Halim Seeds (Lepidium sativum L.): A Nutraceutical Treasure Phytochemistry, Pharmacology and Therapeutic Potential

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***Abstract*—The present article gives important information of Lepidium sativum on therapeutic use, traditional medicinal uses mention in various Ayurvedic literature, phytochemical and pharmacological properties of modern era. Lepidium sativum, garden cress is a fast-growing annual herb that is native to Egypt and West Asia, although it is now cultivated in the entire world. Lepidium sativum seeds contain proteins, dietary fibre, omega-3 fatty acids, iron, other essential nutrients and phytochemicals. Lepidium sativum seeds are commonly used to heal fractures and to increase milk secretion during lactation. Their seeds are highly nutritious and are excellent source of iron. It mainly contains alkaloids, carbohydrates, proteins, amino acids, flavonoids as chief phytochemical constituents. This review article shows various pharmacological activities of Lepidium sativum as an anti-diabetic, laxative, hypo cholesterolemic, fracture healing, analgesic, Anti-inflammatory, antipyretic and analgesic, laxative, diuretic, hepatoprotective, anti asthamatic, antidiarrheal, antispasmodic and anti-cancer activities of Garden cress seeds (Lepidium sativum).**

***Index Terms*—Lepidium sativum, Garden cress, pharmacological activities.**

I. INTRODUCTION

In India, locally it is known as "halon" because halon is an edible fast-growing plant [1]. All parts of garden cress including seeds, leaves, and roots possess economic importance. However, the plant is cultivated mainly for seed. The Garden cress seed is galactogogue, bitter, thermogenic, depurative, rubefacient, aphrodisiac, ophthalmic, antiscorbutic, antihistaminic, diuretic, and acts as a tonic. It is used as a remedy of various diseases such as asthma, coughs with expectoration, diarrhea, dysentery, poultices for sprains, leprosy, skin disease, splenomegaly, dyspepsia, lumbago, leucorrhoea, scurvy, and seminal weakness, which can be treated using garden cress seed [2].

The herb is an important medicinal plant since the Vedic era. The various Sanskrit names of L. sativum as mentioned in the old literature include Ashalika, Bhadra, Chandrashura, Chandrika, Dhrighabija, Kalmesha, Nandini, Raktbija and Vasupreshpa. Among these Chandrashura is the most common name which is still popular among the Ayurvedic physicians (Ayurvedic Pharmacopoeia,1990) [3].

II. CHEMICAL COMPOSITION

Garden cress is considered a superfood due to its highly nutritious profile. It has a protein content of 21–25%, which is essential for muscle growth and tissue repair. Fat (23–25%) and carbohydrates (30–34%) make the seeds a good source of energy for those who are undernourished. Protein (24.2), fat (23.2), carbohydrate (30.7), fiber (11.9), ash (7.1), and moisture (2.9) were found in garden cress seeds [4].

III. MORPHOLOGY

Garden cress (Lepidium sativum) seeds are smooth, small and reddish brown in color. Shape is oval with point and triangular at one end. Seed length is about 3-

4 mm and wideness is 1 -2 mm. When seed is soaked in water seed coat swells and gets covered with transparent, colorless, mucilage and give mucilaginous taste. [5].



Fig 1: Lepidium sativum seeds

In this novel effort, electroanalysis of copper ions in water samples was successfully achieved by employing a green, sustainable, and low-cost synthesis method using zinc oxide (ZnO) nanoparticles synthesized with Halim seed extracts, which were drop-casted on a graphite electrode. The seed extract acts as an eco-friendly, non-toxic reducing and capping agent, providing a facile synthesis process. The crystallite structure, morphological structure, elemental mapping, and composition were investigated and confirmed using X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), Transmission Electron Microscopy (TEM), Scanning Transmission Electron Microscopy (STEM), and Energy dispersive X-ray microanalysis (EDX). The modified graphite electrode sensing behavior was examined using cyclic voltammetry (CV) in the presence of potassium chloride (KCl) solution. The sensor was subjected to differential pulse voltammetry (DPV) for copper quantification in water. Optimized result was achieved at pH = 7.5. The limit of detection (LOD) of 80 ppb and limit of quantification (LOQ) of 200 ppb were ascertained from the calibration plot of DPV analysis. The sensor was able to adsorb copper ions selectively in the presence of cations such as zinc, lead, cadmium, bismuth, and nickel and anions such as chloride, sulfate, and hydroxide ions. The green sensor exhibited a linearity from 0 to 1 ppm with correlation coefficient of 0.99. The stability of the sensor ensures feasibility of fabrication for real-time analysis [6].

