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Lepidium sativum: A potential functional food

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ABSTRACT

Lepidium sativum Linn. (family Cruciferae) is an edible herb that is botanically related to watercress and mustard, having their peppery, tangy taste and odour. Traditionally *L. sativum* seeds are used to treat wounds, sprains, asthma, bronchitis, cough and is considered useful as abortifacient, aphrodisiac, antibacterial, diuretic, expectorant, gastrointestinal stimulant, gastroprotective, laxative and stomachic. Many of these traditional uses have been scientifically validated using different *in vitro* and *in vivo* studies and in this review are compiled in an inclusive manner. Seeds are reported to be rich in carbohydrates, vitamins, amino acids, proteins, triterpenoids, steroids and saponin glycosides possessing different pharmacological activities. **Aim of the study:** This study is an effort to collate complete scientific literature published till March 2021 in order to generate a succinct summation on the distribution, traditional beneficial potential, chemical constituents, phytochemistry, pharmacology and toxicology of this coveted species of genus *Lepidium*. **Materials and Methods:** Exploring assorted **s**cientific databases. **Results**: The present methodically compiled review article accentuates medicinal and nutritional significance of this highly valued plant by focusing on various aspects of the plant such as the, physicochemical characterisation and pharmacological studies that validates folklore uses. Thus, this annotated script on *L. sativum* would be a handy tool to explore the future prospective of research on this traditional plant.

Keywords: Cruciferae, Garden cress, *L. sativum*, Pharmacology, Phytochemistry.

INTRODUCTION

L. sativum Linn. (Family Cruciferae) is an annual, glabrous, erect, and fast-growing, herb commonly known as “common cress,” “garden cress,” “garden pepperweed,” “chandrashoor,” “raktbija”, “aseliyo” and many more. The plant is native to Europe and southwestern Asia, introduced and cultivated throughout India, Europe, United States, England, France, Asia, etc. as a salad plant [1-3]. All parts are of commercial value, but it is cultivated throughout the world mainly for its seeds and leaves of which the later are consumed as salad for piquant flavour [4, 5]. The plant is also used in poultices for wounds and sprains [6]. Seeds are used to treat respiratory diseases like asthma [7-9] bronchitis and cough [7-9], bleeding piles [10], scorbutic diseases [11], liver complaints [12-18], Root is specifically valued in the treatment of secondary syphilis and tenesmus [19].

Documented records on phytochemical aspects revealed that raw seeds in particular are rich in vitamins A, C, and K; minerals, carbohydrates, dietary fibres, protein, and fat [20-23].

L. sativum is also known for its several pharmacological actions such as anti-bacterial [6, 24-31], anti carcinogenic [32-39], anti-inflammatory [6, 30, 40-45], cardioprotective, antioxidant [11, 30, 46-51], hypolipidemic [16, 17, 40, 52-58], diuretic [59-61], gastro-protective [62-67], stomachic [62, 64, 65, 68], gastrointestinal stimulant [62-67], and laxative [67] and many more.

The present review is an assemblage of literature on identification, traditional uses, phytochemical and pharmacological research work on *L. sativum*, that explicate the all-round medicinal utilities of this plant.

HABITAT

L. sativum can be grown all over around the year at all altitudes but the most favourable season is winter. Cultivation is done on both mass scales and individual scales and it is suitable for hydroponic cultivation also and can thrive well in slightly alkaline water [4, 5].

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DISTRIBUTION

Global distribution

L. sativum is native of Egypt and Southwest Asia that as a naturalised or more frequently casual plant is widespread in Asia, Afghanistan, Bhutan, China, India, Japan, Kazakhstan, Kyrgyzstan, Nepal, Pakistan, Russia, Tajikistan, Turkmenistan, Uzbekistan, Vietnam; Africa; Europe; North America; South America [69].

Local distribution

It is found to be growing throughout India in cultivated fields, gardens, roadsides and near railway tracks, at an altitude up to 2000 m [10].

