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Exploring potential of fortification by garden cress (*Lepidium sativum* L.) seeds for development of functional foods—A Review

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Garden cress (*Lepidium sativum* L.) belonging to Brassicaceae family is widely grown in India, Europe and US. It has been used as an important medicinal plant since the Vedic era. In Ayurveda, it is considered as hot, bitter, galactogogue and aphrodisiac and claimed to prevent *Vata* and *Kapha*. Garden cress seed is good source of essential and non- essential amino acids and they are also used as a novel source of hydrocolloid. Its extract exhibit strong shear-thinning behaviour and is used as a substitute for gum Arabica in the formulation of different products. The garden cress seed oil has a balanced amount of both polyunsaturated fatty acids and monounsaturated fatty acids and is a good source of linolenic acid. It contains natural antioxidants, viz. tocopherols and carotenoids and eugenol that help in preventing cancer and protect the oil from rancidity. Its seed, oil and powder contain significant amount of protein, fat, minerals, fibers and phytochemicals which are incorporated in many functional beverages and foods. A number of clinical trials have been conducted on rats that also support the efficacy of garden cress seeds. The functional properties of Garden cress seeds stimulate us to review its different valuable properties and the fortified products developed by incorporating Garden cress seeds.

Keywords: Galactogogue, *Lepidium sativum* L., Garden cress seed, Fortification, Functional foods, Natural antioxidants.

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Introduction

Garden cress (*Lepidium sativum* L.) is a fast growing annual herb, native to Egypt and west of Asia and presently it is cultivated all over the world. In local languages garden cress (GC) is also known by Chandrasur and it is considered as an important medicinal crop in India[1]. The plant is an erect, glabrous, annual, herbaceous growing up to the height of about 15-45 cm. It has small white flowers in long racemes and the pods are broadly or obovate, rotund, elliptic, emarginated notched at apex and winged. Garden cress can be sown and harvested several times throughout the year; although, January, February and November are the most suitable months of the year to sow in a Mediterranean climate[2]. Garden cress seed (GCS) possess several of pharmacological properties like anti-anemic, antioxidant, galactogues, etc. and has tremendous potential for the development of functional food by fortification with it[3,4]. Generally GC is consumed as cooking material and with salad. In recent years efforts are made to develop human diets in such a way that it acts as medicinal foods in order to exploit several health benefits and to prevent increased diversity of diseases. Isothiocyanates are most important biochemical agents from the human health point of view as they are the major inducers of carcinogen-detoxifying enzymes. The most potent isothiocyanates are benzyl isothiocyanate (BITC) which is present in ample quantity in garden cress[5]. GCS have been used in traditional medicine since ancient times in India[6]. The GCS are galactogogue, bitter, thermogenic, depurative, rubefacient, aphrodisiac, ophthalmic, antiscorbutic, antihistaminic, diuretic and act as tonic. Various diseases like asthma, coughs with expectoration, diarrhoea, dysentery, poultices for sprains, leprosy, skin disease, splenomegaly, dyspepsia, lumbago, leucorrhoea, scurvy and seminal weakness can be treated using garden cress seed[7]. It is supplemented in the diet of lactating women to increase the milk secretion during post natal period and also recommended for the treatment of diarrhoea and dysentery[8,9]. Seeds of GC are prescribed by Ayurvedic practitioners for the treatment of bronchial asthmatic patients. Garden cress seed oil (GCSO) has a balanced amount of polyunsaturated fatty acids (PUFA) (46.8 %) and

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monounsaturated fatty acids (MUFA) (37.6 %). It contains natural antioxidants like vitamin A, E and eugenol which help to protect cells from damage by free radicals[10]. It also protects oil from oxidation and causing rancidity. It was reported that GCS contain 22.5 % protein, 27.5 % fat, 30 % dietary fiber, and 1193 mg/100 g potassium[11]. Hence, it can potentially be used as a functional food. The oil content of dried cress seed is 22.7 % and the primary fatty acids found in cress oil are oleic (C18:1; 30.6 %), linolenic (C18:3; 29.3 %), palmitic (C16:0; 9.4 %), linoleic (C18:2; 7.6 %), erucic (C22:1; 3.0 %), stearic (C18:0; 2.8 %) and arachidic (C20:0; 2.3 %) acids[11,4]. GCSO contain high concentrations of γ- (1422 ppm) and α (356 ppm) tocopherols.

