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Lepidium sativum: Its nutritional composition and therapeutic properties

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Abstract

Lepidium sativum, belonging to family Brassicaceae, is also known by various common names including garden cress seed. Garden cress seeds are widely cultivated as a culinary, traditional medicine and oilseed crop all over the world. It is highly nutritious as it contains 30.7g carbohydrate, 24.2g protein and 23.2g lipids. Garden cress seeds have several pharmacological properties (anti-bacterial, anti-fungal, anti-asthmatic, diuretic, anti-anaemic, anti-diabetic, anti-oxidant, anti-inflammatory, hepatoprotective and chemo protective) as well. It has immense health benefits as it protects against cancer, helps in regulating menstrual cycle, prevents anaemia and also increases the breast milk production. Although it has many beneficial properties but it could be harmful due to the presence of teratogenicity effect which can cause allergy or toxicity if taken in excess amount. Traditionally, garden cress seeds are used to treat asthma, bronchitis, dysentery, diabetes, leprosy, diarrhea, dyspepsia, scurvy, leucorrhoea, seminal weakness and splenomegaly. Garden cress seeds are also used for the development of various value-added food products and are commercially available in the market. These value-added food products intended to improve the overall health of individuals include fortified health drinks, iron rich biscuits, noodles, nutrient rich cutlets, instant UPMA mix, fortified dahiwalwa bread and muffins. This review aims to highlight the various aspects of garden cress seeds viz. nutritional composition, pharmacological value, health benefits, toxicity, commercial utilization, traditional utilization and future perspectives.

Keywords: *Lepidium sativum*, nutritional and phytochemical composition, biological activity, health benefits, diseases

Introduction

Lepidium sativum also known as Garden cress seeds belong to Brassicaceae family which is also known as mustard family. It is commonly known as Common cress in English, Halim in Bengali, Aseliyo in Gujarati, Chansur in Hindi, Kapila in Kannada, Alian in Kashmiri, Asali in Malayalam, Haliv in Marathi, Allivirai in Tamil and Aadal in Telugu. Garden cress seeds are native to Egypt and South west Asia and are widely cultivated in North America, India and some parts of Europe including Britain, France, Italy and Germany. In some areas, it is known as garden pepper grass, pepper cress, pepperwort or poor man's pepper (Sharma, 2020). It is extensively cultivated for various purposes such as cooking, traditional medicines and as an oilseed crop all over the world. It does not require a lot of agricultural resources as it is suitable to be cultivated in any type of climate and it has an ability to tolerate slightly acidic soil and can be grown like white mustard (Lahiri and Rani., 2020) [18]. It can grow well in semiarid regions, in low fertility soils and in temperate climate where the average rainfall varies from 300-2000mm. Garden cress seeds can be harvested in 70-90 days and the estimated yield is 800-1000kg/ha (Musara *et al.*, 2020). Its stature is about 50cm long, the seed coat is of cream to brick red color and its endosperm is of yellow color (Jagdale *et al.*, 2021). The seed is 2.60mm long, 1.20mm wide and 0.94mm thick (Vaishnavi *et al.*, 2020). According to scientific research, garden cress seeds have 80–85% endosperm, 12–17% seed coat and 2–3% embryo. It is a rich source of various macro and micronutrients including carbohydrates (30.7g/100g), protein (24.2g/100g), fat (23.2g/100g) and fibre (11.9g/100g), vitamins and minerals. The mineral content of garden cress seeds varies between its different species; for calcium it is 266.35±1.44mg/100g, for potassium it is 1236.51±1.67mg/100g, for phosphorus it is 608.63±1.39mm/100g. Potassium is considered to be the most significant mineral in garden cress seeds accounting for 1635.62mg/100g, followed by calcium (480.72mg/100g), phosphorus (637.25mg/100g) and magnesium (631.06mg/100g). The lowest levels of minerals in garden cress seeds are of zinc and manganese (Jagdale *et al.*, 2021).

According to the studies conducted on garden cress seeds it is known that these seeds have a lot of pharmacological activities which include properties such as anti-anaemic, anti-diabetic, aperients, diuretic, and tonic and it also exhibit activities such as galactagogue and emmenagogue. Essential fatty acids (linoleic acids and arachidic acids) of these seeds are used as memory boosters (Jagdale *et al.*, 2021). Oil withdrawn from garden cress seeds is extremely beneficial as its polyunsaturated fatty acids (PUFA) value is 46.8% and monounsaturated fatty acids (MUFA) value is 37.6% thereby making the seeds a great source of fatty acids for our body which helps in increasing our metabolism and reducing the risk of diseases such as cardio vascular diseases, cancer, obesity, asthma and arthritis (Maheswaraiah *et al.*, 2018). These seeds also contain vitamin A and vitamin E which helps in the protection of cells from the damage and protects the Garden Cress seeds oil from oxidation and rancidity (Lahiri and Rani., 2020) [18].

Garden cress seeds have been used in traditional medicines in India since ancient times to treat number of diseases such as asthma, coughs with expectoration, diabetes, diarrhoea, dysentery, leprosy, skin disease, dyspepsia, leucorrhoea, scurvy, and seminal weakness. The galactagogue properties of garden cress seeds are well known and earlier these were used to prepare kheer for lactating mother to increase the milk production. Garden cress seeds are used as ethno veterinary medicines as laxative, dressing for sores in camels and horses; and are also known to possess galactagogue and emmenagogue properties (Musara *et al.*, 2020).

Lepidium sativum is getting recognized as a functional food as it is highly nutritious because of the presence of various micro and macro nutrients, various vitamins and minerals (calcium, iron, phosphorus) which help in increasing the productivity of an individual. People consume it as a dietary supplement. In India, Garden cress seeds are consumed either in processed form (roasted, boiled, soaked) or raw form. These processes are in turn helpful in increasing the shelf life as well as its acceptability (Jagdale *et al.*, 2021). Different types of food products are prepared from these seeds and are marketed, such as noodles, biscuits, heath drinks, flakes, cereals, laddoo, snacks, instant 'dhokla' mix, and nutri-cookies etc. Leaves of *Lepidium sativum* possess number of health benefits and have a tangy taste because of which they are employed in the preparation of salads. The seeds of garden cress are used as soil purifiers as they have a tendency to absorb metals and

remove them from the soil by a process called phyto extraction in which plants absorb metals from the soil via roots and transfer them to the shoots where they are piled up and are harvested later on so that the extracted metals can be recovered. (Shah *et al.*, 2021) (Pures and Ihlam, 2014).

