



A brief review on bioactivities and therapeutic potentials of garden cress (*Lepidium sativum* L.)

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Abstract

Garden cress (*Lepidium sativum* L.) is an annual, erect, glabrous and edible herbaceous plant that belongs to the family of Brassicaceae and it is cultivated as culinary vegetable in different regions of the Asia and Europe. It is a plant indigenous to south west Asia and Western Europe. The garden cress can only be grown in a well fertilized, fully nutritive and properly moisturized soil where it can attain the height of 60 cm. *Lepidium sativum* L., the wildy growing edible herb is known to contain approximately 175 species among which "garden cress" (*Lepidium sativum* L.), "Maca" (*Lepidium meyenii*) and "Walp" (*Lepidium peruvianum*) are the most important one. The leaves of *Lepidium sativum* L. contain water, carbohydrates, protein, fat, phosphorous, calcium and mineral matter along with iron, cobalt, iodine and nickle. However, small amount of vitamin A., riboflavin, thiamin, ascorbic acid, glucosinolates, niacin, benzyl cyanide and benzyl iso-thio-cyanate is also evident in different parts of this plant. Seeds of garden cress possess appreciable concentration of different alkaloids, sinapin, glucotropaeolin, sinapic acid, mucilaginous matter and uric acid. Saturated and unsaturated fatty acids that are found in seed oil of garden cress include palmitic acid, behenic acid, lignoceric acid, stearic acid, arachidic acid, linoleic acid and oleic acid. This herbaceous plant is extensively used in traditional and modern systems of medicines due to their excellent therapeutic potentials owing to anti-diarrheal, anti-spasmodic, nephron-protective, prokinetic, laxative, bronchodilatory, hypoglycaemic, hypolipidemic, anti-microbial, anti-inflammatory, anti-hypertensive, analgesic, coagulative, anti-pyretic, fracture healing, cardio-protective, free radical scavenging, total glutathione s-transferase, reduced glutathione and chemo-protective effects of *Lepidium sativum* L.

Keywords: *Lepidium sativum* L., glabrous herb, nutritive soil, fatty acids, alkaloids, medicinal plant, therapeutic potentials, biological activities

Full length article *Corresponding Author, e-mail: farwa668@gmail.com

1. Botany

1.1 Introduction

Garden cress (*Lepidium sativum* L.) is a yearly, glabrous, erect and edible herb belonging to the Brassicaceae family that is cultivated as a culinary vegetable all around the Asia and Europe. It is a plant indigenous to south west Asia and was evident to spread over Western Europe many centuries ago. The genus *Lepidium* comprises of a range of 175 to 220 species mostly growing in warm temperature climate [1]. Worldwide distribution of these species was recorded with greatest variety into the regions of Mediterranean, some areas of North America and in Central and West Asia [2-3]. *Lepidium sativum* L. is most commonly known as "Halim", "Common cress" or "Garden cress". In Saudia Arabia, it is also known as "Thufa" or "Habel Rashaad" and more popularly is grown into the regions of Eastern, Hijaz and Al-Qaseem provinces of Saudia. In India, locally it is known as "halon" because halon is an edible fast growing plant. Shabbir et al., 2018

Ethiopia and Eritre are the basic centre of origins of polymorphous *Lepidium sativum* species [4]. In some areas, it is also well known as "pepper wort", "garden pepper cress" along with its some others names such as "town cress" owing to its cultivation into the regions of enclosure or tounnes. Similarly from Passer, it is commonly known as "passer age" owing to its healing powers; it wipe out the people suffering from hydrophobia [5].

Some of its common names in different languages are as follows; in Urdu and Sanskrit "Halim"; in English "Common Cress"; in Hindi "Chansur"; in Kashmiri "Alian"; in Marathi "Ahaliva"; in Oriya "Chandasura"; in Tamil "Allivirai"; in Malayalam "Asali" and in Gujrati "Aseliyo" [6]. Almost all parts of Garden cress including leaves, roots and seeds have economic importance; but basically for seeds, this crop is cultivated all around the World. In India, it is grown as important medical herb [7]. It is a rigid, glabrous, herbaceous annual plant usually growing upto the height of 15-45 cm. It possesses the long racemes of white

small flowers. It has elliptical, obovate and rotundate pods usually winged and notched at the point where apex emarginated. Garden cress can be grown all over round the year in all altitudes but the most precious herb is found into the winter season. The stimulated leaves of garden cress are utilized for the purpose of garnishing into the salad and are also cooked along with other vegetables [8-9]. Seeds having oval shape are usually of brownish red colour. Seeds of *Lepidium sativum* are taken as the most precious medicinal remedy in many countries of Africa to cure the diseases like asthma and bronchitis. In South Asia, garden cress is utilized as traditional medicine to cure the cough, asthma and bronchitis and is also taken as efficient medicine for anti-bacterial, diuretic, gastro-protective, stomachic, gastro-intestinal stimulant and laxative [10].