Although, fruit and vegetable juices are rich sources of vitamin and minerals but these are limited in protein and fat content. For the compensation of these components garden cress extract or powder can be added. As garden cress also acts as thickening agent, the combination of both juices and extract may lead to the formation of health promoting beverages having good textural, sensory attributes and nutritional properties. A beverage was developed by combining lime juice and saccharin, honey and garlic for the compensation of proteins and fat[12]. Similarly, Mohite *et al* designed a health drink by combining GCS powder with skim milk powder for providing promising health benefits[13].

Chemical and nutritional composition of garden cress seeds

Proximate composition (%) of *L. sativum* seeds reported by Zia-Ul-Haq *et al* indicates the presence of appreciable amounts of protein (24.2±0.5), lipids (23.2±0.2), carbohydrates (30.7±1.2), fiber (11.9±0.4), ash (7.1±0.1) and moisture (2.9±0.1)[14]. Proximate composition varies depending upon plant variety, agronomic practices and stage of collection of seeds and climatic and geological condition of area from where seeds are collected. It is an important factor for evaluation of nutritional status of fruits and seeds of plants and crops and it dictates further studies on components which seem more interesting[15]. Higher amounts of ash contents indicate that the GCS are good source of minerals. The low moisture content is an index of stability, quality and increased shelf life of seeds[16]. Higher protein and lipid contents indicate that GCS have high food energy.

Qualitative and quantitative amino acid profile as presented in Table 1, well introduces the nutritional quality of GCS protein[4,14]. All essential amino acids are present in high amounts in garden cress, except tryptophan and S-containing amino acids methionine and cysteine. Glutamic acid and aspartic acid are the major non-essential amino acids in the GCS. The total essential amino acid percentage (47.08 %), suggests that this seed may contribute significantly to the supply of essential amino acids in the diet. Essential amino acid score is 28.53 % with methionine being the most limiting amino acid. Aspartic and glutamic acids are present in significant amount in this oilseed.

Table 1—Amino acid profile, mineral content and fatty acid profile of garden cress seed

Amino acid profile (g/100 g protein)	
Essential amino acids	
Histidine	3.87±0.14
Threonine	2.66±0.09
Arginine	4.51±0.03
Valine	8.04±0.03
Methionine	0.97±0.02
Phenyl alanine	5.65±0.03
Isoleucine	5.11±0.03
Leucine	8.21±0.01
Lysine	6.26±0.39
Non essential amino acids	
Aspartic acid	9.76±0.03
Glutamic acid	19.33±0.19
Serine	4.96±0.09
Glycine	5.51±0.07
Alanine	4.83±0,02
Tyrosine	2.69±0.09
Proline	5.84±0.38
Mineral content (mg/100 g)	
Calcium	266.35
Copper	5.73
Iron	8.31
Magnesium	339.23
Manganese	2.00
Phosphorus	608.63
Potassium	1236.51
Sodium	19. 65
Zinc	6.99
Fatty acid profile (%)	
Palmitic acid (16:0)	10.30 ± 0.12
Palmitoleic acid (16:1)	0.70 ± 0.30
Stearic acid (18:0)	1.90 ± 0.19
Oleic acid (18:1)	30.50 ± 0.16
Linoleic acid (18:2)	8.60 ± 0.38
Linolenic acid (18:3)	32.18 ± 0.59
Arachidic acid (20:0)	2.10 ± 0.57
Eicosaenoic acid (20:1)	13.40 ± 0.66

Adopted from: Gokavi *et al* and Zia-Ul-Haque *et al*[4, 14]

Glutamic acid is an important excitatory neurotransmitter and it plays a vital role in metabolism of sugars and fats[17]. The body uses methionine to derive the brain food, choline. It also aids in digestion, as well as serving as a fat burner. It can interact with other substances to detoxify harmful agents, and is essential for the production of cysteine and taurine. It is also necessary for the production of niacin and is used by the body to make the neurotransmitter, serotonin[18]. These play a very important role in human nutrition. Lysine helps in proper maintenance of nitrogen balance. L-Tryptophan acts as a sleep aid. The presence of tryptophan and cystine in GCS is also reported[14].