Morphology and microscopy

L. sativum is an annual edible herb 15–50 cm in height, straight, branched, glabrous, rarely pilose with pinnatisect basal leaves that are 5-10 cm long, 2.5-3.5 cm broad, stalked to subsessile, while cauline leaves are linear and sessile with entire margin as shown in Fig. 1. Racemes are much-branched, each 20-40 flowered, ebracteate. Flowers are small about 3 mm in size, white or pinkish; Fruit is on suberect to ascending pedicel that is appressed to rachis and 5 to 6.4 mm in size. It is obovate or broadly elliptic, emarginated, apically broadly winged with apical notch 0.2 to 0.8 mm deep. Seeds are ovate-oblong, 3 lobed, 3 mm long, 1 mm broad, brownish-red in colour as shown in Fig. 2.

Figure 1: Leaf of *Lepidium sativum*

Figure 2: Seeds of *Lepidium sativum*

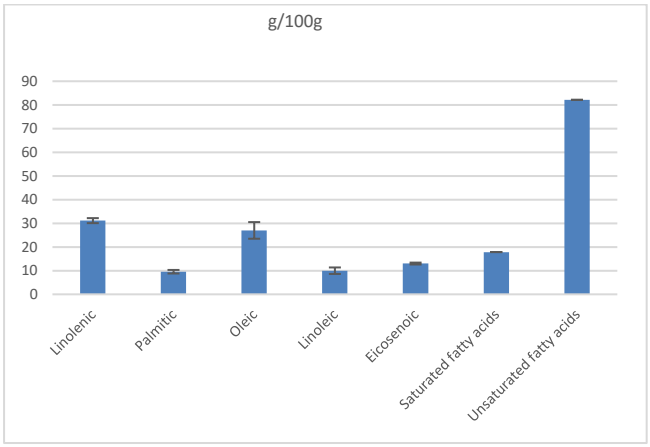

Figure 3: % Major Fatty acids

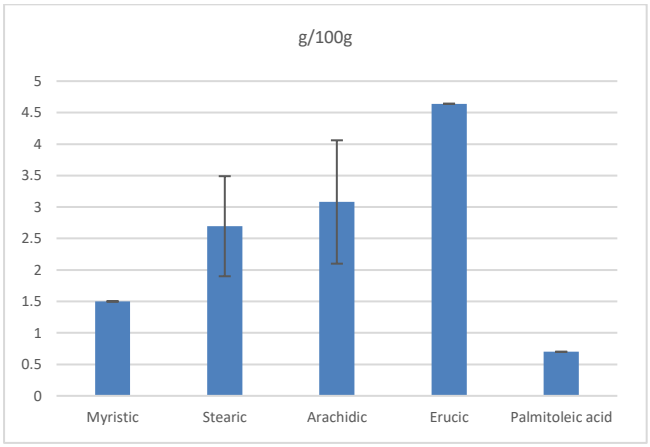

Figure 4: %Minor Fatty acids

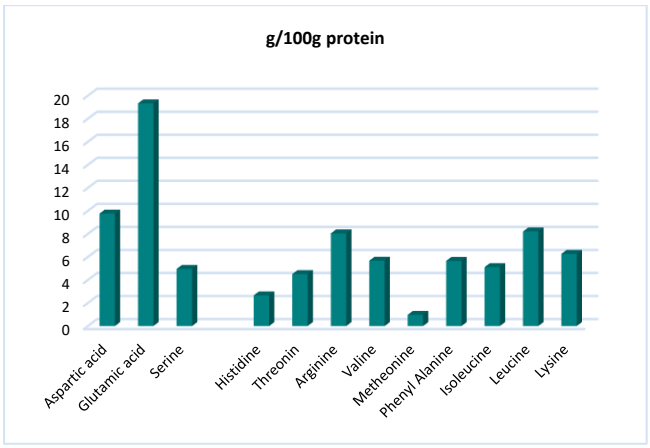

Figure 5: % Amino acids

Traditional use

L. sativum has been traditionally used for many diseases such as cold infusion of seed is used in treatment of high cough, spleen and liver chronic enlargement, flatulence, diarrhoea, dysentery, indigestion, rheumatic pain, inflammation, viscous humours, tenesmus, secondary syphilis, abortion, anaemia and weakness [70-72]. For sprains, dysentery, leprosy, skin diseases they are mostly used as poultices. The seeds are also recommended as depurative, tonic, aphrodisiac, hemogenic, galactagogue and diuretic. Moreover seeds are useful in preventing the hair loss and stimulating the appetite [73].