1.2 History/Origin

This plant is basically intrinsic to Mediterranean regions but now it is most similarly found indigenous to West India as it is widely cultivated throughout the India. In India, it is largely cultivated in Utter Pradesh, Maharashtra, Gujarat, Madhya Pradesh and Rajasthan [11]. It is considered to have originated from Persia and after that extended towards the areas of Syria, Egypt, India and Greece. Garden cress is still popular and frequently consumed type of leafy vegetables in Europe, especially in Scandinavia, Netherlands, England and France (the centers of garden cress cultivation) where it is grown commercially. Due to its delightful and peppery taste, it is grown all over the world and it is used as healthy addition to salads and sandwiches.

Lepidium sativum L. is an edible and fast growing plant that is botanically associated with mustard and watercress owing to their aroma and tangy, peppery flavor. Although, exact origin of it is still not clear but it is believed that it might be originated from the North-East Africa, most importantly from Egypt, Ethiopia, South-West Asia, Iran and Eritrea. The plant of garden cress is highly suited to all types of climates and soils but doesn't stand by frosts. It has highest growth rate into the temperate regions. Due to availability of a wide range of dominant *Lepidium sativum* L. into the Ethiopia regions, Vavilov (1926) took it to Ethiopia that is its main centre of origin. While secondary origin centers of *Lepidium sativum* L. are of Mediterranean, Central and East Asia. It is now cultivated widely throughout the numerous parts of Europe such as British Isles. Wild cress extends from the Sudan to the Himalayas. Most authors consider it to be a native of Western Asia, from where it passed very quickly to Europe and the rest of Asia as a secondary crop, probably associated with cultivars of flax.

Lepidium sativum L. is categorized among the horticultural crops which are ignored and are less utilized. In Ethiopia, it includes highly essential oil containing species of aromatic plants that are required for medicinal and other

purposes. It contains edible seeds oil having incites, appetite stimulant and anti-scorbutic medicinal properties. Getahun (1976) stated that seeds of *Lepidium sativum* L. have high medicinal values such as this plant has several medical implications as a human skin disorder, livestock drench for stomach-disorders, sunburn, amoebic infection thus applied on skin as insect-repellant. Additionally, it is also utilized by the soldiers for the warmth feeling at night and for cramps in stomach [12].

1.3 Demography/Location

Lepidium sativum L. can be grown indoor or outdoor. When preparing soil, *Lepidium sativum* L. seeds should be ploughed and mixed into a well-proportioned fertilizer, after that the seeds should be sowed into 5-6 cm deep soil and 45-60 cm apart from each other to obtain the continuous crop. *Lepidium sativum* L. leaves shouldn't stay wet for long time because the soil accumulates there when water stays on them and then it's impossible to washout the damaging leaf. As said before, its requirements are simple and broad that it tolerates changes, it can nourish in moist and semi shaded soil or even in open areas. However, in summer, to avoid the direct exposure of heat to the seeds, it's preferred to be covered with some shade. Proper irrigation is also required because they're shallow rooted seedlings which can be dry up within few days. It's true that the crop can be collected all over the year, but in the winter season, the well-nourished and flourished crop is obtained. So, on the hilly areas, the seeds should be sown from September to February. Seeds are sown thick and covered until germination begins. After 4-6 days of sowing, the seeds begin to sprout. Within two to three weeks after sowing, plants are ready for cutting. By that time, this plant attains yellowish coloration. In order to get a continuous supply of leaves farmers sow cress seeds in series at intervals of 8 days [13].

Lepidium sativum L. is also known as "pepper grass" owing to the peppery flavor of its leaves. It can easily be grown in containers and windowsills of kitchen under sunshine. For the growth of garden cress for proper sprouting, its baby leaves should be harvested as early as true leaves mature and appear. Loose soil and sunny location is most suitable for optimum growth of garden cress. The plantation of garden cress should be ensured after every 10 to 14 days starting from the spring to obtain the continuous crop. Plant of garden cress can grow upto the height ranging from 12 to 20 inches. The most suitable and narrow pH range for optimum garden cress growth is in between 6.0 to 7.0 i.e. slightly acidic to neutral environment. Germination of garden cress seeds starts probably within 5 to 15 days but under some dedicated growing media including "Rapid Rooters", "Oasis Root cubes" or "Grodan Stone wool", it could also germinate from 24 hours to 4 days. Indoor garden cress satisfactory growth could be obtained under standard fluorescent lamps. It should be kept

above two to four inches from plants top. In order to acquire sturdier, shortest and more stimulant plant habitat, stirring of seeding's with an oscillating fan must be ensured for at least 2 hours per day. Due to the requirement of constantly moist soil, above average water supply is needed. It has not any pest and serious disease issues.

1.4 Botany, Morphology and Ecology

Garden cress is an annual, glabrous, erect herbaceous plant growing up to the height of 60 cm with a lot of branches on the upper part. Leaves are entire or pinnately dissected, variously lobed often with linear segments; up to 5-6 cm long and lobes are 0.7-1.2 to 0.3-0.6 cm in size. The upper leaves are usually, entire and 2-3 cm long, oblanceolate, sessile and made up of two or more discrete leaflets that are arranged alternatively i.e. one leaf per node. The leaves and stems are green in color. Racemes are 7 to 15 cm long axillary and terminal; flowers are white or pale pink; pedicels are 3 to 5 mm long. Pods are obovate or broadly elliptical, roundate, emarginated slightly but thickly winged above. The seeds of garden cress are pointed and oval shape usually triangular on one end smooth and tiny having an arrow present on both sides. The seeds are 1 to 1.5 mm wide and 2 to 3 mm long with reddish brown color. The slight wing like extension on both sides of seeds helps in soaking well into the water, after that seed swells up and get covered itself with colorless and transparent appearance [11].