Mineral contents of seeds (Table 1) varied between species, but potassium constituted the major mineral in GCS 1,236.51 mg/100 g, while zinc and manganese contents are low. GCS is a good source of calcium, phosphorus and magnesium. GCS has potential for providing essential nutrients for human and other animals, as the nutritional activity of any plant is usually related to the particular elements it contains[19]. With these minerals content it can be utilized for development of a number of supplementary food products.

Fatty acid composition (Table 1) reveal high content of linolenic acid (32.18%) and oleic acid (30.5%) in the garden cress seed oil (GCSO). Higher intake of oleic acid is associated with decreased risk of coronary heart disease caused by high cholesterol level in blood[20]. The fatty acid composition of the GCSO is interesting from the nutritional point of view for their higher contents of unsaturated fatty acids; especially it is rich in ω-3 fatty acid which is beneficial for health. Palmitic acid is the most abundant saturated fatty acid, in the amounts of 10.3±0.12 g/100 g in GCS. Similarly palmitoleic acid is the least abundant unsaturated fatty acid, with values 0.70±0.30 g/100 g in GCS.

Physico-chemical properties of garden cress seed oil

Physico-chemical parameters provide important information regarding storage, stability and quality of the product. The physico-chemical properties of GCSO extracted by the different methods[21] are presented in Table 2. The total oil content of solvent extracted GCSO was 21.54 %, supercritical CO_2 extraction was 18.15 % and cold expression was 12.60 %. Maximum oil extraction was obtained by soxhlet method (21.54 %). The oil content in GC seeds is relatively less compared to other edible oil seeds such as mustard (25–40 %), rapeseed (40–45 %) and camelina or false flax (40–45 %) of Brassicaceae family[22]. GCSO has a typical smell of mustard oil but less pungent than mustard oil. The physicochemical properties of GCSO as summarized in Table 2 establish the potential of garden cress for development of novel products with several functional properties.

Physical properties of garden cress seed oil

Physical properties like colour, odour, viscosity, specific gravity, refractive index are important during the development of food products, because these properties may affect the different quality parameters of the developed products.

Color

The color of oil is an important feature which often determines the consumer acceptability of the product.

Table 2—Physico-chemical properties of garden cress seeds extracted by various extraction methods

Attributes	Cold pressed oil	Soxhlet extracted oil	Supercritical CO_2 extracted oil
Oil yield (% dry weight)	12.6 ± 0.87^a	21.54 ± 1.32^c	18.15 ± 1.20^b
Refractive Index (nDt)[1]	1.47 ± 0.001	1.47 ± 0.003	1.47 ± 0.002
Specific gravity (g/mL)[2]	0.91 ± 0.001	0.90 ± 0.001	0.91 ± 0.001
Viscosity (η)[3]	64.3 ± 0.90^a	55.5 ± 0.37^b	53.8 ± 0.6^b
Peroxide value (mequiv peroxide/kg oil)	0.70 ± 0.13^a	4.09 ± 0.16^c	2.63 ± 0.81^b
Free Fatty Acid (% oleic)	0.28 ± 0.02^a	0.39 ± 0.04^b	1.52 ± 0.28^c
Saponification value (mg KOH/g)	178.85 ± 0.46^a	182.23 ± 0.73^c	174 ± 0.82^b
Unsaponifiable matter (g %)	1.65 ± 0.24^a	1.39 ± 0.10^b	1.16 ± 0.30^c
Iodine value (g of I_2 absorbed/100 g)	122 ± 0.70^a	131 ± 3.26^b	123 ± 1.68^a

Each value is a mean ± SD of three determinations. Values within the same row with different alphabetical superscripts are significantly different at $P< 0.05$.