L. sativum is noted to relieve the body's allergic responses to insect bites. According to Ayurvedic system of medicine it exhibits hot, bitter, tonic, and aphrodisiac properties [4, 3, 74-76].

Other uses

Recently, *L. sativum* is getting recognition as a functional food. As it has high nutritive value, people consume it as a dietary supplement. In some of the countries, noodles [77], biscuits [78], health drinks [79], flakes [80], cereals [81], ladoo [82, 83, 72], snacks [84], instant 'dhokla' mix [85], and nutricookies [86], prepared from the seeds are marketed. Leaf of *L. sativum* used in salad preparation because of its tangy taste and health benefit [22, 69,73, 87-92]. Seeds serve a source of mucilage that is used as pharmaceutical excipients [22, 93, 94].

Seed cake of *L. sativum* is also used as a water purifying bed. Also seeds have the capacity to absorb heavy metals from the soil and so are used as soil purifier for their removal of from the soil [95, 96].

Phytochemistry

L. sativum is known for its various activities since ancient time and recently seeds in particular are being popularly promoted as functional food too. The seeds are rich in minerals, vitamins, essential fatty acids. protein, amino acids and flavonoids, alkaloids, saponins.

Basic component

Basic nutrient like total carbohydrate, protein, moisture content, and ash value of *L. sativum* is mentioned in Table 1 [4, 20-23].

Table 1: Basic components of *L. sativum*

Parameter	% w/w± SD
Moisture	5.70±1.71
Protein	22.6±2.32
Ash	5.14±0.49
Crude fibre	8.21±1.85
Carbohydrates	34.23±4.71
Fat	24.82±2.66
oil	22.66

Vitamins

Vitamins are essential in our day to day life. Some evidences confirm the presence of vitamins in *L. sativum* as mentioned in Table 2 [20, 97, 98].

Table 2: Vitamins obtained from *L. Sativum*

Vitamins	% daily value
Vitamin A	138%
Vitamin C	115%
Vitamin D	0%
Vitamin B-6	10%
Cobalamin	0%

* % Daily Values are based on a 2000 calorie diet.

Minerals

Minerals are those elements which are required for our body development and function normally. *L. sativum* is reach in minerals Table 3 [4, 20-23, 97-99].

Table 3: Mineral content of *L. sativum*

Mineral Content	% DWB± SD
Iron (Fe)	0.04±0.02
Copper (Cu)	0.01±0.02
Zinc (Zn)	0.01±0.02
Manganese (Mn)	0.01±0.008
Boron (B)	0.01
Molybdenum (Mb)	0.004
Aluminium (Al)	0.02
Potassium (K)	4.63±5.16
Phosphorus (P)	2.87±2.62
Calcium (Ca)	1.16±1.26
Sodium (Na)	0.13±0.08
Magnesium (Mg)	1.73±1.42
Sulphur(S)	2.93

Essential fatty acids

L. sativum serves as a potential source of fatty acids, some essential fatty acids are ethyl linolate; ethyl octadecenoate and many more and their diagrammatical representation is given in Fig. 3 and Fig. 4 [20, 22, 97, 101, 102].

Saturated fatty acids and its derivative

L. sativum is reported to contain *n*-hexadecanoic acid, hexadecanoic acid ethyl ester, glycidyl palmitate; ethyl (E)-octadec-9-enoate; ethyl icosanoate; glycidyl Oleate; 1,3-dihydroxypropan-2-yl hexadecanoate, dodecanoic acid, ethyl pentadecanoate, tetradecanoic acid, ethyl tetradecanoate; pentadecanoic acid, ethyl pentadecanoate, pentadecanoic acid, 6,10,14-trimethylpentadecan-2-one, pentadecanoic acid ethyl ester, hexadecanoic acid methyl ester, 9-hexadecenoic acid, ethyl 9-hexadecenoate, (e)-9-octadecenoic acid ethyl ester, heptadecanoic acid, ethyl ester, octadecanoic acid, ethyl ester; 4,8,12,16-tetramethylheptadecan-4-olide, behenic alcohol, docosanoic acid, ethyl ester, hexacosylheptafluorobutyrate, ethyl tetracosanoate, 1-heptacosanol [20, 97, 101-04].