Proximate nutritional composition of garden cress seeds

The garden cress seeds consist of ample amounts of carbohydrates (30.7±1.2g/100g), protein (24.2±0.5g/100g), dietary fibre (11.9±0.4g/100g), fat (23.2±0.2g/100g), calcium (480.72mg/100g), magnesium (631.06mg/100g), potassium (1635.62mg/100g), and iron (28.82mg/100g), which will be useful to make post pregnancy diet in India (Pattnaik, 2003) [33]. The proportion for vitamin B complex is higher in them than the other vitamins. In the mineral nutritive analysis of garden cress seeds as dry form, the percentage of calcium, potassium and magnesium is quite in larger amount from others. As they are in prominent amount of potassium (1635.62 mg/100g), and reduced amount of sodium (36.25mg/100g), so they can be utilized as an ingredient for the health foods. They are also enriched with high potassium (1635.6 mg/100g) level so they can be used in high potassium diets for athletes who are involved in hard exercise and for who are suffering from high blood pressure disorders (Luft FC 1987). The percentages of leucine (8.21±0.01g/100g), and valine (8.04±0.03g/100g) in the section of essential amino acids are the highest while methionine's (0.97±0.02g/100g) proportion is the lowest in the same. For non-essential amino acids, the ratio of glutamic acid (19.33±0.19g/100g) is high, on the other hand the proline (2.69±0.09g/100g) is present in less amount (Frias *et al.*, 2012). The garden cress seeds' (GCS) oil is a rich source of tocopherol which acts as a natural antioxidant. The total amount of tocopherol in GCS oil is about (139.73±0.91mg/100g) in which (17.19±0.52 mg/100g) consists of α -tocopherol and (111.55±0.37mg/100g) consists of β - tocopherol and γ - tocopherol (Zia-Ul-Haq *et al.*, 2012) [45]. Furthermore, the presence of the antinutritional factors decrease the bioavailability of nutrients in our body and phytates and oxalates hinder the bioavailability of nutrient, such as forming phytic protein complexes by phytates, chelate elements of mineral by oxalates to reduce the absorption (Nduagu *et al.*, 2008) [28]. The proximate nutritional composition of garden cress seeds is described as macronutrients and micronutrients (minerals, vitamins) as per (% /100g) in the Table 1.

Table 1: Proximate nutritional composition of garden cress seeds

Nutrient	Nutrient amount per 100g raw <i>Lepidium sativum</i> L. seeds	References
Energy (kcal)	474 ± 1.06	Gokavi <i>et al.</i> (2004); Guo <i>et al.</i> (2004); Malleshi <i>et al.</i> (2004); Zia-Ul-Haq <i>et al.</i> (2012) [45]
Carbohydrate (g)	30.7 ± 1.2	
Moisture (g)	2.9 ± 0.1	
Protein (g)	24.2 ± 0.5	
Fibre (g)	11.9 ± 0.4	
Lipids (g)	23.2 ± 0.2	
Ash (g)	7.1 ± 0.1	
Vitamin (dry weight basis)		
Vitamin A (µg)	90	Yadav <i>et al.</i> (2010); Sharma & Agarwal (2011); Zia-Ul-Haq <i>et al.</i> (2012) [44, 45]
Thiamine (mg)	0.59	
Riboflavin (mg)	0.61	
Niacin (mg)	14.30	
Vitamin C (mg)	10.62	
Vitamin E (ppm)	258.74	

Mineral (dry weight basis)		Gokavi <i>et al.</i> (2004); Yadav <i>et al.</i> (2010); Agarwal & Sharma (2013) ^[44]
Calcium (mg)	480.72	
Cooper (mg)	12.51	
Iron (mg)	28.82	
Manganese (mg)	46.07	
Magnesium (mg)	631.06	
Phosphorus (mg)	637.25	
Potassium (mg)	1635.62	
Sodium (mg)	36.25	
Zinc (mg)	62.69	
Amino acid content		Gokavi <i>et al.</i> (2004); Zia-Ul-Haq <i>et al.</i> (2012) ^[45]
Essential amino acids		
Arginine (g)	4.51 ± 0.03	
Histidine (g)	3.87 ± 0.14	
Isoleucine (g)	5.11 ± 0.03	
Leucine (g)	8.21 ± 0.01	
Lysine (g)	2.66 ± 0.09	
Methionine (g)	0.97 ± 0.02	
Phenyl alanine (g)	5.65 ± 0.03	
Threonine (g)	6.26 ± 0.39	
Valine (g)	8.04 ± 0.03	
Non-Essential amino acids		
Aspartic acid (g)	9.76 ± 0.03	
Alanine (g)	4.83 ± 0.02	
Glutamic acid (g)	19.33 ± 0.19	
Glycine (g)	5.51 ± 0.07	
Proline (g)	2.69 ± 0.09	
Serine (g)	4.96 ± 0.09	
Tyrosine (g)	5.84 ± 0.38	
Fatty acid Profile		Gokavi <i>et al.</i> (2004); Zia-Ul-Haq <i>et al.</i> (2012) ^[45]
Arachidic acid (20:0)	2.10 ± 0.57	
Eicosaenoic acid (20:1)	13.40 ± 0.66	
Linoleic acid (18:2)	8.60 ± 0.38	
Linolenic acid (18:3)	32.18 ± 0.59	
Oleic acid (18:1)	30.50 ± 0.16	
Palmitic acid (16:0)	10.30 ± 0.12	
Palmitoleic acid (16:1)	0.70 ± 0.30	
Stearic acid (18:0)	1.90 ± 0.19	
Antinutritional factor (raw)		Gopalan <i>et al.</i> 2011; Jain <i>et al.</i> 2016 ^[12]
Phytin phosphorus (mg)	447.2 ± 3.34	
Oxalates (mg)	134 ± 1.00	

Effect of different treatment on antinutritional factor of the garden cress seeds

It was observed that there was reduction in the value of phytin phosphorus and oxalates when processing methods were applied on them. Most of the depletion in the level of phytin by boiling which was more than other two methods of processing methods (soaking and roasting). About 9.65% decline in the value of total phytin phosphorus after boiling and the resultant value was 404.03mg/100g. The reduction was seen in the level of phytin phosphorus after soaking and roasting and the outcome values were 431.5 and

440.03mg/100g with 3.51 and 0.46% drop respectively (Gopalan *et al.*, 2011; Jain *et al.*, 2016) ^[12].