Lepidium sativum L. is an annual herb, its stem is finely striate, branched and glabrous (hairless, smooth). In the stem's bottom, the leaves are long and are arranged on the top of stalk oppositely having green color. They could differ a bit in shape but not in taste. They're irregularly pinnate and alternate upto 12 cm. Petiole of its flowers are up to 4 cm long. Leaflets are opposite, in outline ovate or ovate-lanceolate, glabrous (hairless, smooth), 1.5-8.0 cm larger and thin. The flowers of *Lepidium sativum* L. are regular and bisexual, 4-merous, having 1.5 to 4.5 mm long pedicel, ascending; sepals are ovate, 1-2 mm long; petals are spatulate with short claw, up to 3 mm long, usually pale pink or white in color; anthers are usually of purplish colour. The globose fruits are 1.2 cm across with hard ribbed endocarp of purple black color [13]. The *Lepidium sativum* L. seed oil is one of the most suitable raw oil for the biodiesel production as it is very fast growing yearly herb.

The seed oil of *Lepidium sativum* L. usually comprises of 27.7% unsaturated fatty acids such as oleic acid, linolenic acid, gagoic acid and linoleic acid [14]. Shehzad et al. reported that without weeds completion, the optimum seed yield of about 305.9 kg per hectare can be obtained from the *Lepidium sativum* L. Although it can be cultivated and harvested many times in a year but the months of January, February and November are most appropriate months for its growth in the climates of Mediterranean [5-15]. The effect of temperature on the

viscosity is more evident at low concentration, as shown by a reduction in activation energy with increasing concentration. The frequency factors increase from 0.001 to 0.075 (Pas) as the concentration increases (2-3.5%) [16]. The pH variation has only a little impact on obvious viscosity and reliability coefficient and has no significant impact on the flow behavior in the yield stress above the range of 3-9 at different CSG concentrations (1, 1.5 and 2%). Under the alkaline and acidic conditions, CSG is stable in viscosity over a wide range of pH 0s, which are a good indicator of its possible applications in food formulations [17].

2. Chemistry

Lepidium sativum L. is wild growing edible herb whose genus consists of approximately 175 species; some of which are cultivated which include garden cress (*Lepidium sativum* L.), Maca (*Lepidium meyenii*) and Walp (*Lepidium peruvianum*). The presence of Chandrasur, the basic ingredient of Chaturbija compound suggests that the seeds are of esteemed value for garden cress medicinal properties. The seeds of *Lepidium sativum* L. are tonic, aperient, carminative, diuretic, emmenagogue, demulcent, galactagogue and are used to procure an abortion and also possess anti-bacterial and anti-fungal properties. Raval and Pandya conducted clinical trials of *Lepidium sativum* L. and showed that it provides good relief in cardinal signs, symptoms like pain in joints, swelling, stiffness, crepitus, tenderness and difficulty in movement. The high molecular mass gum is produced from this plant. It has numerous characteristics like disintegrating, binding and gelling [18].

Chandrasur (*Lepidium sativum* L.) is one of the important herbal seed that is claimed to possess varied nutritional and medicinal properties for example as a galactagogue, a diuretic, an alternative tonic, a demulcent, an aphrodisiac, a carminative and emmenagogue properties. The color of the chandrasur seed is brick red to cream color while its endosperm is yellow. Traditionally, in the period of postpartum, it is utilized for the promotion of lactation and alleviation from lower back pain. It also works efficiently for the genetic tonic of lactating mother. It also has strong anti-septic, anti-bacterial and therapeutic properties for the treatment of gastro-intestinal complaints [19].

Kholif and Abt El-Gawad (2001) and Abo El-Nor and coworkers (2004) has cited that *Nigella sativa*, *Lepidium sativum* and *Crum carvi* seeds could be beneficial for the lactating buffaloes as a galactagogue. In spite of its various medicinal and nutritional values, it does not still received its deserving attention and very little reported work is found regarding its nutritional values, medicinal importance and its impact on the quality of milk [20]. The anti-inflammatory activity of *Lepidium sativum* L. is due to the presence of flavonoid groups containing compounds. It is also reported to be utilized in the treatment of migraine [5].

2.1 Chemical Composition

Leaves of *Lepidium sativum* L. have the following chemical constituent: 82.3% water, 8.7% carbohydrates, 5.8% protein, 1.0% fat, 0.11% phosphorous, 0.36% calcium and 2.2% mineral matter. It also possesses the trace elements such as (28.6 mg/100 g) iron, (12 µg/kg) cobalt, (110 µg/kg) iodine and (40 µg/kg) nickel. Small amount of vitamins is also reported into the cooked leaves; 3.300 IU vitamin A, 0.15 mg riboflavin, 70 µg thiamin, 39 mg/100 g ascorbic acid and 0.08 mg niacin. Glucosinolates are the major basic secondary compounds of this plant. By steam distillation, it gives 0.115% cress oil possessing pungent characteristics odor with a variable amount of benzyl cyanide and benzyl isothiocyanate. Anti-bacterial activity against *Micrococcus pyrogenes var. aureus* and *Bacillus subtilis* is reported by the volatile products of garden cress's crushed leaves [5-21].