Unsaturated fatty acids and its derivatives

Unsaturated fatty acids and their derivatives are identified in *L. sativum* are γ-tocopherol, 8,11,14-eicosatrienoic acid methyl ester, linoleoyl chloride, trans-9,12-octadecadienoic acid propyl ester, ethyl (9z,12z)-octadeca-9,12-dienoate, benzenepropanoic acid octadecyl ester [20, 97, 101-105].

Different monounsaturated fatty acids and their derivatives are identified include *cis*-9-hexadecenal; erucic acid, oleoyl chloride, (Z)-18-octadec-9-enolide, (E)-3,7,11,15-tetramethylhexadec-2-en-1-ol, trans-phytol, dichloroacetic acid tridec-2-ynyl ester, (14r)-14-methylhexadec-

8-yn-1-ol, (z)-octadec-9-enal;fumaric acid, 2-dimethylaminoethyl octadecyl ester [20, 101, 102, 104].

Phytosterols and its derivatives

Phytosterols are the phytoconstituent which have steroidal skeleton. They serve lots of advantages as they act as steroids present in human body. Important phytosterols such as stigmasterol, γ -Stigmasterol; β-sitosterol, campesterol, isofucosterol, squalene, along with [(3s)-17-[(e)-5-ethyl-6-methylhept-3-en-2-yl]-10,13-dimethyl 2,3,4,7,8,9,11,12, 14,15,16, 17-dodecahydro-1h-cyclopenta[a]phenanthren-3-yl] acetate, stigmast-5-en-3-ol, oleate, stigmast-5-en-3-ol, 4-campestene-3-one, 4,22-stigmastadiene-3-one, gamma-sitostenone, (5r,8s,9s,10r,13r, 14s,17r)-4,4,10,13-tetramethyl-17-[(2r)-6-methylheptan-2-yl]-2,5,6,7, 8,9,11,12,14,15,16,17-dodecahydro-1h-cyclopenta[a]phenanthren-3-one,(5s,8s,9s,10r,13r,14s,17r)-17-[(2r,5r)-5-ethyl-6-methylheptan-2-yl]-10,13-dimethyl2,4,5,7,8,9,11,12,14,15,16,17 -dodecahydro-1h-cyclopenta[a]phenanthrene-3,6-dione have been identified in *L. Sativum* [101, 102, 104, 106].

Amino acids

Essential amino acids and non-essential amino acids both are required for human body development. Entire genomes of human based on amino acids but human body dose not generate these amino acids by themselves. In such situation amino acids are taken from the natural sources. *L. sativum* is reach in amino acid content, some of them are mentioned in Table 5 and their percentage description given in Fig. 6 [4, 20, 22, 97, 100].

Volatile compounds/aromatic compounds

Seeds of *L. Sativum* contain plenty of volatile oil that is rich in neral, citral, linalool (monoterpenoid), carvone (terpenoid), linalyl acetate, geraniol (monoterpenoid), terpinyl formate, eugenol, geranyl acetate, methyl eugenol, (4R,4aR)-1,1,4,7-tetramethyl-1a,2,3,4,4a,5,6,7b-octahydrocyclopropa[e] azulene (tricyclic sesquiterpene), caryophyllene (bicyclic sesquiterpene), 1,2-15,16-diepoxyhexadecane, 1,2-benzenedicarboxylic acid [101, 104].