It was noticed that the oxalates' value in the raw seeds was about 134mg/100g. While by boiling, about 14.13% depletion in the oxalates level and the final value was observed 115.06mg/100g which is noticeable decrease, whereas the least reduction (4.98%) was computed by roasting which was about 127.33 mg/100g. Furthermore, by applying the soaking method, 120.73mg/100g was the outcome value with 9.90% decrease from the initial value (Gopalan *et al.*, 2011; Jain *et al.*, 2016) ^[12].

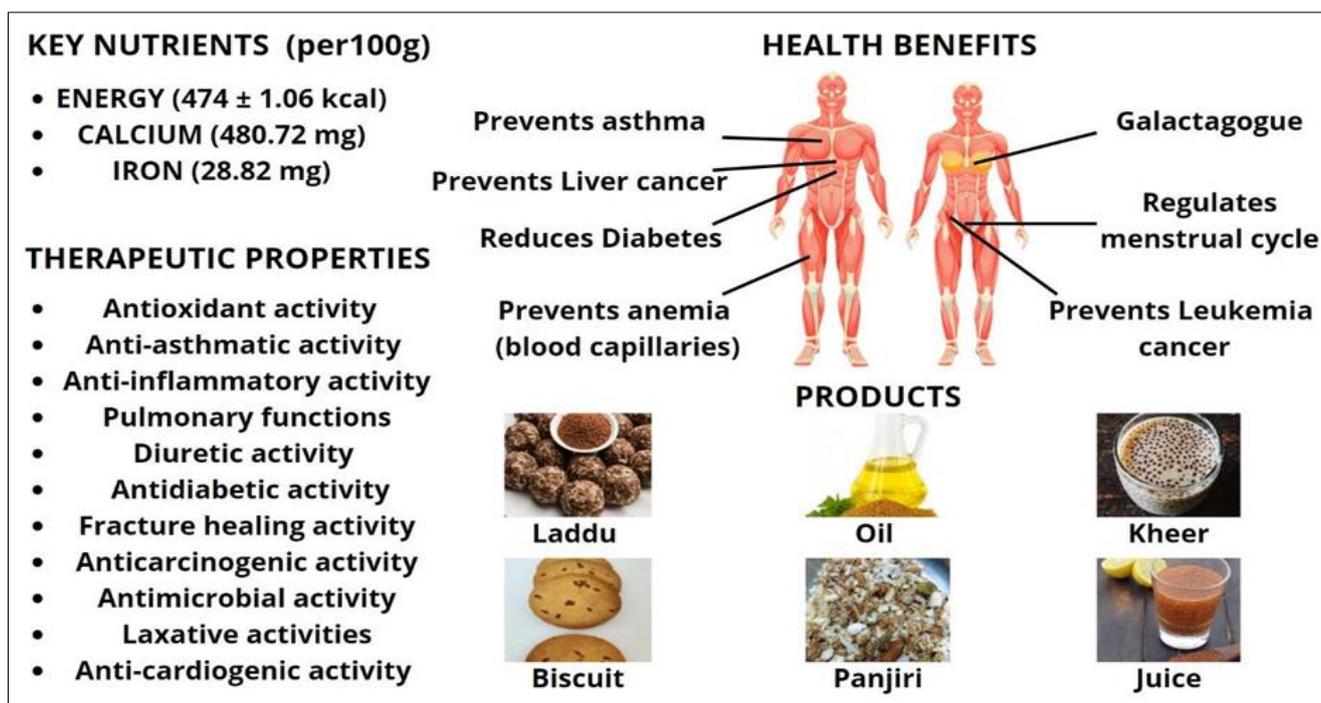


Fig 1: Overview of garden cress seeds-key nutrients, therapeutic properties, health benefits and products

Phytochemical composition and therapeutic properties

The garden cress seeds have vast range of phytochemicals (organosulphur compounds, extract of leaf aqueous, petroleum ether extract, aqueous extract, imidazole compounds, methanol extract, ethyl acetate extract, alpha linolenic acid and etcetera) which causes various kinds of biological activities such as carcinogenic detoxification, apoptosis, antitumour activity, free radical scavenging

activity, anti-oral cancer activity, antioxidant activity, anti-asthmatic activity, anti-inflammatory activity, pulmonary functions, antihypertensive effect, arterial blood pressure functions, diuretic activity, hypoglycaemic effect, antidiabetic activity, fracture healing activity, anticarcinogenic activity, antibacterial activity, antifungal activity, laxative activities, anti-cardiogenic activity and many more, as reported by different researchers in (Table 2).