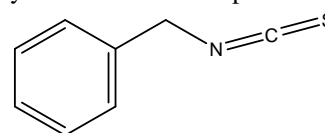
Due to the presence of 25-39% protein contents into the whole seed of garden cress, it is recommended for health promotion. It also contains 2.4% crude fat, 6.4% minerals, 33% carbohydrates, 7.6% crude fiber, 0.723% phosphorous, making it functional raw material of food. It also contributes in food industry due to its tangy nature, peppery flavor and specific aroma. Additionally, in most of the regions, its sprouts are utilized as more popular ingredient of salads and sandwiches [12]. The amount of ascorbic acid (vitamin C) was estimated in a recent experimental investigation where whole plant showed 11.74±0.83 mg and stem showed 11.74±0.83 of ascorbic acid [13-22].

2.2 Phytochemistry

Analysis of cress seed yields the following nutritional and phytochemical components such as it contains 0.9% sulphur, 15.91% fat, 1.65% phosphorous, 23.5% proteins, 5.7% ash and 0.31% calcium. The seeds possess 0.19% alkaloid, sinapin (choline ester of sinapic acid), glucotropaeolin, sinapic acid (4 hydroxy-3:5-dimethoxycinnamic acid, C₁₁H₁₂O₅ having melting point of about 192°C), 5% mucilaginous matter and 0.108 g/kg uric acid. By steam distillation, similar to the herb, they give volatile oil. The obtained oil possessed an estrogen activity as the application of 3-4 drops on immature rats has resulted in enhanced development and increases weight of ovaries as compare to the control with the presence of many hemorrhagic follicles into the ovaries. Yellowish brown semisolid oil up to 25.5% from seeds having specific displeasing odour is utilized into the manufacturing of soap and for burning purposes. The seed oil possesses the following properties; 0.95 acidic value, 0.909 specific gravity, 185.0 saponification value, 93.8 hehner value, 131.4 iodine value, 5.8 acetyl value and 1.8% un-saponified matter. Saturated and unsaturated fatty acids have the following percentages into the seeds oil, 1.27% palmitic acid, 1.73% behenic acid, 0.2% lignoceric acid, 6.01%

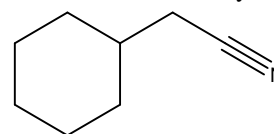
stearic acid, 1.54% arachidic acid, 28.0% linoleic acid and 61.25% oleic acid. While unsaponifiable matter comprises of 1830 µg/g oil α-tocopherol and β-sitosterol. It also possesses the anti-oxidant activity and 10% is the optimum utilized additive amount of linseed oil.

In Arabic gum and tragacanth, seed mucilage is utilized as a substituent and also known as cress mucilage. In the cases of diarrhea and dysentery, in intestine, it allays mucous membrane irritation. Cress mucilage contains polysaccharides of 18.3% and cellulose along with uronic acid which after hydrolysis yields L-rhamnose, D-galacturonic acid, L-arabinose, D-glucose and D-galactose. In seed oil, numerous lepidine, B, C, D, E and F and alkaloids along with two new monomeric alkaloids e.g. semilipidene side A and B is also found. Sinapin and sinapic acids were isolated from the defatted seed's methanolic extract. It is also found that a range of active constituents such as steroids, tannins, sugars, flavonoids and alkaloids is also found into the ethanolic extract. In leaves, carotene presence is also reported [5]. The major volatile contents of seed consist of 12.3% 1,8-cincole, 26.2% benzyl isothiocyanate and 52.9% phenylacetone nitril. Roots and other non-arial parts of plant possess 11.8% and 13.9% α-pinene, 65.0% and 24.5% benzyl isothiocyanate and 9.1% and 18.0% hexadecanoic acid respectively. On the basis of dry weight, total content of *Lepidium sativum* L. lipid is found to be 13.8%. Predominantly, 86.7% contents of natural lipids are found to be in the oil along with 5.8% phospholipids and 7.7% glycolipids in minor amounts. In small amount, on the dry weight basis, 29.7% lysophosphatidyl ethanol amine and 33.5% lysophosphatidyl choline are also reported into the oil.



Benzyl isothiocyanate

Fig 1 Chemical structure of Benzyl isothiocyanate



Phenylacetone nitril

Fig 2 Chemical structure of Phenylacetone nitril

3. Postharvest Technology

For the storing and preserving of garden cress, specific precautions should be taken to avoid the presence of any slime mark, discoloration or witting. Leaves must be present on the stem until they are not required to be utilized [13]. Under refrigerator, garden cress can be stored upto five days within the plastic bags. The stem of garden cress should be held into the glass filled with water and then glass should be bagged and refrigerated to prolong the life of plant [5].