Organic compounds

Important secondary metabolites recorded in the *L. Sativum* comprise kaempferol-7-O-α-L-rhamnopyranoside; quercetin-7-O-L-rhamnoside; rutin; 3-methoxy-4-hydroxybenzoic acid; syringaldehyde; 2-phenylacetamide; benzoic acid, 2-(dimethylamino) ethyl ester; benzyl nitrile; (isothiocyanatomethyl)-; 3',5'-dimethoxyacetophenone; 2-(dimethylamino) ethyl 3-cyclopentylpropanoate; 4-O-[2-(dimethylamino) ethyl] 1-O-nonyl (E)-but-2-enedioate; O-ethyl s-2-dimethylamino ethyl ethyl phos; eucalyptol; benzyl isocyanate; 2,4-ditert-butyl-6-(1-phenylethyl)phenol; neophytadiene; 1,5-pent-2-ene-3-methyl-5-(2,6- dimethylhept; 3-cyclopenta-2,4-dien-1-yl-n,n-dimethylpropan-1-amine; 3-cyclopentylpropionic acid 2-dimethylaminoethyl ester; 1-cyclohexyldimethylsilyloxybutane; cyclododecanone; 2-(3-hydroxybutyl)-2-nit [101, 104, 106].

Pharmacological activity

Anti carcinogenic activity

Phenolics compound present in the seed coat of *L. sativum* has been shown to possess inhibitory action of trypsin with an IC50 value of 14.6 µg/mL [32]. *L. sativum* juice is reported to exhibit protective action against benzo(a)pyrene-induced DNA damage in human derived cells [33]. Furthermore, chemoprotective effect of *L. sativum* constituents, glucotropaeolin and benzylisothiocyanate is shown to be mediated through enhancement of detoxification of 2-amino-3-methyl-imidazo [4,5-f] quinoline by glucuronosyl transferase [34-36]. The methanolic extract is shown to be cytotoxic in MTT and neutral red assays *in-vitro* on colon and endometrium cancer cells and human peripheral lymphocyte cells in a concentration-dependent manner. A high content of phenolic and flavonoid compounds in the extract is shown to be responsible for significant antioxidant activity. Apoptotic activity and genotoxic effects of the plant extract were significantly found to be increasing with 200 µg/ml concentrations at 48 hours incubation [37]. Alkaloid extract of *L. sativum* containing six alkaloids and proto-alkaloids, viz., benzyl isothiocyanate (1), 2-ethoxy-4H-3,1-benzoxazin-4-one (2), (4R)-2-(2-aminophenyl)-4-phenyloxazoline (3), 5-acetyl-1,2-dihydro-6-methyl-2-oxo-4-phenyl-3-pyridinecarbonitrile (4), benzo[b, 1,8]-naphthyridin-5(10H)-one,2,4,7-trimethyl (5) and 1,4-diaminoanthraquinone (6) is reported to be cytotoxic to Jurkat E6-1 cells, with median lethal concentration (LC_{50}) of 75.25 µg/mL. In further experiments with Jurkat cells at LC_{50} and sub-LC_{50} doses the extract is shown to demonstrate DNA fragmentation, activate caspase-3 and cause time-dependant phosphatidylserine translocation (apoptosis) from inner to outer cell membranes [38]. However, the alkaloid extract is also shown to be possessing nontoxic and proliferative (1.6-fold) effects in healthy PBMCs. The aqueous extract of seed is shown to inhibit growth of breast cancer cells MCF-7 cells, time and dose-dependent manner [39].

Anti-diarrheal and anti-spasmodic activities

The methanolic extract of *L. sativum* seeds is reported to have a substantial reduction in the severity and frequency of diarrhoea produced by castor oil due to the ability of the extract to increase re-absorption of NaCl and water by decreasing the intestinal motility. Further, this activity of the extract is attributed to the presence of flavonoids, alkaloids and saponins that are known for inhibiting autacoid and prostaglandin, in that way inhibiting the motility and secretion [62-67].

In various animal experimental studies the crude extract of *L. sativum* is shown to exert antispasmodic effect through a combination of multiple pathways including activation of K+ channels, and inhibition of muscarinic receptors, Ca++ channels and PDE enzyme [62, 64, 65, 68].

Anti-hypertensive activity

The aqueous extract of *L. sativum* in various experiments is shown to cause a significant decrease in blood pressure while no changes in heart rate [41, 60, 70, 97, 99, 107-109].