IV. TAXONOMICAL CLASSIFICATION [7]

Kingdom	Plantae
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Dilleniidae
Order	Capparales
Family	Brassicaceae
Genus	Lepidium L
Species	Lepidium sativum L.

V. TRADITIONAL USES

Folk medicine: The plant is used in Indian folk medicine by the tribals and rural population for a wide spectrum of diseases. In Sikkim and West Bengal, the plant is used by the aborgines in the treatment of asthma, bronchitis, dysentery, pain, pneumonia and stomachache (Jain, 1970). In Purulia district of West Bengal, the leaves of the plant are used as edible vegetable (Jain, 1966).

Unani: In Unani system of medicine seeds and leaves of the L. sativum are claimed to possess diuretic, aperient and aphrodisiac activity and recommended in inflammation, chest complaints, bronchitis, rheumatism and muscular pains. It is reported to improve brain power and brightening of the intellect (Kirtikar and Basu, 1933).

Ayurveda: Ayurvedic literature describes the plant as hot, bitter, galactogogue and aphrodisiac. It is claimed to destroy Vata and Kapha. The fresh fruits of L. sativum are listed as the useful drug for injuries, skin and eye diseases. Kasturyadi gutica- a drug useful in Kapha contains the seeds of the plant as one of the ingredients (Kirtikar and Basu; 1933, Ayurvedic Pharmacopoeia, 1990) [8].

VI. PHARMACOLOGICAL USES

6.1. 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 [9].

6.2. Protective effect against chemical induced genotoxicity and preneoplastic lesions

The chemoprotective effect of garden cress (GC) L.sativum and its constituents, glucotropaeolin (GT) and benzylisothiocyanate (BITC), a breakdown product of GT, towards 2-amino-3-methyl-imidazo [4,5-f] quinoline (IQ)-induced genotoxic effects and colonic preneoplastic lesions was investigated in single cell gel electrophoresis (SCGE) assays and in aberrant crypt foci (ACF) experiments, respectively.

Pretreatment of F344 rats with either fresh GC juice (0.8 ml), GT (150 mg/kg) or BITC (70 mg/kg) for three consecutive days caused a significant ($P < 0.05$) reduction in IQ (90 mg/kg, 0.2 ml corn oil/animal)-induced DNA damage in colon and liver cells in the range of 75 - 92%. Chemical analysis of GC juice showed that BITC does not account for the effects of the juice as its concentration in the juice was found to be 1,000-fold lower than the dose required to cause a chemoprotective effect. Parallel to the chemoprotection experiments, the modulation of the activities of Cytochrome P4501A2, glutathione-S-transferase (GST) and UDP glucuronosyltransferase (UDPGT) by GC juice, GT and BITC was studied. Whereas GT and BITC did not affect the activity of any of the enzymes significantly, GC juice caused a significant ($P<0.05$) increase in the activity of hepatic UDPGT-2. In the ACF assay, IQ was administered by gavage on 10 alternating days in corn oil (dose 100 mg/kg). Five days before and during IQ treatment, subgroups received drinking water which contained 5% cress juice. The total number of IQ-induced aberrant crypts and ACF as well as ACF with crypt multiplicity of > or = 4 were reduced significantly ($P < 0.05$) in the group that received IQ plus GC juice compared with the group that was fed with IQ only [10].

6.3. Osteoarthritis

It is one of the most common degenerative joint disorders. In Ayurveda, the disease Sandhivata resembles with osteoarthritis which is described under Vatavyadhi. Classical texts of Ayurveda, recommends different single herbal remedies for the management of Sandhivata, and many of them are now in routine clinical practice. The present review has been made from different pre-clinical and clinical research works carried out on single herbal drugs for the management of Sandhivata at Dravyaguna department of IPGT&RA, Gujarat Ayurved University, Jamnagar. Analysis of results shows that, about 22 research works comprising of 3 clinical and 19 experimental studies have been conducted by Dravyaguna department of IPGT&RA on Sandhivata. Drugs like seeds of Lepidium sativum Linn, whole parts of Leonotis nepetifolia (L.) and roots of Blepharispermum subsessile DC are found effective clinically, in the management of Sandhivata [11].