Table 2: Phytochemical composition and therapeutic properties

Sr. No.	Chemical constituents	Biological activity	Mechanism	Reference
1.	Glucosinolates, benzyl isothiocyanate	Carcinogenic detoxification, cell cycle arrest and apoptosis, inhibit tumour cell proliferation (antitumour activity) and free radical scavenging activity	<ul style="list-style-type: none"> Benzyl isothiocyanate: it is effective to cause sensitivity to the cell lines of the pancreas (PANC-1 and MIAPaCa-2) through radio therapy, as result of it, latter increase in apoptosis which is caused by efforts from ionising radiations and benzyl isothiocyanate. Glucosinolates: The mechanism of this chemical constituent includes inhibit angiogenesis, controlling low levels of systemic oxidative stress and preventing cell cycle progression, which helps to promote the apoptosis of cancerous cells. 	Williams <i>et al.</i> (2009)
2.	Imidazole compounds	Antihypertensive effect, diuretic activity, antidiabetic activity, bone protective property	<ul style="list-style-type: none"> Imidazole: The mechanism includes the blocking action to the synthesis of the ergosterol which is the basic cell sterol of fungi. The affected enzyme in this mechanism is a fungal cytochrome P-450. It does changes in the peroxidative activities of enzyme and oxidative. 	Patole <i>et al.</i> (1998); Eddouks, (2004); Maghrani <i>et al.</i> (2005); Juma, (2007); Tiwari <i>et al.</i> (2012) [32, 9, 20, 4]
3.	Alpha linolenic acid	Anti-cardiogenic activity, antiinflammatory activity and anticarcinogenic activity	<ul style="list-style-type: none"> Alpha linolenic acid: It helps to inhibit the development of carotid plaque. It also stimulates a neuronal background channel of potassium which leads to hyperpolarization of membrane ultimately raise in the magnesium block of the calcium channel linked with the NMDA receptor which induce an important role settling glutamate mediated excitotoxic neuronal cell death. 	Simopoulos, (1991); Diwakar <i>et al.</i> (2008); Diwakar <i>et al.</i> (2010) [41, 6, 7]
4.	Lepidimoide	Antidiabetic activity,	<ul style="list-style-type: none"> Lepidimoide: It heavily inhibits the development of abscission which automatically prevents the mineral loss then in turns to control the blood glucose level. 	Eddouks <i>et al.</i> (2005)
5.	Phenolic acids, flavonoids, anthocyanins	Antioxidant activity, antimutagenic activity, anti-carcinogenic activity, ability to modify gene expression	<ul style="list-style-type: none"> Polyphenol: It has been linked to various anticancer activity by restricting induction of apoptosis and oxidative stress. Flavonoids: it is found that they cause mitochondrial apoptotic-dependent gastric cancer stem cell development retardation by preventing the P13K-Akt- the route of signals. 	Tapiero <i>et al.</i> (2002); Nakamura <i>et al.</i> (2003); Shen <i>et al.</i> (2016) [39]

			<ul style="list-style-type: none"> • Anthocyanin: this mechanism induces the antioxidant activity which includes the prevention of the reactive species generation by the inhibition of enzyme or the trace elements are squeezed which are further responsible for the production of free radicals. 	
6.	Triterpenes	Antioxidant antimicrobial activity	<ul style="list-style-type: none"> • Tetripenes: in this mechanism, isothiocyanate prevent the signaling of NF-κB, which is responsible for the gene activation which are indulged in the inflammation. 	Abdel-Bary <i>et al.</i> (2017) ^[1]

Health Benefits

The garden cress (*Lepidium sativum*) seed, an essential herb that is very important for human body. Due to the presence of different types of nutrients like-protein, calcium, dietary fiber, iron, phosphorus, VIT-A, VIT-C etc., it helps to prevent many diseases (Gokavi *et al.*, 2004; ZiaUI-Haq *et al.*, 2012) ^[45] such as- asthma, diabetes, cancer, anemia, menstrual cycle disorder etc.

By the presence of ethanol extract in garden cress seed, it is exhibited against acetylcholine (ACh). Then it helps to prevent asthma (Paranjape and Mehta, 2006; Mali *et al.*, 2008) ^[30, 22]. On the other hand, it has some alkaloids such as-lepidine, glucotropaeolin that are beneficial against diabetes. So, the presence of anti-diabetic property, it helps to reduce blood glucose levels (Prajapati and Dave, 2018) ^[34]. Oral administration of 20mg/kg (15 seed/day), significantly reduced glucose blood level in chronic and acute treatment with no effect on insulin secretion. Garden Cress seed is also

used for the treatment of diabetes mellitus (Eddouks *et al.*, 2002) ^[8]. Besides, garden cress seed has an enough amount of iron and fiber contents for preventing anaemia by increasing haemoglobin levels in blood (Paranjape and Mehta, 2006) ^[30]. It also regulates menstrual cycle due to the presence of estrogenic trails (Singh *et al.*, 2015) ^[42]. Consumption of *L. sativum* after birth of baby milk production is increased and secretion in lactating mothers. Because of its high in iron and protein content. It is mainly given postpartum as effective galactagogue to induce lactation in nursing mothers (Pattnaik, 2003) ^[33]. Besides, by taking this herb regularly it also protects from cancer diseases. Being a good source of alpha linolenic acid and other phytochemicals (phenolic compounds, terpenoids, alkaloids, and organosulphur compounds), protect against different type of cancers. Presence of omega-3 and omega-6 fatty acids, it also helps to prevent breast cancer (Khan *et al.*, 2008) ^[17].