4. Processing

Coffee grinder is used for the grinding of cress seeds. After that in Soxhlet apparatus, the essential oil is extracted from the grinded seeds with hexane for 24 hours. In rotary evaporator, hexane is separated out under reduced pressure. For total oil content determination, triplicates of 10 g grounded seeds were extracted in Soxhlet apparatus for 24 hours, after the hexane removal under reduced pressure. The calculation of residual oil weight was made. The seeds of *Lepidium sativum* L. have major role against the growth of human breast cancer cells. These seeds were locally obtained and powdered via electric grinder. Furthermore, plant extract was prepared by dissolving 1g of *Lepidium sativum* L. powder in 99.87 ml deionized water along with addition of 0.14 ml dimethyl sulfoxide. Furthermore, it was found that 0.1% dimethyl sulfoxide exhibited highest extract concentration. In this experiment, various extract's dilutions were prepared at the ratio of 1:3, 1:1 and 3:1 and were stored at about 80°C.

5. Value Addition

Due to the tangy flavor, garden cress is added to the salads, sandwiches and soups. The seed pods in fresh and dried form are utilized as peppery seasoning. It is also taken as sprouts. Cut shoots of garden cress along with salt, boiled eggs and mayonnaise is taken in the United Kingdom [23]. For infants, hot water along with crushed garden cress is the best colic treatment. According to a research in a regions of Tafilalet Morocco *Lepidium sativum* is utilized into the decoration for management and treatment of diabetes [24]. Leaves of garden cress are also cooked with vegetables curries and also used in decorations [13].

6. Uses of *Lepidium sativum* L.

Throughout the India, *Lepidium sativum* L. has been tragically used for the treatment of number of ailments. To get relieve from high cough, the seed's cold infusion is used. For the carminative adjunct to the purgatives and for spleen and liver chronic enlargement, the seeds of *Lepidium sativum* L. are extensively used. For relieve from rheumatic pains and inflammations, the lime juice is mixed with bruised seeds to be used for local application.

The seeds of garden cress are depurative, emmenagogue, tonic, aphrodisiac, rubefacient, hemogenic, galactagogue, diuretic and bitter in nature. For sprains, dysentery, leprosy, skin diseases and asthma, they are most commonly used as poultices [6]. Diuretic and mild stimulant leaves are utilized for the treatment of liver illnesses and for scorbutic diseases [25]. The bitter and acrid roots are utilized to treat Tenesmus and secondary syphilis are used as condiment [26].

Administration of boiled seeds along with milk causes abortion. For the treatment of dysentery, indigestion and diarrhea, the mixture of sugar with powdered cress seeds is utilized. In general, debility treatment, a common homemade remedy made up by mixing the sugar, butter and

seeds of garden cress proves to be helpful in its restoration [6].

6.1 General Uses

Different parts of *Lepidium sativum* L. are considered to be an essential component of human diet since ancient times. Seeds, leaves and stems of garden cress are preferably eaten but only the stems and leaves are eaten as salad and used for various other culinary purposes. This healing and culinary herb is known to have papery taste that is comparable to the taste of water cress and leaf mustard that is actually not very surprising as garden cress is botanically related with both of them. Due to the distinctive flavour and high nutritional value, this plant is known to make food healthy and tasty when added in sandwiches or taken as salads.

Lepidium sativum L. (Family-Brassicaceae) is also generally known as "Chansur". It is almost 15 to 45 cm long herbaceous, annual glabrous and small plant that is cultivated throughout the India as a salad supplement. Cress seeds are oblong, slightly curved on one side having rugous surface and are of reddish color. Traditionally, Chansuris has been found to possess the alternative, aphrodisiac, tonic, carminative and aperient properties. In the treatment of scorbutic disease, cress leaves appear to be slightly diuretics and stimulants in nature [27]. Western Asian, Mediterranean and Indian cultures have used the seeds of garden cress to cause laxative effects, to induce labor or to relieve pain. The roots have been used to treat syphilis and Tenesmus (urge to evacuate the stools). The leaves have been used as an anti-bacterial agent, a diuretic (increases urination), and a stimulant, as well as to treat liver disorders and scurvy (disease from vitamin C deficiency). At this time, there is a lack of evidence supporting the efficacy of garden cress for any condition. However, various traditional uses still exist.

Limited reports stated that garden cress is useful for treating several illnesses, including "colic", "viscous humors" and "leprosy". Garden cress may relieve the body's allergic responses to insect bites. It has also been used as a fumigant (pest control substance), an anthelmintic (to eliminate parasitic worms) and an aphrodisiac. Also, garden cress may be useful in preventing hair loss and renal cooling, and stimulating the appetite. According to the Ayurvedic system of medicine, garden cress displays the following properties: it is hot, bitter, tonic and aphrodisiac. It is also useful in the treatment of dysentery, pain in abdomen, blood and skin disorders, injuries, tumors and eye diseases. Garden cress may stimulate the production of breast milk and prevent postnatal complications. The traditional medicines of Saudi Arabia and other Arab countries use the garden cress plant and seeds for healing bone fractures, although there is little evidence to support the effectiveness of this use.

6.2 Pharmacological Uses

Lepidium sativum L. is a widely growing edible herb which is botanically correlated with the mustard and watercress, distributing their tangy, peppery flavor and aroma. To prevent the post natal impediments, the cress seeds are of great medicinal prominence. This plant is also utilized for the treatment of cough, asthma and bleeding piles. For the treatment of fungal and bacterial infections, seeds of garden cress are also found beneficial. Cress seeds about thousands in quantity vary in weight from 1.545 g–1.752 g having elliptical shape spatulate embryos [28].