6.4. Menstrual cycle regulation

Our overall goals in these studies were first to determine the effect of LS seed consumption, both in the acute and chronic states, on the endocrinology of ovulation, second on the development of visceral organs and finally on the indices of spermatogenesis in the male rat model. We have demonstrated that a preovulatory surge-like gonadotropin-releasing hormone (GnRH) secretion is inducible in vitro in the ovariectomized, estrogen-primed, and progesterone-treated rats. Our results indicated that LS supplementation tended to cause an earlier, attenuated preovulatory surge-like GnRH secretion. Temporally, LH secretion from the pituitary gland in all treatment groups decreased over time. Perifusate LH levels were high varying from 15 to 36 ng/mL pre-GnRH administration. We observed no stimulatory effect of 10 ng/mL GnRH administration. Consequently, no surge-like LH secretion was observed. Future studies should investigate the use of a higher concentration of GnRH to stimulate the surge of LH. There was, however, a suppressive effect of progesterone in progesterone-treated rats on average LH secretion. Overall, follicle-stimulating hormone (FSH) decreased from time 0 to about 180 min before stabilizing. Average FSH levels were significantly higher in ovariectomized, estrogen-primed, progesterone-treated rats compared to ovariectomized, and estrogen-Primed rats. LSE administration significantly increased average FSH secretion in ovariectomized, estrogen-primed rats but had no effect in the ovariectomized, estrogen-primed, and progesterone-treated rats. Administration of GnRH at 10 ng/mL had no effect of FSH secretion.Future studies should investigate the use of a higher concentration of GnRH to stimulate the surge of FSH. There may be differential regulation of FSH secretion due to the increased average FSH secretion observed

in the ovariectomized, estrogen-primed, and LS aqueous extract treated rat [12].

6.5. Used for treating chronic constipation

An ayurvedic compound formulation in capsule form containing Lepidium sativum as one of the ingredients along with Aegle marmelos and Plantago ovata was tried on cases of 16 years old chronic constipation and irregular bowel movements with diarrhea from 1-6 months were found to be cured. The recovery was assessed with the disappearance of the symptoms like intermittent and incomplete evacuation, intermittent diarrhea etc. in most of the cases. The response was good in 90% cases and patient preference was very high.

VII. SIDE EFFECTS

The oil extracted from the plant was edible and was used as a cooking medium, some people may experience symptoms of indigestion due to its use. However, consuming of large quantities of the plant caused digestive difficulties in some people. Furthermore, it contained goitrogens that prevent iodine absorption in thyroids and can lead to hypothyroidism. It should be avoided by patients of hypothyroidism. It was an abortifacient; pregnant women should avoid taking the plant in any form because it induces uterine contractions and triggered spontaneous abortion [13].

VIII. CLINICAL USE

This study evaluated the topical effect of Lepidium sativum lyophilized seed extract (LSLE) towards Sustanon-induced alopecia in male adult Wistar albino rats in vivo, compared to minoxidil topical reference standard drug (MRD). LC–MS/MS together with molecular networking was used to profile the metabolites of LSLE. LSLE treated group revealed significant changes in alopecia related biomarkers, perturbation of androgenic markers; decline in testosterone level and elevation in 5α-reductase (5-AR); decline in the cholesterol level. On the other hand, LSLE treated group showed improvement in vascular markers; CTGF, FGF and VEGF. Groups treated topically with minoxidil and LSLE showed significant improvement in hair length. LC–MS/MS profile of LSLE tentatively identified 17 constituents: mainly glucosinolates, flavonoid glycosides, alkaloids and phenolic acids. The results point to the potential role of LSLE in the treatment of alopecia through decreasing 5(alpha) dihydrotestosterone levels. Molecular docking was attempted to evaluate the probable binding mode of identified compounds to androgen receptor (PDB code: 4K7A) [14].

Nutritional composition of Garden cress seeds

Amino Acid, Mineral, and Fatty Acid Profile

The sample contains a good balance of essential and non-essential amino acids, indicating that it is a rich source of protein. Among the essential amino acids, leucine (8.21 ± 0.01 g/100 g protein) was present in the highest amount, followed by valine (8.04 ± 0.03 g/100 g protein), lysine (6.26 ± 0.39 g/100 g protein), phenylalanine (5.65 ± 0.03 g/100 g protein), isoleucine (5.11 ± 0.03 g/100 g protein), arginine (4.51 ± 0.03 g/100 g protein), histidine (3.87 ± 0.14 g/100 g protein), and threonine (2.66 ± 0.09 g/100 g protein). Methionine (0.97 ± 0.02 g/100 g protein) was found in the lowest amount among the essential amino acids.