Table 3: Health benefits of garden cress seeds

Sr. No.	Health benefits	Components Responsible	Key findings	References
1.	Prevents asthma	<ul style="list-style-type: none"> • N,N-dibenzylthiourea, leporine, N,N-dibenzyl urea, sinapic acid, riboflavin etc. 	<ul style="list-style-type: none"> • Presence of ethanol extract in garden cress seeds exhibited bronchoprotection against acetylcholine (ACh) and helps to prevent asthma. 	Paranjape and Mehta (2006); Mali <i>et al.</i> (2008) ^[30, 22]
2.	Regulates menstrual cycle	<ul style="list-style-type: none"> • Flavonoids, cardio tonic glycosides, coumarins, glucosinolates, saponins, sterols, sinapic acid, tannins, triterpene, uric acid and volatile oil etc. 	<ul style="list-style-type: none"> • Due to presence of estrogenic trails, help to maintain the proper regulation of menstrual cycle. • Emmenagogues, the substance which stimulates blood flow in the pelvic area and uterus which induce menstruation. 	Pattnaik (2003); Ghante <i>et al.</i> (2011); Singh <i>et al.</i> (2015) ^[42]
3.	Prevents anaemia	<ul style="list-style-type: none"> • Glutamic acid, aspartic acid, potassium, calcium, phosphorus, iron, manganese, zinc, fibers, linoleic acid, oleic acid etc. 	<ul style="list-style-type: none"> • It is a rich source of non-heme iron (iron found in hemoglobin), which helps to increase the hemoglobin levels in blood and also helps to prevent anemia. • Hematic agent is present in this seed. 	Monsen (1988); Paranjape and Mehta (2006) ^[27, 30]
4.	Increases breast milk secretion	<ul style="list-style-type: none"> • Tocopherols, carotenoids, ascorbic acid, flavonoids, phytosterol, proteins, irons, glutamic acid, aspartic acid etc. 	<ul style="list-style-type: none"> • It is a potent source of iron and protein content for increasing the milk secretion of a lactating mother. • It is given postpartum as effective galactagogue for stimulating the breast milk. 	Pattnaik (2003); Singh <i>et al.</i> (2015) ^[42]
5.	Diabetes	<ul style="list-style-type: none"> • Alkaloids like- lepidine, glucotropaeolin etc. • Antioxidants like-tocopherols, carotenoids, and ascorbic acid etc. 	<ul style="list-style-type: none"> • Due to the presence of anti-diabetic property, it helps to reduce blood glucose levels. • Garden Cress seeds contains alkaloids which are beneficial against diabetes. • It has a hypoglycemic effect independent of insulin secretion and used for the treatment of diabetes mellitus. 	Eddouks <i>et al.</i> (2002) ^[8] ; Abdullah J (2007); Prajapati and Dave (2018) ^[8, 4, 34]
6.	Protects cancer	<ul style="list-style-type: none"> • Phytochemical & antioxidant components such as-tocopherols, carotenoids, eugenol, terpenoids, glucosinolates (glucotropaeolin and 2-phenyl ethyl glucosinolate), 3',5'-dimethoxyacetophenone, hexadecanoic acid, methyl ester are present. 	<ul style="list-style-type: none"> • Being a good source of alpha linolenic acid and other phytochemicals (phenolic compounds, terpenoids, alkaloids, and organosulfur compounds), protect against different type of cancers. • Presence of glucosinolates, the secondary metabolites which inhibit carcinogenesis against the development and proliferation of cancers. • Presence of omega-3 and omega-6 fatty acids, help to prevent breast cancer. 	Kassie <i>et al.</i> (2002) ^[15] ; Gee <i>et al.</i> (2002) ^[25] ; Kassie <i>et al.</i> (2003) ^[16] ; Matthaus and Angelini (2005) ^[23] ; Tracy <i>et al.</i> (2007); Radwan <i>et al.</i> (2007) Khan <i>et al.</i> (2008) ^[17] ; Diwakara <i>et al.</i> (2008) ^[6] ; Conforti <i>et al.</i> (2008) ^[5] ; Barba <i>et al.</i> (2016); Rajasekaran and Suresh (2021) ^[15, 25, 16, 23, 17, 6, 5, 11, 35]

Toxicity

The seeds of *L. sativum* have many beneficial applications for preventing non-communicable diseases such as cancer, obesity, anaemia, diabetes, asthma etc. but it could be harmful due to the presence of teratogenicity effect by taking excess amount (Sharma and Agarwal, 2011; Juma and Martin, 2011)^[3] and further causing toxicity or allergy related problems. One toxicity test showed that the administration of ethanolic extract of *Lepidium sativum* in single doses of 0.5 to 3.0 g/kg did not produce any adverse effects or mortality in mice (Yahya *et al.*, 1994). In another study, the acute toxicity level 0.5–5.0 g/kg bw of the seed powder was administered through diet to rats and obvious symptoms of toxicity and mortality were monitored for 72 h (Datta *et al.*, 2011). Besides, due to the presence of different type of antinutritional components such as phytate, phytin-phosphorus, oxalate in garden cress seeds to reduce the nutrient bioavailability (Nduagu *et al.*, 2008)^[28].

Traditional Utilization

Garden cress seeds are originated from Egypt ancient where they consume it as food and became well known in various parts of Europe including, Britain, France, Italy and Germany and South-West Asia, but now it is cultivated throughout the world for its seeds (Sharma and Agarwal, 2010, Dixit *et al.*, 2020). These are extensively used in the Arabic Counties for various purposes such as febrifuge, anti-rheumatic, diuretic and many more. It is also used in menstrual, abdominal discomfort and to enhance sexual desires, which was observed in a survey that was conducted in different regions of Saudi Arabia.

In Sikkim and West-Bengal the plant is used in the treatment of asthma, bronchitis, dysentery, pain, pneumonia, and stomach-aches (Mali *et al.*, 2007). Even the leaves of the plants are used as edible vegetable in Purulia district in West-Bengal. India has used this plant to cure asthma, dysentery, bleeding piles and menstrual disorder (Jagdale *et al.*, 2021). It is found throughout

India in cultivated fields, gardens, roadsides and even near the railway tracks (Shah *et al.*, 2021).

In China and other Eastern Countries, the seeds are used for the treatment of abdominal colic, sexual debility, asthma, pleurisy, and dropsy (Sharma and Agarwal, 2010). In Africa they chew the seeds to cure the throat disease, asthma, headaches, diuresis, and rapid bone fracture healing (Dixit *et al.*, 2020). It is considered as one of the best medicinal plants in countries. In Roman and Greek time, Muslims used these seeds as a cure for stomach-ache and to kill stomach worms (Falana *et al.*, 2014).

When it comes about the seeds and the plant of *Lepidium sativum*, these are consumed raw in salads, because of its tangy taste and health benefits. They are also cooked in the curries and even used as garnish in salads (Mali *et al.*, 2007, Falana *et al.*, 2014). These plants have anticarcinogenic, antioxidants and anti-asthmatic factors. The antihypertensive and diuretic effects of aqueous extract of seeds were investigated in both normotensive and spontaneously hypertensive patients. Therefore, these seeds are one of the important medicinal plants, which have considerable nutritive value of fats, minerals, protein, fibres, and phytochemical and these play crucial role in many functional beverages and foods (Hanan *et al.*, 2019)^[13]. Garden Cress seeds have potential of both foodstuff and nutraceutical in plant and seed

forms.

The plant is used as fodder for horses and camels and the roots are used in secondary syphilis and tenesmus (Mali *et al.*, 2007, Agarwal and Sharma, 2012). It is claimed that it destroys Vata and Kapha (Mali *et al.*, 2007, Sharma and Agarwal, 2010). The fresh fruits of Garden cress seeds are listed amongst the useful drugs for treating injuries, skin, and eye diseases. *Kasturyadigitrica* is a drug useful in kapha which contains the seeds of the plant as one of the ingredients (Mali *et al.*, 2007). These are 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 (Shah *et al.*, 2021). Leaves are mildly stimulant, diuretic, useful in scorbutic diseases, aphrodisiac properties, aperient, chest problems, muscular pain, and liver complaints (Mali *et al.* 2007). For sprains, dysentery, leprosy, and other skin diseases they are mostly used as poultices.

