L, Zheng Y. Phenolic alkaloids as a new class of antioxidants in *P. oleracea*. Phyto ther Res. 2009 Jul;23(7):1032-5.
43. Prabhakaran V, Kumar BSA, Shekar DS, Nandeesh R, Subramanyam P, Ranganayakulu D. Evaluation of the hepatoprotective activity of *P. oleracea* L. on D-galactosmaine-induced hepatic injury in rats. Bol Latinoam Caribe Plant Med Aromat. 2010;9(3):199-205.
44. Al-Howiriny TA. Protective effect of 'Purslane' on rat liver injury induced by carbon tetrachloride. Saudi Pharmaceutical Journal. 2008; 16(3-4):239-244.
45. Ahmida MH. Evaluation of *in vivo* antioxidant and hepatoprotective activity of *P. oleracea* against paracetamol-induced liver toxicity in male rats. American Journal of Pharmacology and Toxicology. 2010;5(4): 167-176.
46. Karimi G, Khoei A, Omidi A, Kalantari M, Babaei J, Taghiabadi E, Razavi BM. Protective effect of aqueous and ethanolic extracts of *P. oleracea* against cisplatin induced nephrotoxicity. Iranian Journal of Basic Medical Sciences. 2010;13(2): 31-35.
47. Li-Wei D, Wan-Yin W, Yi-Tian Y, Min L**.** Effects of flavones extracted from *P. oleracea* on ability of hypoxia tolerance in mice and its mechanism. Journal of Chinese Integrative Medicine. 2005;3(6):450-454.

48. Wang W, Gu L, Dong L, Wang X, Ling C, Li M. Protective effect of *P. oleracea* extracts on hypoxic nerve tissue and its mechanism. Asia Pac J Clin Nutr. 2007;16 (Suppl 1):227-233.
49. Hongxing Z, Nancai Y, Guofu H, Jianbo S, Yanxia W, Hanju H, Qian L, Wei M, Yandong Y, Hao H. Neuroprotective effects of purslane herb aqueous extracts against d-galactose induced neurotoxicity. Chemico-Biological Interactions. 2007;170:145–152.
50. Moneim A E A, Nasr I, Dkhil M A, Quraishy S. Neuronal activities of *P. oleracea* in adult rats. Journal of Medicinal Plants Research. 2012; 6(16):3162-3168.
51. Parry O, Marks JA, Okwuasaba FK. The skeletal muscle relaxant action of *P. oleracea*: role of potassium ions. J Ethnopharmacol. 1993; 40(3):187-94.
52. Okwuasaba F, Ejike C, Parry O. Skeletal muscle relaxant properties of the aqueous extract of *P. oleracea*. J Ethnopharmacol. 1986; 17(2):139-60.
53. Parry O, Okwuasaba F, Ejike C. Effect of an aqueous extract of *P. oleracea* leaves on smooth muscle and rat blood pressure. J Ethnopharmacol. 1988 Jan;22(1):33-44.
54. Gao D, Li Q, Fan Y. Hypoglycemic effects and mechanisms of *P. oleracea* L. in alloxan-induced diabetic rats. Journal of Medicinal Plants Research. 2010; 4(19):1996-2003.
55. Gong F, Li F, Zhang L, Li J, Zhang Z, Wang G. Hypoglycemic Effects of Crude Polysaccharide from Purslane. Int J Mol Sci. 2009;10:880-888.
56. Li F, Li Q, Gao D, Peng Y, Feng C. Preparation and antidiabetic activity of polysaccharide from *P. oleracea* L. African Journal of Biotechnology. 2009; 8 (4):569-573.
57. Sharma A, Reddy G, Vijayakumar M, Unnikrishnan MK, Rao CV. Action of *P. oleracea* against streptozotocin-induced oxidative stress in experimental diabetic rats. Continental J. Pharmacology and Toxicology Research. 2008;2:12 - 18.
58. Musa KY, Ahmed A, Ibrahim J, Ojonugwa OE, Bisalla M, Musa H, Danmalam UH. Toxicity studies on the methonolic extract of *P. oleracea* L. (Fam. Portulacaceae). J Biol Sci. 2007; 7(7): 1293-1295.
59. Chan K, Islam MW, Kamil M, Radhakrishnan R, Zakaria MNM, Habibullah M, Attas A. The analgesic and anti-inflammatory effects of *P. oleracea* L. subsp. sativa (Haw.). J Ethnopharmacol. 2000; 73(3);445-451.
60. Rashed AN, Afifi FU, Disi AM. Simple evaluation of the wound healing activity of a crude extract of *P. oleracea* L. (growing in Jordan) in *Mus musculus* JVI-1. **J** Ethnopharmacol. 2003 Oct;88(2-3):131-6.
61. Kumar A, Sharma A, Vijayakumar M, Rao CV. Antiulcerogenic effect of ethanolic extract of *P. oleracea* experimental study. Pharmacology online. 2010;1: 417-432.
62. Karimi G, Hosseinzadeh H, Ettehad N. Evaluation of the gastric antiulcerogenic effects of *P. oleracea* L. extracts in mice. Phytother Res. 2004;18(6):484-7.
63. Londonkar R, Nayaka HB. Evaluation of anti-implantation and abortificient properties of *P. oleracea* in albino rats. International Journal of Pharma and Bio Sciences. 2011; 2(4)501-508.
64. Malek F, Boskabady MH, Borushaki MT, Tohidi M. Bronchodilatory effect of *P. oleracea* in airways of asthmatic patients. J Ethnopharmacol. 2004 Jul;93(1):57-62
65. Besong SA, Ezekwe MO, Ezekwe EI. Evaluating the effects of freeze-dried supplements of purslane (*P. oleracea)* on blood lipids in hypercholesterolemic adults. International Journal of Nutrition and Metabolism. 2011; 3(3):43–49.