Anti-inflammatory activity

Several studies on anti-inflammatory potential of seed oil of *L. sativum* report its potential to alleviate inflammatory conditions by modulating inflammatory mediators such as NO and leukotriene B4 and the effect has been attributed presence of α-linolenic acid, 7,10-hexadecadienoic acid, 11-octadecenoic acid, 7,10,13- hexadecatrienoic acid, and behenic acid in the seed oil at 300µg/mL [41, 6]. The anti-inflammatory activity of methanolic extract of seed was studied in rats at three different doses 50 mg/Kg, 100 mg/Kg, and 200mg/Kg and the highest activity is shown to be at 50mg/kg dose [43]. *L. sativum* crude extract containing a high concentration of flavonoids quercetin, kaempferol, luteolin, apigenin, naringin and naringenin has been found to mitigate inflammatory conditions in experimental animals [40]. In another study crude extract of *L. sativum*, polyphenols and organosulfur compounds are shown to be responsible for the antioxidant and anti-inflammatory activities [42]. The crude extract of *L. sativum* is shown to exert strong anti-inflammatory activity in carrageenan-induced paw oedema and reduce the yeast-induced hyperpyrexia by inhibiting the proliferation of fibroblasts and also modulation of connective tissue [30, 44, 45, 110].

Anti-microbial activity

The ethanol extract of seeds of *L. sativum* at 200 mg/ml is reported to inhibit growth of *Streptococcus equine* and *Corynebacterium pseudotuberculosis* [24]. In multiple experiments seed extracts (ethanol, methanol and chloroform) are assessed against different strains of bacteria like *Klebsiella pneumoniae, Staphylococcus aureus,* Methicillin-Resistance *Staphylococcus aureus*, *Streptococcus pneumonia* and *Escherichia coli* strains and the major compounds fatty acid esters and alkaloids are shown to be responsible for anti-microbial activity [25-31, 104, 111]. *L. sativum* seed oil is reported to possess anti-microbial effect against *Pseudomonas aeruginosa, Salmonella enterica, K. pneumoniae, S. aureus, Bacillus subtilis, E. coli and Candida albicans* [6].

Analgesic activity

The methanolic extract of seed *L. sativum* rich in carbohydrates, proteins, fatty acids and vitamins (*β*-carotene, riboflavin, niacin and ascorbic acid) along with volatile oils, fixed oils, flavanoids, isothiocynate glycoside is reported to possess analgesic activity in mice in tail flick and hot plate methods [43, 45]. In one of the study on the neurobehavioral effects, the total alkaloid fraction from seeds of *L. sativum* is reported to considerably potentiate the thiopental induced hypnosis, decrease locomotor activity and motor coordination, and increase preference to plus maze open arm [112]. Flavonoidal constituents from the methanolic extract of *L. sativum* seed has been shown to give analgesic activity in rat model [113]. The seed of *L. sativum* is found to exert analgesic activity of in the acetic acid-induced writhing syndrome and formaldehyde-induced paw licking response by significantly increasing latency of onset and producing significant inhibition of neurogenic and inflammatory pain [114].

Anti-osteoporotic effect

Treatment with *L. sativum* is shown to improve the serum Ca, albumin, P, bone architecture bone-specific alkaline phosphatase (b-ALP), and decreased tartrate-resistant acid phosphatase (TRAP) in glucocorticoids-induced osteoporosis in experimental animals [114, 115].

Anti-oxidant activity

Lepidium seed oil consists of fatty acid (oleic acid and linoleic acid), γ-tocopherol, δ-tocopherol and flavonoid is reported to cause significant reduction in free oxidative species in blood [11, 47-50]. 7,10-hexadecadienoic acid, 11-octadecenoic acid, 7,10,13- hexadecatrienoic acid, and behenic acid phytoconstituents found in *L. sativum* are shown to possess free radical scavenging activity (DPPH) [6, 46]. Of the ethanolic extracts of different parts of *L. sativum* studied for antioxidant activity (DPPH assay) shoot extract is shown to be supreme in scavenging activity and stem as least active [51] In one of the study *L. sativum* antioxidant activity is reported against melanin production enhancement on exposure to UV-c radiation [116]. The activity of glutathione s-transferase enzyme, reduced glutathione activity and reducing power was found to be more in ethanolic extract of seed than other plant parts [51, 117].