Seeds of the plant are useful for the rubefacient, galactogogues, emmenagogues, laxative, tonic, aphrodisiac, depurative, hemogenic and diuretic (Mali *et al.*, 2007). Garden Cress seeds have been used traditionally for many diseases like cold; infusion of seed is used in treatment of high cough, spleen and liver chronic enlargement, flatulence, diarrhoea, dysentery, indigestion, rheumatic pain, viscous humours, tenesmus, secondary syphilis, abortion, anaemia, and weakness. The seeds are useful in preventing hair loss and stimulating the appetite. These seeds are widely used as an analgesic, anti-spasmodic, anti-diarrhoeal, galactogogues, hepatoprotective, anti-inflammatory, diuretic, aperient, alterative, tonic, aphrodisiac, emmenagogue, aperient and carminative properties.

Moreover, the seeds are used in treating hypertension and renal diseases. In addition, it is used as an essential drug to improve the health of mother as well as her children as it is an abundant source of calcium and phosphorus and is an alternative to the supplements prescribed for the dispersion of the chronic enlargement of spleen (Agarwal and Sharma, 2012).

The seeds and leaves of the plant have been reported to boost brain strength and brighten the intellect in the Unani system of medicine (Mali *et al.*, 2007, Sharma and Agarwal, 2010). Asthma, cough, and bleeding piles treatments, as well as bronchodilators and diabetes control are also treated. Roasted seeds in ghee and mixed with sugar are given as tonic for general weakness in young girls and after childbirth to increase the breast milk (Agarwal and Sharma, 2012). The oil extracted from the seeds roasted in till oil is used as analgesic medicated oil in gout, rheumatism, glandular swelling etc, it is important for irritant and therefore care must be taken to use little at a time (Sharma and Agarwal., 2010). Also, these seeds have the capacity to absorb heavy metals from the soil (Shah *et al.*, 2021).

Sugar-rich source laddu are made by these seeds. these are mainly given to post-natal women to strengthen their bones and help to regain the energy because of its high iron and protein content it is also often given to postpartum to lactating mothers (Agarwal and Sharma., 2012). These seeds have undergone extensive research to prove their usefulness as a therapeutic agent through pharmacological studies and clinical trials, explaining the varied role of this natural substance.

The herb is used to treat asthma, cough, expectorant, and bleeding piles by crushing the plant and making an infusion

with water that is taken twice a day for asthma and whole herbs paste that is taken every 4 hours for cough and expectorant. Diuretics are made by boiling the leaves with water and drinking the decoction three times a day. The powdered root for syphilis is to be taken with Luke's cow's milk. The abortion seeds are boiled with milk and administered within 45 days of conception. (H. Falana *et al.* 2014).

Garden cress seeds powder is useful in improving various parameters of Pulmonary Functions in Asthmatic and Curse Diarrhoeas, Indigestion and Dysentery. Usually, to make comfit with seeds which are useful for expelling worm in old

and young alike, seeds are also used to firm for those who have lost the ability to speak due to apoplexy are advised to chew seed often. The plant is also useful in reducing blood glucose level as depicted by a study. The seeds extract has hepatoprotective properties which protect the liver from damage by the toxic agents. They also cure scanty urination which is caused due to liver disorders and irritation of the intestinal mucous membranes. Other uses recently *Lepidium sativum* is getting recognition as a functional food as it has high nutritive value, people consume it as a dietary supplement.

Table 4: Distinct parts of garden cress used for different purposes

Parts of the plant	Used for	References
Plant	<ul style="list-style-type: none"> Cure for asthma, dysentery, bleeding piles and menstrual disorder. Fodder for horses and camels reducing blood glucose level 	Mali <i>et al.</i> , (2007) Agarwal and Sharma., (2012) Jagdale <i>et al.</i> , (2021)
Seeds	<ul style="list-style-type: none"> Used for the treatment of abdominal colic, sexual debility, asthma, pleurisy, and dropsy and cure the throat disease, asthma, headaches, diuresis, and rapid bone fracture healing For sprains, dysentery, leprosy, and other skin diseases they are mostly used as poultices. Hypertension and renal diseases. Roasted seeds in ghee and mixed with sugar are given as tonic for general weakness in young girls and after childbirth to increase the breast milk 	Mali <i>et al.</i> , (2007) Sharma and Agarwal., (2010) Dixit <i>et al.</i> , (2020)
Roots	<ul style="list-style-type: none"> Used in secondary syphilis and tenesmus Syphilis the powder is to be taken with Luke cow's milk. 	Mali <i>et al.</i> , (2007) Agarwal and Sharma., (2012)
Leaves	<ul style="list-style-type: none"> For Diuretics they are boiled with water and decoction to be taken three times a day. Leaf paste as well as black pepper paste are in ratio 2:1(w/w) which is used by Lodhas for getting relief from boils. Paste of fresh leaves against urinary infection. 	Sharma <i>et al.</i> , (2011) Sahu and Gupta., (2012) Falana <i>et al.</i> , (2014)
Herb	<ul style="list-style-type: none"> Expectorant, Bleeding piles by preparing the plant crushed and made infusion with the water and taken a twice a day and for asthma whole herbs paste should be taken every 4 hours for cough as well as for expectorant. 	Falana <i>et al.</i> , (2014)

Commercial Utilization

The edible whole seed is known to have health promoting properties; hence it is believed that these seeds can serve as raw material for the functional foods, sharing its peppery, tangy flavour and aroma. Certain experts believed that if the seeds are so medical, the seed's sprouts should be an even superior source of all the medicinal compounds. As a result, the decision was made to make supplement whey protein concentrates with the powder of the seeds, however such a notion remained solely of academic attention due to poor consumer acceptance. (Snehal Y Mohite *et al.*, 2012). Although there are few recipes using the Garden Cress seeds which are reported but there is no report available on Ready-to-eat foods and drinks from garden cress seeds. Considering the wide spectrum of health benefits and nutritional properties of Garden Cress seeds should be used to create ready-to-eat recipes and beverages. As a result, the current research focuses on the development and evaluation of a ready-to-eat sweet snack made from garden cress seeds in terms of nutritional, shelf life, and sensory qualities. (Snehal Doke *et al.*, 2017). The functional health benefits of Garden Cress Seeds may be exploited by incorporating them in several food formulations and health drink preparations. The plant, its seeds, and the oil found in them have a lot of potential for further research, both for their ability to prevent chronic diseases and as interesting ingredients for new functional food compositions. The Ironrich biscuit was prepared by combining garden cress and rice flakes to prevent Anaemia in adolescents (Singh and Paswan, 2017). These studies were

conducted in order to develop products based on Garden cress seeds that would be helpful to humans and easy to ingest.