6.2.1 Anti-Diarrheal and Anti-Spasmodic Activities

The methanolic (70%) seed extract of *Lepidium sativum* L. at 100 and 300 mg/kg inhibits diarrhea into the rats caused by the castor oil. It is considered that anti-diarrheal and anti-spasmodic activities are facilitated through the dual obstruction of Ca⁺⁺ channels and muscarinic receptors [29]. Gilani et al. (2012) also observed similar results. *In-vitro* experiments utilizing the two different sections of intestine (jejunum and ileum) by guinea-pig, rabbit and rats have demonstrated that by the utilization of multiple various pathways such as K⁺ channels opener, inhibition of PDE enzyme and Ca⁺⁺ antagonist, the activities of plant as anti-spasmodic and anti-diarrheal were observed [17].

6.2.2 Nephroprotective and Curative Activities

Significant nephron protective and curative activities can be attained by using ethanolic extract of *Lepidium sativum* L. seeds (200 mg/kg for 16 days) against nephron toxicity damage induced by cisplatin (an anti-cancer drug) as evident by inhibiting the anti-oxidant enzyme activity into the renal tissue, increase in the active substance of thio-barbituric acid and depletion of glutathione [17-30].

6.2.3 Prokinetic and Laxative Activities

In mice, the administration of 30 and 100 mg/kg of aqueous-methanolic seeds extract of the *Lepidium sativum* L. has showed laxative and prokinetic action. Investigation on the preparation of isolated jejunum and ileum from different animals, e.g. guinea-pig, mouse and rabbit has illustrated the species and tissue-selectivity. The extracts are more efficacious in the preparations of gut of rabbit as compared to that of mouse or guinea-pig [17].

6.2.4 Bronchodilatory Effects

In order to explore the medicinal uses or therapeutic potentials of *Lepidium sativum* L. aqueous methanolic extracts of this plant were used to treat hyperactive airways disorders. Some recent investigators have indicated that these extracts repressed the carbachol (CCh: 1 µM) and potassium (K⁺, 80mM) prompted contractions in a manner comparable to that of dicyclomine. This inhibitory effect is induced through the blending of anti-cholinergic, Caantagonist and PDE (phosphodiesterase) inhibitory pathways [17].

6.2.5 Hypoglycaemic Activity

Aqueous extract of *Lepidium sativum* L. (20 mg/kg) in an acute (single dose) or chronic (15 daily repeated administration) oral treatments, prompts a considerable decrease of glucose level into the blood of streptozotocin-induced diabetic rats. Daily intake of oral administration for two weeks marked the normalization of glycemia. The concentration of insulin into the basal plasma do not differ considerably in the *Lepidium sativum* L. extract-treated groups compared to untreated group either in diabetic and normal rats when treated with 20 mg/kg dose on daily basis [17-31].

6.2.6 Hypolipidemic Activity

In order to find out the hypolipidemic activities of *Lepidium sativum* L. aqueous extracts of this plant were administered into hypercholesterolemic rats for eight weeks after which feeding efficiency ratio, weight gain, triglycerides VLDL-cholesterol, serum cholesterol, LDL-cholesterol level, cholesterol/HDL-cholesterol, LDL-cholesterol/HDL-cholesterol, urea, serum (AST and ALT), serum creatinine, total lipid levels and liver cholesterol levels all decreased in comparison with the control group (hypercholes-terolemicrat), with a significant increase in both liver triglycerides and serum globulin level [17-32].

6.2.7 Anti-Microbial Activity

Methanolic extracts of seeds of *Lepidium sativum* L. has also been used in combination with some anti-biotics like penicillin and erythromycin to combat the anti-biotic resistance of the *Pseudomonas aeruginosa* [8]. In another experimental investigation, anti-microbial activity of the petroleum ether, methanol and water extracts of seeds of *Lepidium sativum* L. were demonstrated against six opportunistic pathogens named as *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Proteus vulgaris* and only one fungus named as *Candida albicans*. Petroleum ether has shown to be the finest solvent for the extraction of potential anti-microbial substances from the seeds of *Lepidium sativum* L. as compared with the methanol and water [17-33].

6.2.8 Anti-Inflammatory Activity

The ethanolic extract of the seeds of *Lepidium sativum* L. (500 mg/kg) were used orally to significantly inhibit the carrageenan-induced (0.05 ml of 1% carrageenan sodium salt) inflammation in albino rats [17]. Results of this experiment showed that the seeds of *Lepidium sativum* L. are known to contain potential anti-inflammatory compounds.

6.2.9 Anti-Hypertensive Activity

The diuretic and anti-hypertensive effect of aqueous extract of the seeds of *Lepidium sativum* L. were investigated in normotensive Wistar Kyoto (WKY) rats and spontaneously hypertensive rats (SHR). After (20 mg.kg⁻¹, daily) oral administration for 3 weeks, the aqueous extract of *Lepidium sativum* L. exhibited a significant decrease in

blood pressure and increase electrolytes excretion in SHR, whereas no significant change in water excretion is noted in this experiment [8]. The similar results were obtained by Patel et al. (2009) when they investigated the diuretic effects of methanolic and aqueous extracts of seeds of *Lepidium sativum* L. in normal rats. These results showed a considerable increase in urine volume following two doses of methanol and aqueous extracts (100 and 50 mg/kg) as compared to the control group (Hydro-chlorothiazide, 10 mg/kg) [17].