Anti-pyretic activity

The methanolic extract of *L. sativum* in dose of 100 mg/Kg is reported to produce significant reduction in the yeast-induced hyperpyrexia (antipyretic effect) [45].

Bronchodilatory effects

L. sativum is extensively used in traditional medicine to treat respiratory tract disorders, such as asthma, bronchitis and cough. The crude extract of *L. sativum* at higher concentration is shown to inhibit carbachol and K+ induced contractions in a pattern which is similar to that of dicyclomine, suggesting that bronchodilatory effect of these crude extract is mediated through a combination of anticholinergic, calcium ion channel antagonist and phosphodiesterase inhibitory pathways, providing complete mechanistic background for its medicinal use in the overactive airways disorders [8, 9, 62, 70, 118- 126].

Cardioprotective effect

The ethanolic extract of *L. sativum* (i.p.) is recorded to cause significant rise in blood pressure and increase the rate and force of auricular and ventricular movements of open chest cat heart preparation. The cardio-stimulant action is also reported to be observed on isolated rabbit auricles. It is noted in the study that the extract, when given intraperitoneal route to mice at up to 1000 mg/kg, did not produce behavioural or toxic effects [127].

Coagulant activity

The ethanolic extract of *L. sativum* is shown to significantly increase in fibrinogen level and an insignificant decrease in prothrombin time, confirming its coagulating property [45].

Diuretic activity

The aqueous extract of *L. sativum* produces has been shown to increase glomerular filtration rate causing significant increase of urinary excretion, along with sodium, potassium and chlorides ions in normotensive rats [60]. The aqueous saponin rich fraction extract of *L. sativum* on oral administration is reported to show dose-dependent increase in urinary excretion along with sodium ion excretion [61].

Fracture healing activity

L. sativum is reported to show fracture healing activity in fracture in the midshaft of the left femur induced in adult white rabbits [94, 107, 128].

Growth performance and gonadotropins secretion

The gonadotropins effect of *L. sativum* seed supplement because of presence of phytosterols is reported to be mediated through the activation of estrogen receptors thereby producing agonistic effects that resulted in significant increase in LH and FSH secretion dose-dependently in rabbits [129].

Hepatoprotective effect

L. sativum has been widely used to treat numeral aliments in our folk medicine. Many investigations are done to ensure hepatoprotective this activity of *L. sativum*. The extract of *L. sativum* is noted to reduce oxidative stress and thereby reduce cytotoxicity induced by hydrogen peroxide in the human liver cell (HepG2) [14]. In an experimental study, the ethanolic extract of *L. sativum* is shown to significantly decrease oxidative stress markers, protein level and albumin level along with down-regulating mRNA expression of iNOS and HO-1 and also noted to cause concomitant increase in MPO activity and NFkB DNA-binding effect [15, 16]. The seed oil of *L. sativum* also is recorded to exhibit hepatoprotective activity by helping in reducing bad cholesterol and hence improving liver enzyme activity [17]. In an experiment, *L. sativum* is rated as functional food that possesses number of activities and hepatoprotective activity is one of them [18].

Hypoglycemic activity

In our folk medicine *L. sativum* is used to treat diabetes as well. There are many evidences which give base to this claim. Many scientific activities have been done to establish proper mechanism of hypoglycemic activity of *L. sativum* as raw and its crude extract.