Future prospective

In recent years various efforts were made to develop human diets in such a way that it acts as functional foods and act as medicine for fighting several health benefits and to prevent increasing state of diseases over the time. It has been sentenced that Garden cress seeds is used as traditional medicine since ancient times in our country. (Mali *et al.* 2007). Stems, leaves and seeds of the garden cress are palatable and can be used in culinary purposes. These seeds fall under the category of functional foods that promote overall health and while keeping diseases at bay, apart from providing nutrition. In market, garden cress seeds are segmented into organic and conventional. The rising demand for organic product in the global market and the value for the organic segment are expecting high sales over the forecast period. The garden cress comes under food, pharmaceutical and cosmetic industry and therefore has wider scope if its market potential is explored. Its seeds have large application in food mainly used in salads, sandwich, can also be added in dishes for flavour. New products are developed by the fortification technique. (Singh and Paswan 2017). Stems, leaves and seeds of the garden cress are palatable and can be used in culinary purposes. Being functional food which is highly nutritious, their seeds can be incorporate into various recipes to improve nutritional status of population. Four traditional foods such as pinni, panjiri, laddu and burfi were

developed. The supplementation showed increased nutritional value in burfi with highest protein, fat and iron (Bansal, 2013), content while pinni was found with highest fibre, calcium and zinc content. (Nagi and Mann, 2003).

On the other hand, it also plays a role in the medical field which provide various health benefits such as cardiovascular benefit, prevents osteoporosis, protects nervous system, antioxidant activity, chemoprotective effects and can act as a tonic against diarrhoea, dyspepsia, eye disease, leucorrhoea, scurvy, asthma, cough, cold and seminal weakness. (Singh & Paswan, 2017). Several awareness and promotional programs should be carried out among its target segment since the

penetration of the product is comparatively very low. Its critical functions and properties of garden cress seeds are driving the demand for the product in the global market.

The approaches for researching the production of garden cress seeds products have been going on. In the market place garden cress seeds are displayed in the form of organic seeds or in conventional form. As rising demand of this seeds and continuous researches, they might introduce ready to eat food supply or seeds incorporated food products in the market which will be helpful for human health as well as innovation for food industry.

Table 5: List of the garden cress seed products researchers developed

Anticipating Products	Aggregate Research	Post Results	Reference
Garden cress seeds Noodles	<i>Lepidium sativum</i> seeds powder along with semolina was used in preparation of noodles.	<ul style="list-style-type: none"> Moisture content was slightly low in the noodle enriched with the 15% incorporation of the GCS. Protein content was high in 15% incorporation of GCS than the control noodles. Fat content was also increased with addition of GCS ranged from 1.857 to 5.212. Fiber was the highest in the GCS noodles Carbohydrate content was the lowest in the GCS noodles as compared to the control noodles. Noodles were supplemented with 15% garden cress with raised amounts protein and fiber concentrations which were up to 13.06% and 76.80% and the sensory evaluation of noodles fortified with garden cress which is acceptable. 	Hanan, MA AL-Sayed, S Zidan and A. Abedelaleem (2019) ^[13]
Cookies	Integrated with oats flour, Bengal gram flour, semolina, cardamom powder and garden cress seeds.	<ul style="list-style-type: none"> Fat content of garden cress seeds enriched cookies is more. Carbohydrate content of all the GCS enriched cookies showed significant increase in carbohydrates composition with overall increase level of nutrient enrichment. Calcium content of GCS enriched cookies was more. T4 sample with 10.5% incorporation of GCS recorded maximum iron concentration of 12.89mg. It is also noted that energy value increases with increase in enrichment of garden cress seeds. The treatment T1 with 5.5% incorporation of the product was found to be highly acceptable with scores 7.39, 7.66, 7.57 for color, flavor and taste. 	Yadav, Singh, Sharma, Bhatt and Govila (2018) ^[44]
Milk based health drink	Incorporated with 5% sugar, 1% fat and 3% garden cress seeds.	<ul style="list-style-type: none"> It has been found that the product made was highly acceptable and meeting the score demands of sensory parameters. 	Lahiri and Rani (2020) ^[18]
Brioche Bread	The product was developed with the incorporation of Garden cress seeds using grinder seeds were converted into the powder form. Wheat flour was replaced by garden cress seed powder.	<ul style="list-style-type: none"> The fiber content is highest in the sample which has maximum incorporation of garden cress seeds. carbohydrates (CHO) decreased directly proportional to the level of GCS powder added in the formulation of brioche Fat content is increased. Best overall acceptability of resulting brioche bread can be obtained by replacing wheat flour with 1- 3% GCS powder in brioche formulation. 	Omaira, M. Dewidar, Ghada and El-Kherbawy (2019)
Cereal beverage	The processing technology of standardization is used for preparation of cereal milk which is fortification with garden cress seeds as well as pumpkin seed powder.	<ul style="list-style-type: none"> It is observed that highest fat is recorded in addition of pumpkin seeds which is 27.83% and lowest was recorded in the addition of barley which is 2.6%. It is observed that cereal grains had higher carbohydrate content than the pumpkin seeds and garden cress seeds. It is also concluded that the lactic acid fermentation of these cereal by LAB starter culture containing <i>Lactobacillus acidophilus</i>. The maximum score which is 8.8 is for overall acceptability which was observed in sample A consisting of 70 per cent barley and 30 per cent sorghum and 3% <i>Lactobacillus acidophilus</i> as well as <i>Bifid bacterium bifidum</i> starter culture. 	Shendge SN and Patharkar SR (2019) ^[40]
Instant UPMA mix	Product was carried out in the form instant UPMA mix of foxtail millet and garden cress seeds	<ul style="list-style-type: none"> The different formulations of UPMA mix contains moisture from 6.15 to 7.62 percent, protein 11.30 to 13.84 percent, fat 7.30 to 16.80 percent, carbohydrate 55.16 to 64.07, ash 2.89 to 4.43 percent, fiber 3.90 to 4.31 percent, and energy value 371.06 to 427.50 Kcal/100 g. 10% garden cress semolina scored the highest for all the sensory characters which is for appearance and colour (7.8), taste (7.9), texture (7.8), flavour (7.7), and overall acceptability (7.8) as comparative to other four formulations. 	Rodge SM, Bornare DT and Babar KP (2018)