Among the non-essential amino acids, glutamic acid (19.33 ± 0.19 g/100 g protein) was the most abundant, followed by aspartic acid (9.76 ± 0.03 g/100 g protein). Other non-essential amino acids such as proline, glycine, serine, alanine, and tyrosine were also present in appreciable quantities. The presence of these amino acids suggests that the sample has good nutritional quality and can support normal growth, tissue repair, enzyme synthesis, and various metabolic activities.

The mineral analysis showed that potassium (1236.51 mg/100 g) was the most abundant mineral, followed by phosphorus (608.63 mg/100 g), magnesium (339.23 mg/100 g), and calcium (266.35 mg/100 g). Moderate amounts of iron (8.31 mg/100 g), zinc (6.99 mg/100 g), copper (5.73 mg/100 g), manganese (2.00 mg/100 g), and sodium (19.65 mg/100 g) were also detected. These minerals play important roles in maintaining bone strength, blood formation, enzyme activity, muscle function, nerve transmission, and overall physiological health.

The fatty acid profile showed that the sample is rich in unsaturated fatty acids. Linolenic acid (32.18 ± 0.59%) was the major fatty acid, followed by oleic acid (30.50 ± 0.16%), eicosaenoic acid (13.40 ± 0.66%), and linoleic acid (8.60 ± 0.38%). Saturated fatty acids such as palmitic acid (10.30 ± 0.12%), arachidic acid (2.10 ± 0.57%), and stearic acid (1.90 ± 0.19%) were present in lower amounts, while palmitoleic acid (0.70 ±

0.30%) was detected in a small quantity. The predominance of unsaturated fatty acids indicates that the sample has a favorable lipid composition and may offer potential health benefits, particularly in supporting cardiovascular health and reducing the risk of chronic diseases [15].

Food and Food Ingredients from Garden cress seeds

SS Gokavi et al. developed dietary fiber formulation using Garden cress seed coat fraction. The powdered seed coat (5 kg) was blended with fresh carrot pulp (500 g), lime extract (100 g) and lecithin (100 g) and the blend was dispersed in potable water (100ml), boiled for 5 min and homogenized in a colloidal mill and the slurry was spray dried. The formulation was a free-flowing smooth powder with yellowness index of 37.2. Its water holding capacity, viscosity (5% slurry) and dietary fiber content were 23.6 ml/g, 5100 mPas and 74.3% respectively. N Agarwal and S Sharma analyzed proximate and phenol content of Garden cress seeds in two forms; whole Garden cress seed powder (WGCSP) and roasted Garden cress seed powder (RGCSP). Both the forms were rich in nutrients and phenols. They developed food product (Sev) using both the forms of Garden cress seeds. Sensory evaluation of Gc enriched sev on nine-point hedonic scale showed that the Sev developed from RGCSP was more acceptable than that of WGCSP incorporated Sev but less acceptable than that of control one. Authors reported that the products developed from both forms of v seed powders were loaded with various nutrients along with antioxidants which are beneficial for curing a plethora of diseases SY Mohite et al. developed a health drink with processed Garden cress seeds keeping in view the health benefits of Garden cress seeds. The Garden cress seeds were boiled at 95°C for 15 minutes in potable water, dried and powdered. Health drinks were prepared with different concentration (1-5% w/v) of processed Garden cress seeds in skimmed milk. Sensory analysis of health drink showed that the overall acceptability of health drink containing 3% (w/v) of processed Garden cress seed powder was highest (8.75) compared to other drinks N Agarwal and S Sharma prepared different forms of Garden cress seed powder (GCSP) such as whole GCSP, husk removed GCSP, husk GCSP, roasted GCSP and microwave processed GCSP. Mathri (a wheat-based food product) was developed by incorporating different forms of GCSP at different levels (2.5%, 5% and 7.5%). They found that only 5% incorporation gave the acceptability scores on sensory analysis. Mathri incorporated with 5% husk removed GCSP showed maximum overall acceptability score of 7.66 next to standard (8.46) mathri. Authors reported that GCSP incorporated mathri is more nutritious than standard mathri and has the potential to acts as nourishing as well as therapeutic agent due to antioxidant potential of Garden cress protein isolate was prepared and evaluated by RF Mohammed. Protein isolate of Garden cress seed contained 86.90% protein. Authors concluded that high water absorption capacity (229 ml H_2O/100 g) of Garden cress seed protein isolate makes it a potential ingredient in meat, bread, and cakes industries. Also, high oil absorption capacity (3.5 ml oil/gm) of Garden cress seed protein isolate makes it a good ingredient for the cold meat industry, particularly for sausages, where the protein can bridge the fat and water in these products. Therefore, the protein isolated from Garden cress seed could be a desirable food ingredient and can be used as nutrient substitution or supplementation and as functional agent in food systems. Microencapsulation of Garden cress seed oil using different wall materials such as sodium caseinate whey protein concentrate, blend of maltodextrin, gum arabica and skimmed milk powder was carried out using spray-drying method by SS Umesha et al. Authors concluded that the microencapsulated Garden cress seed oil powder can be supplemented in food products to enhance plant-based n-3 fatty acid [16].