Oxidative stress is a major cause of diabetes and its associated complication. In streptozotocin along with high-fat diet diabetes mellitus experimental mouse model among raw *L. sativum* and crude extract, the former is reported to give better effect as evidenced by significant reduction into the blood glucose level and improved blood lipid metabolism in diabetic mice by improving activity of antioxidant defence enzymes with improved the body's antioxidant emergency response [16, 130, 47, 53]. The flavonoid rich extract of *L. sativum* is shown to improve insulin sensitivity, dyslipidaemia, inflammation, and pancreas *β* cell integrity [40]. A research study shows that trace element present in plant gives antidiabetic activity [131]. The methanolic extract of the *L. sativum* is shown to exhibit potent antioxidant and hypoglycemic activity in alloxan-induced diabetic rate model through changing the pathology of the pancreas [54]. In some of the experimental studies *L. sativum* is given as a dietary supplement and daily consumption of seeds of *L. sativum* is reported to significantly improve body functioning. Also, phenolics present in the seed coat of the *L. sativum* are noted to inhibit carbohydrate hydrolysing enzymes such as *α*-amylase and *α*-glucosidase and lower postprandial glucose level [32]. Furthermore, imidazole alkaloids, lepidine and semilepidine of seeds of *L. sativum* are reported to produce antidiabetic action by the potentiating of pancreatic secretion of insulin from the remaining islet β-cells [55]. The aqueous *L. sativum* extract is shown to inhibit renal glucose reabsorption which in turn reduce blood sugar [132, 133]. All of this experiment conclude that *L. sativum* have significant role in hypoglycemic activity [107, 111, 118, 134-138].

Hypolipidemic activity

There are several experiments which provide strong evidence for the hypolipidemic activity of *L. sativum*. Several experimental reports show that after consumption of L. sativum in raw form or extract, there a significant reduction in total cholesterol (TC), triglyceride (TG), low-density lipoprotein (LDL) while the major increase in high-density lipoprotein (HDL) level indicating improved lipid metabolism because of flavonoids [16-18, 30, 40, 48, 52-58, 139-141].

Laxative activity

The seeds of *L. sativum* have been shown to possess a strong laxative effect in mice and thus supports a rationale for its traditional use in indigestion and constipation. Various experiments performed on the intestine and jejunum tissue of rat, mice, and rabbit revealed that tissue selectivity differed based on the type of animal tissue. The methanolic seed extract of *L. sativum* is reported to be antidiarrheal as well as laxative [67].

Menstrual cycle regulation

One of the experiments aimed to determine the effect of the *L. sativum* seed consumption on the endocrinology of ovulation and the development of visceral organs in the rat model. showed that *L. sativum* supplementation tended to cause an earlier, attenuated preovulatory surge-like GnRH secretion. Also temporally, luteinizing hormone (LH) secretion from the pituitary gland in all treatment groups decreased over time. Overall, follicle-stimulating hormone (FSH) decreased from time 0 to about 180 min before stabilizing. *L. sativum* extract administration is reported to significantly increase average FSH secretion in ovariectomized, estrogen-primed rats but did not affect in the ovariectomized, estrogen-primed, and progesterone-treated rats [142].

Nephroprotective and curative activities

L. sativum is reported to give compelling nephroprotective and curative activities by scavenging of free oxidative radicals in cisplatin induced nephrotoxicity experimental animal model. The methanolic seed extract balanced border enzymes like Na+/K+ ATPase, Ca++ ATPase and Mg++ ATPase [32, 46, 71, 123, 143-145].

Male fertility improvement

In one of the experiment, Oral supplementation of tocopherol extracted from seeds of *L. sativum* is reported to improve histoarchitecture of rabbit testis and could be used to improve the fertility of rabbits [105].

CONCLUSION

L. sativum has been used for many purposes. The scientific research on *L. sativum* suggests a huge biological potential of this plant. *L. sativum* has been used as nutraceuticals, and pharmaceutical excipient. Besides being used as nutraceutical and pharmaceutical excipients *L. sativum* has been extensively used for functional food and as a traditional medicine. Besides being used as traditional medicines, several compounds and extracts of *L. sativum* showed pharmacological activities. It is believed that detailed information as presented in this review on pharmacognostical, phytochemical and various pharmacological activities and the uses of different extracts might provide detailed evidence for the use of this plant in different medicinal systems. The phytochemical variations and efficacy of the medicinal values of the *L. sativum* is dependent on geographical location. *L. sativum* is effective in asthma, cough, gastrointestinal track disorders, cardiac disease, diabetes, hepatic function, infections and many more. Therefore, with appropriate management, *L. sativum* could be promoted to be used for the benefits of local people and industry, especially pharmaceutical industry, and it may enhance food security, health security, environmental security and economic security.

Conflict of Interest

None declared.

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