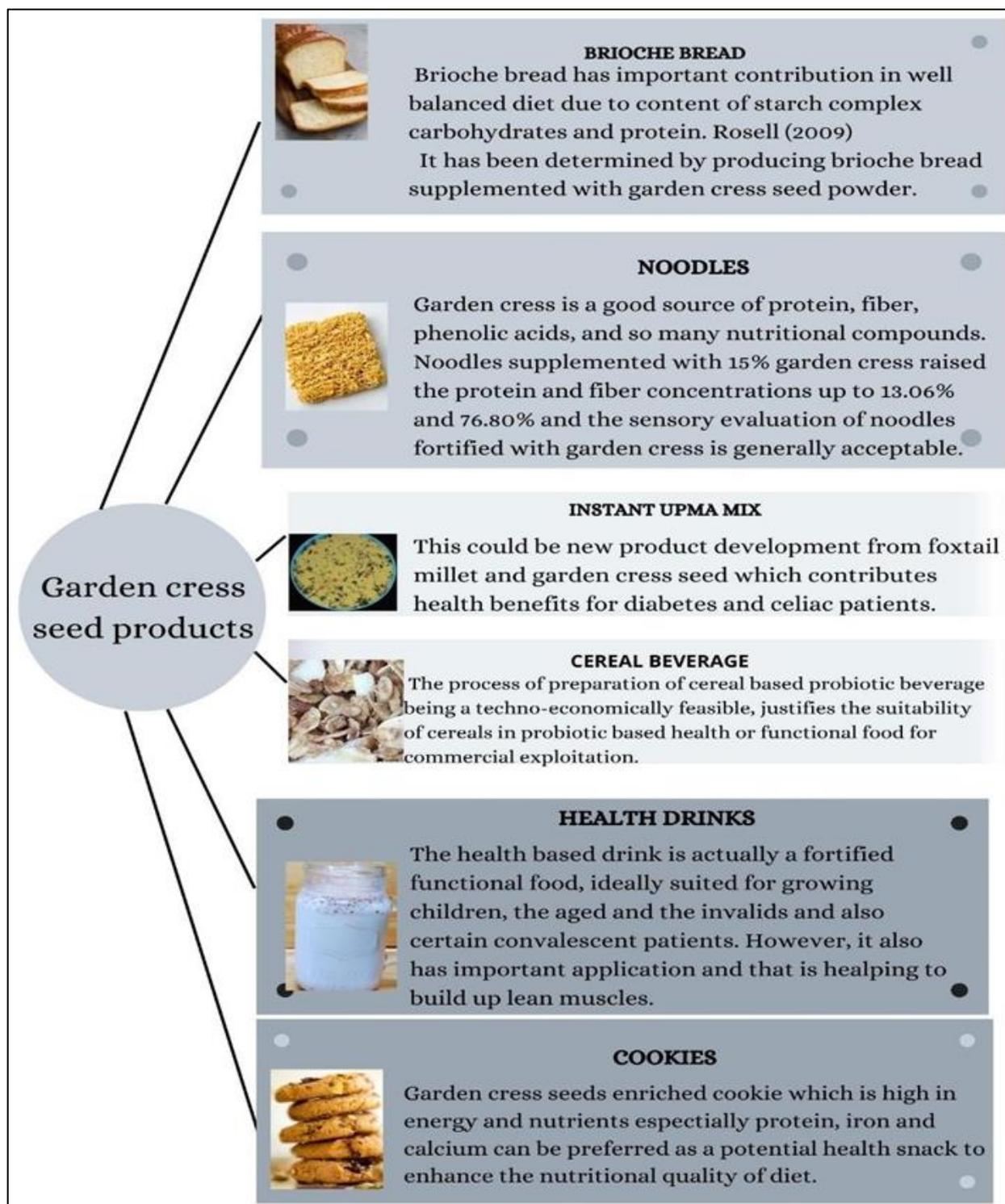


Fig 2: A few examples of garden cress seeds-based food products

Conclusion

The garden cress seeds can also be considered as new valuable source. The use of these underutilised seeds can provide a new opportunity and emerging market share to food industry not only in the field of new product development but also for other therapeutic uses. These seeds are the indication of good source of amino acids, minerals and fatty acids and have high content of phenolic compounds. Due to high protein, fiber and carbohydrate content and other minerals, the seeds can be utilised for development of various value-added products. Therefore, garden cress plant, seeds as well as oil present have a wide scope for further inventions for their

potential preventive effects towards chronic diseases and also in the development for new functional food formulations (Singh *et al.*, 2017). As we discussed that these seeds are very much abundant with enough iron and calcium, so mainly the people such as children, women, are suffering from Malnutrition, Calcium deficiency and Iron deficiency anemia, can get best result from this product. Furthermore, people who are healthy now, but in future, they can get suffered from any health and nutrition related disorder. So better to consume these kinds of products in daily life to maintain the healthy life and to prevent these disorders in the upcoming life. There are numerous of other benefits of this product to mothers for

milk production, for sugar patients that these seeds have low glycaemic index, maintaining the normal haemoglobin level, reducing the body fat faster and have immunogenic properties. Last but not least, this product is very nutritionally healthy and various good effects on our body. So, it should be consumed on a daily basis to control the nutrition related problem and if this kind of product would be introduced by government to the lower grade-income group or those who cannot afford food for their body's daily requirements, so we can say that it would make great change in any nation to make their population healthy.

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