IX. PLANT MATERIAL AND EXTRACTION

Seeds of Lepidium sativum were soaked in 70% methanol for three days and then filtered through muslin cloth and Whatman filter paper (Maidstone, UK). This procedure was repeated three times, and all the filtrates were pooled and evaporated on rotary evaporator under reduced pressure to obtain the crude extract of Lepidium sativum yielding approximately 15% [17].

X. SAFE LEVEL OF GARDEN CRESS SEED AS FOOD

Although Garden cress seed used widely, there are very few reports available in the literature regarding safe consumption level of Garden cress seed for use as

food. Datta PK et al. conducted a study on adult rats to assess the safety of Garden cress seed. For the acute toxicity study, rats were fed seed powder 0.5 –5.0 g/kg body weight mixed with standard diet and symptoms of toxicity and mortality were monitored for 72 hours. No toxicity and mortality symptoms were found in rats. To observe the subchronic toxicity effect of seed, rats were fed 1.0 – 10.0% seed powder mixed with standard diet for 14 weeks. No any adverse effect was found in any rats, after completing the experimental period. However, there were significant increase in the serum alpha linolenic acid (ALP) and serum glutamyl oxaloacetic transaminase (SGOT) in male rats receiving 5.0 and 10% of Garden cress seed. It was shown that acute and subchronic feeding of seed for 14 weeks do not produce any kind of toxic effects in both male and female rats [18].

XI. MICROSCOPIC CHARACTERS

The microscopic features of Garden cress (Lepidium sativum L.) seeds reveal key details about their structure:

11.1. Endosperm

The endosperm consists of thick-walled polygonal cells, indicating a strong, geometrically shaped cellular structure that serves as a food reserve for the developing seed.

11.2. Embryo

The embryo is made up of small polygonal cells, which are minute in size compared to the endosperm. These cells are encased by the endosperm, providing protection and nutrients for growth.

11.3. Seed powder

When ground into powder, the see has a creamish yellow hue. It shows a consistent structure with uniform thick-walled cells and contains reddish-brown fragments of the seed coat, which may indicate the presence of pigments. The endosperm in the powder is oily, suggesting a rich source of fats. The presence of reddish coloring matter may be attributed to natural pigments like flavonoids or anthocyanins [19].

XII. INFLUENCE OF HEAVY METALS ON LS SEEDS

The paper presents the results of studies on the influence of selected concentrations (10–100 mg L−1) of heavy metals (Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Zn) and metalloids (As, Sb, Se) on the germination and root elongation of garden cress (Lepidium sativum L). There are not many studies on phytotoxicity of heavy metals and metalloids with the complex use of single plant species so far. On the basis of the germination index (GI) and inhibition concentration IC50, the following order of phytotoxicity of the tested elements was determined: Se> As> Hg> Sb > Mo > Cd> Co > Zn > Ni. The other metals showed no phytotoxicity or even stimulating effect. In our study the stimulating effect of the majority of Pb concentrations and the lowest concentrations of Cd and Hg has been revealed. These metals do not play any role in living organisms; however, some authors confirm their stimulating effect on plants at low concentrations. Toxic concentration of metals and metalloids calculated as IC50 are lower than the concentration calculated as GI (not phytotoxic). It is well known that seeds are more independent and tolerant to toxicants when they contain reserve substances which are used during the germination period. On the basis of conducted research, high tolerance of L. sativum to heavy metals and metalloids was found, which may indicate its usefulness for phytotoxicity assessment of leachate from contaminated soil or waste (e.g. foundry waste) and its application for bioremediation to manage heavy metal pollution of soils or foundry wastes containing heavy metals and metalloids. The understanding of heavy metal and metalloids toxicity will facilitate bioremediation.