6.2.10 Analgesic Activity

Oral administration of ethanolic extract of *Lepidium sativum* L. at a dose concentration of 500 mg/kg produced a significant prolongation of the reaction time of mice on the hot plate [17].

6.2.11 Coagulant Activity

Several haematological investigations demonstrated a significant increase in the level of fibrinogen and considerable decrease in prothrombin time (PT) with a stable haemoglobin level when ethanolic extract of *Lepidium sativum* L. was administered in rats at a dose concentration of about 500 mg/kg [17-34].

6.2.12 Anti-Pyretic Activity

The ethanolic extracts of *Lepidium sativum* L. showed a considerable reduction in the yeast-induced hyperthermia at after 24 hours of extract administration (500 mg/kg) after the yeast injection. The temperature decreased to 36.86 ± 0.04 , 36.68 ± 0.05 and $36.53 \pm 0.07^\circ\text{C}$ at 30, 90 and 150 min following the respective treatments [17].

6.2.13 Fracture Healing Activity

Yadav, Jain, Sristava and Jain (2011) investigated that ethanolic extracts of the seeds of *Lepidium sativum* L. are known to have fracture healing activity. X-ray photographic studies demonstrated that at the 2nd, 4th and 8th week of 400 mg/kg ethanolic extract administration, observation of callus formation in considerable amount was evident in test group in comparison with the control group of experiment [17].

6.2.14 Cardioprotective Activity

The 5-fluorouracil (5-FU) is an anti-metabolite fluoropyrimidine analog of the nucleoside pyrimidine possessing strong anti-tumor activities. For treatment of solid tumours, 5-fluorouracil (5-FU) is utilized as a potential chemotherapeutic agent. But the major cardio-toxicity is a major complication of 5-FU therapy. To test the cardio-protective activity of garden cress, the rats were divided into the major three groups. Control group rats received only saline for 8 days, while FU-treated group rats received silly orally for 8 days after that they were injected by I.P along with 5-FU (150 mg/kg B.W) on 5th day. LS-treated group rats were provided by LS (550 mg/kg B.W/day) orally for 8 days after that they were injected by the same dose on 5th day through which 5-FU were treated. The assessment of cardio-toxicity in 5-FU rats was made by lipid profile,

considerable rise in the concentration of cTnI serum, CK-MB and by enlargement of cardiac MDA. In cardiac homogenate, GSH and HDL-c concentration were found to be considerably reduced in 5-FU. By pre-co-post-treatment of LS, all altered factors to the 5-FU were observed suggesting the significant beneficial impact of LS in heart protection against cardio-toxicity induced by the 5-FU by maintaining the activities of anti-inflammatory and anti-oxidant [32].

6.2.15 Free Radical Scavenging Activity

An experiment was conducted to test the percentage yields of free radical scavenging activities obtained for different ethanolic extracts of *Lepidium sativum* L. are stem ($2.69 \pm 0.05\%$), leaf ($10.21 \pm 0.09\%$), seed ($11.63 \pm 0.03\%$) and shoot ($12.19 \pm 0.02\%$). For the analysis of scavenging activity, determination of hydrogen donating ability of DPPH extract was made. When the DPPH is scavenged, the deep violet coloration of this reaction mixture changed into the pale yellow colour that can be preferably found spectro-photometrically. In the ethanolic extract of shoots of *Lepidium sativum* L., shoots exhibited higher scavenging activity as compared to the seeds due to the presence of relatively higher concentrations of total polyphenolic contents. Leaf extracts of this plant showed comparatively higher scavenging activity while the stem extracts showed lowest scavenging activity among all available test extracts. Chloroform and methanolic extracts (0.01 mgdw/ml) of *Hypericum cerastoides* significantly quenched the DPPH ($84.2\% \pm 0.3$), although it exhibited very low total anti-oxidant activities (19.5 ± 0.8 M TE/g). The scavenging potentials of *Hypericum perforatum* has significant values $77.6\% \pm 0.5$ or DPPH and corresponds to the presence of high quality of phenolic compounds. The scavenging potentials might be due to the presence of total polyphenolic compounds in the reaction mixture. These polyphenolic components include flavonoids, anthocyanidins, tannins and xanthones anthraquinones. These compounds have been found to be directly involved in scavenging the free radicals hydroxyl radical and of superoxides by transferring single electron. Although, these phytochemicals were not assayed for *Lepidium sativum* L. in the present study however it is presumed that the species is rich in total phenolic contents [22].