[1]nDt is the unit of refractive index (nD) for light with a wavelength equal to 589.3 nm at temperature, t=24 °C

[2]represent the direct pycnometer determination at 33 °C

[3]represent viscosity determined at 25 °C MPa/s

Data compiled from: Diwakar *et al.*[21]

The color of the garden cress oil is dirty yellow which is mainly due to the presence of some pigments like chlorophyll and carotenoids, unintentionally co-extracted during the oil extraction process[23].

Viscosity

Viscosity of the GCSO ranges from 53.8 to 64.3, respectively (Table 2). The cold pressed GCO was more viscous than the oil extracted by the other two methods. Increasing extraction temperature up to a certain value increased viscosity, but at higher extraction temperatures viscosity decreased. The reduction of gum viscosity with temperature might be the result of irreversible change in molecular conformation[24]. It was concluded that high pH, low water, seed ratio and mild extraction temperatures will give a high viscosity for *L. sativum* L. extract. It decides the flow behavior of the products and is considered much during the formulation of any liquid or semisolid products.

Refractive index

High refractive index value (1.47±0.03) is indication of substantial unsaturation and presence of unusual components such as hydroxyl groups in GCSO[25]. It also provides useful information about the purity of oils. The refractive index of GCO is within the range of edible oils (Table 2); therefore it can be a good fortifying agent for the product development.

Specific gravity

Specific gravity of garden cress seeds (0.91) resembles with the specific gravity value of milk. This suggests that drinks can easily be fortified with processed garden cress seeds powder and thus several health drinks can be formulated by incorporating GCS[13].

Chemical properties of garden cress seed oil

Chemical properties help in determining the stability of the GCSO and the developed blended products. It also helps in determining the shelf life of the food products.

Free fatty acids and peroxide value

The Free Fatty Acids (FFA) and Peroxide Value (PV) of the cold pressed GCSO is lowest compared to the oils extracted by solvent and supercritical CO_2 extraction (Table 2). Supercritical CO_2 extracted GCSO showed the highest FFA value while cold pressed and Soxhlet extracted oil showed lower FFA values. The acid value of GCSO (Table 2) is in range with the specifications of edible oils (0.1–6.0 % of oleic acid). The acid value depends on the extraction types of method adopted. A low acidity value indicates better stability of oil at room temperature (25±2 ^{o}C). The high PV in soxhlet extracted oil could be due to the exposure of the oil to high temperature (60–80 ^{o}C) during extraction. The low PV of cold pressed GCSO indicates that it is less prone to oxidative rancidity at room temperature.

Iodine value

The iodine value (IV) is a measure of average unsaturation of an oil or fat. It depends on all unsaturated components in the oil. The IV of solvent extracted oil was relatively higher than cold pressed and supercritical fluid extracted GCSO (Table 2). The unsaponifiable matter contains many olefinic compounds including carotenoids and squalenes having long chain of unsaturation. The presence of these unsaturated components in oil affects its IV[26]. The solvent extracted oil contained a significantly higher amount of total carotenoids in comparison with the cold pressed oil. Thus, the higher carotenoid content might be responsible for a high IV in solvent extracted GCSO.

Saponification value

Saponification value represents the number of milligrams of potassium hydroxide required to saponify 1g of fat under the conditions specified. It is a measure of the average molecular weight (or chain length) of all the fatty acids present. GCSO showed saponification value in the range of 174.00–182.23 indicating that the oil contained high molecular weight mass fatty acids (Table 2). The saponification value of GCSO (178.36) is lower than that of palm oil (196–205), olive oil (188–196), sunflower oil (186–196), soybean oil (188–195) and safflower oil (186–198)[27], therefore it is appropriate to form or supplement in to other product.

Unsaponifiable matter

Unsaponifiable matter of GCSO extracted by different methods varied between 1.16 and 1.65 g/100 g (Table 2). The unsaponifiable matter content was higher in GCSO compared to other oils such as sesame (1.2 %), white melon (1.1 %), corn (0.92 %), cotton (0.52 %), palm (0.34 %), peanut (0.33 %), palm kernel (0.22 %) and coco kernel (0.09 %)[(Ref. 28)]. The high unsaponifiable matter in the cold pressed oil may be due to the presence of lignans (29.4 %), crude fibre (16.5 %), protein (24.3 %) and minerals (5.4 %) in GC seeds[29].