Highlights

1. Lepidium sativum shows high tolerance to the aqueous solution of $Pb(NO_3)_2$
2. Cr (3+) and (6+) stimulated the germination and roots elongation of L. sativum.
3. L. sativum is sensitive to the influence of an aqueous SeO2 solution.
4. Low concentrations of Cd and Hg may have a stimulating effect on L. sativum [20]

XIII. ACTIVITY OF LS SEEDS

13.1.Antibacterial activity:

Lepidium sativum L., possesses variable proportions of benzylcyanide and benzylisothiocynate which contribute towards its activity against Bacillus subtilis and Micrococcus pyogenes. The plant is also used as an antifertility and antiovulatory drug. Various juvenile (cotyledonary leaves, hypocotyl, radicle) as well as mature explants (leaf, shoot apex, nodal segments) callused on Murashige and Skoog's medium (MS) supplemented with α-naphthaleneacetic acid (NAA)+N6-benzyladenine (BA)+casein hydrolyzate (CH). Regeneration from hypocotyl callus and nodal segments occurred after NAA/BA was replaced with indole-3-acetic acid (IAA)/kinetin (Kn). Lepidine was monitored at regular intervals. Significant amounts of lepidine were detected in in vitro-regenerated plants obtained from juvenile and mature explants. The yield, however, was variable, depending upon the source and type of explant used. High lepidine was detected in 8-wk-old hypocotyl callus. Amongst regenerants, maximum lepidine was obtained from the plantlets at the vegetative stage [21].

13.2.Anti Diabetic Activity of Garden Cress Seeds

Diabetes is a complex metabolic disorder affecting the glucose status of the human body. Chronic hyperglycaemia related to diabetes is associated with end organ failure. The aim of this study to estimate the effect of Lepidium sativum (garden cress) and Glycyrrhiza glabra (Licorice) on bodyweight, feed intake, lipid profiles, renal, hepatic function markersand the glucose levels in diabetic rats. Forty-two adult male albino rats (Sparague Dawley Strain), weighing 150 ± 5 g, were used. Rats of diabetic group were equally divided into 6 subgroups each one include 6 rats. The first group received basal diet as negative control group for 28days.Body weight, lipid profile & renal function (urea, uric acid creatinine) ALT & AST activities in addition to glucose and histological structure of liver and pancrease were estimated .Data showed that diabetic rats without treatments significantly increased liver enzymes and lipid profile concentration compared with negative control, while significantly decreasing final body weight and HDL; meanwhile treatment with Lepidium sativum(garden cress) , Glycyrrhiza glabra (Licorice) and their mixture significantly decreased the lipid profile , liver enzymes whereas administration of herbal powder and its mixture significantly ameliorated these hepatic and pancreatic structures.So, Treatment with Glycyrrhiza glabra (Licorice) followed by herbal mixture and Lepidium sativum(garden cress) improved diabetes and its associated metabolic problems in different degrees. Also, they might be a safe combination on the organs whose functions were examined, as a way to surmount the diabetes state; and it has a distinct anti-diabetes effect [22].

Other Pharmaceutical application of Lepidium sativum

The usability of Lepidium Sativum as an excipient for the preparation of pharmaceutical formulations for many purposes such as disintegrant, film forming agent, gelling agent, binding agent, encapsulating agent, and for controlling drug release is mainly due to its content rich in mucilage. Mucilage is composed of multiple units of uronic acid and sugar units; it swells in the presence of water and forms a viscous sticky solution. The high content of mucilaginous polysaccharides, primarily composed of arabinoxylans and galactomannans, is responsible for its excellent gelling and binding capabilities through hydrogen bonding and entanglement of polymer chains. Also, the presence of antioxidant flavonoids could enhance the stability of oxidation-sensitive active pharmaceutical ingredients (APIs) within the formulation, offering an added advantage over inert synthetic excipients [23].

XIV. CONCLUSION

Halim seeds (Lepidium sativum L.) are a promising nutraceutical resource because of their rich nutritional composition and diverse phytochemicals, including flavonoids, phenolic compounds, alkaloids, glucosinolates, proteins, minerals and mucilage. These constituents contribute to reported antioxidant, antimicrobial, antidiabetic, hepatoprotective, gastrointestinal, bone-healing and other pharmacological activities [24].

Overall, L. sativum has considerable potential for development as a functional food, nutraceutical and herbal therapeutic agent. However, further well-designed clinical studies, standardization of extracts, dose optimization and detailed safety evaluation are

required to establish its therapeutic efficacy and facilitate wider clinical application [25].

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