6.2.16 Total Glutathione S-Transferase Activity

The activity of glutathione s-transferase enzyme in ethanolic extracts of stem of *Lepidium sativum* L. using glutathione and 1-chloro-2,4-dinitrobenzene was found to be very effective while using these specifications 2000 ± 52.6 nmol/ml/min. Estimations of reduced glutathione contents in ethanolic extracts of various parts of *Lepidium sativum* L. Contents Concentration (g/ml) O.D (512 nm) Glutathione content (g/ml) Blank-0.00-S1 10 0.50-S2 20 1.00-S3 30 1.70-S4 40 2.50-Stem 100 0.40 8 ± 0.46 Leaf 100 0.45 9 ± 0.2 Shoot 100 0.30 6 ± 0.31 Seed 100 0.21 4 ± 0.12 O.D., optical

density. Leaf showed 8800 ± 76.4 nmol/ml/min, shoot showed 6000 ± 43 nmol/ml/min and seeds showed 9600 ± 56.3 nmol/ml/min. These values confirmed that extracts contain enhanced anti-oxidant activity. Similar high activity of glutathione s-transferase activity noticed in some other plants like Zygophyllaceae and Euphorbiaceae that have also been related positively with their anti-oxidant potentials [32].

6.2.17 Reduced Glutathione Activity

The reduced glutathione content of the ethanolic extracts of *Lepidium sativum* L. were found to be in stems 8 ± 0.46 g/ml, leaves 9 ± 0.2 g/ml, shoots 6 ± 0.31 g/ml and seeds 4 ± 0.12 g/ml. The intra-cellular reactive oxygen species assay that determines the intra-cellular levels of glutathione (GSH) revealed the release of increased level of anti-oxidants in all types of extracts of *Lepidium sativum* L. The results of present study suggested that levels of glutathione were decreased with corresponding increase in the anti-oxidant potentials. Among the extracts, highest value was observed in the leaves that is evident to be 9 g/ml [22].

6.2.18 Reducing Power (Fe^{3+} - Fe^{2+} Transformation Ability)

Reduction of Fe^{3+} - Fe^{2+} by the process of electron donation has confirmed the presence of any oxidant into the sample of analysis. By the formation of pearl's Prussian blue at the level of 700 nm, the amount of Fe^{2+} complex has monitored, exhibiting the increase in reductive ability level. Increased level of optical density in all the studied extracts of *Lepidium sativum* L. has confirmed that each and every part of the plant is being involved in the reduction of Fe^{3+} - Fe^{2+} . Ethanolic extracts of *Lepidium sativum* L. gives the optical density in increasing concentration in all plant parts and it showed that it has the reducing ability of Fe^{3+} - Fe^{2+} [22].

6.2.19 Chemo-Protective Effects of *Lepidium sativum*

Lepidium sativum L. was also investigated for its chemo-protective properties toward 2-amino-3-methylimidazo quinolin (IQ)-genotoxic effects and in colonic periplastic lesion reduction. The mediators of these protective effects are certain compounds of *Lepidium sativum* L. juice, glucotropeteolin (GT) and a break down product of GI (benzylisothiocyanate BITC). Results were significantly affirmative ($p < 0.05$). IQ-induced DNA damage in colon and liver cells in F344 rats was reduced in range of 75%-92%. It is suggested that this chemo-protective effect is mediated by glucosyl transferase (UDPG) which is a key enzyme in detoxification of IQ. The amount of *Lepidium sativum* L. juice needed to induce these effects is quite small and similar to the amount consumed in regular salad [13].

7. Summary

The *Lepidium sativum* L. also well known as "Chandra shoor" or "garden cress" is basically native plant

of South Asia and later many years ago it has been spread to the Western Europe. Since the age of Vedic, this plant is very famous in India and has been utilized all around the country for culinary uses and as salad. Its harvestation remains continue throughout the year either indoor or outdoor and when it reached the height of 5-10 cm then its sprouts are cut. It has been utilized as nutritional food stuff owing to the presence of significant proportion of fats, iron, proteins, vitamin A, vitamin C, calcium and folic acid and also it has relieved the human from utilizing the non-conventional food stuff of low quality by the manufacturing of garden cress containing products. So, the ingredients of garden cress blended products e.g. citrus khus cooler, garden cress soup and falooda are the ones that provide the refreshment along with high nutritional value. Garden cress has potential, both as a foodstuff and nutraceutical in plants and seeds. In ancient time, it has been used in many regions of the world. In future, we can take nutritional and medicinal benefits from this plant by making the curative and food products from it. Garden cress has been found to be very effective against a surplus of diseases such as inflammation, diabetes mellitus, muscular pain, hypertension, kidney stones, rheumatism and bronchitis. Additionally, it also has the anti-cancer potentials owing to the member of Brassica family. The seeds of garden cress are utilized as galactagogue. From all of the available plants, *Lepidium sativum* L. appears to be the most worthy for further exploration of science and its therapeutic potentials and nutritional applications. We concluded that aqueous extract of seeds of *Lepidium sativum* L. was found to be effective in lowering blood pressure and increasing water and electrolytes excretion. *Lepidium sativum* L. was well known in ancient India and Saudi Arabia and was used for treating various conditions such as bone fracture healing, inflammation, arthritis and many others. It contains different chemicals including fatty acids, proteins, shikmic acids, vitamins, carbohydrates, calcium, phosphorus and trace elements. Garden cress is used as food and a source of medicine. Based on all these studies, *Lepidium sativum* L. has proved its value and worth as potential nutritional component and medicinal compound. However, the active constituents and site of these *Lepidium sativum* L. activities are still unknown.

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