Functional properties and other health benefits of garden cress seeds

As antioxidants: free radical scavenging activity

The antioxidant properties depend on the phenolic compounds presents in garden cress seeds. The main phenolic compounds present in GCS extracts are tocopherols. Tocopherols act as biological scavengers of free radicals that inhibit oil oxidation. Tocopherols also help in preventing diseases, besides possessing an important nutritional function for human beings as a source of vitamin E[30,31]. High amounts of tocopherols present in GCS can be responsible for the stabilization of fats and oils to prevent the oxidative deterioration and for its applications in dietary, pharmaceutical, or biomedical products[32]. Total tocopherol contents in GCSO is 139.73±0.91 mg/100 g and δ tocopherol was the most abundant in the seed oil of GC. Vitamin E (tocopherol) is an important antioxidant, which protects vitamin A and essential fatty acids from oxidation and prevents breakdown of body tissues.

Garden cress seeds possess maximum DPPH inhibition activity at concentrations of 100, 150 and 200 µg of methanolic extracts as reported during DPPH radical scavenging assay. These values are comparable with the standard free radical scavenger BHA at concentration 10, 50 and 100 µg[33]. Due to high free radical scavenging potential of GCS, its fortification to prepare balanced diet may help in incorporating and exploiting its rich nutritional as well as medicinal value to the developed food.

As galactogogue and emmenagogue: for inducing milk secretion and menstruation

GCS can be used as a supplement for proper regulation of the menstrual cycle, because it has mild oestrogenic properties. It shows emmenagogue like herbal properties which gave it an important place in *vedic* era. Emmenagogues are herbs which have the ability to provoke menstruation. They stimulate blood flow in the pelvic area and uterus and thus induce menstruation. GCS is used as emmenagogue in order to stimulate menstrual flow when menstruation is absent either due to pregnancy to cause an abortion or prevent pregnancy or for reasons other than pregnancy, such as hormonal disorders or conditions like oligomenorrhea. Similarly, consumption of GCS after birth of baby, increases milk production and secretion in lactating mothers. Because of its high iron and protein content, it is often given post-partum as effective galactogogue to induce lactation in nursing mothers to meet the nutritional requirement of their children. Galactogogues promotes lactation in humans and other animals. They exert their pharmacological effects through interactions with dopamine receptors, resulting in increased prolactin levels and thereby augmenting milk production[34].

As gastro intestinal tract cleansing agent

Garden cress helps in cleansing gastro intestinal tract and stimulates appetites. Since the testa of these seeds contain mucilage which can be used during constipation as a laxative and a purgative. Paste made with GCS can be taken internally with honey to treat amoebic dysentery. The mucilage of the germinating seeds reduces the irritation of the intestines in dysentery and diarrhoea. Crushed garden cress seeds drunk with hot water is beneficial to treat colic disease especially in infants. The plant is also used in treating bleeding piles.

As haematic agent

Garden cress seeds is the rich source of non-haeme iron (iron found in haemoglobin) which is an easily absorbed dietary iron. It helps to increase the haemoglobin level in blood. When taken regularly, it helps to alleviate anaemia. It is advisable to have vitamin C half an hour after consumption of these seeds as it enhances iron absorption. L-ascorbic acid facilitates iron absorption by forming a chelate with ferric iron at acid pH converting them to ferrous state that remains soluble at the alkaline pH of the duodenum which gets easily absorbed[35,36.]

Other health benefits

Garden cress seeds are considered as a memory booster due to presence of arachidic and linoleic acids[32]. They help to increases the lean body mass because they are a good source of iron and protein. The absorbility of iron increases when GCS is soaked in lime water, which help in strengthening of hair. The leaves are mildly stimulant and diuretic, useful in scorbutic (related to or resembling scurvy) diseases and liver complaints[37]. A paste of the seeds with water is effective against chapped lips and sunburn. As it is a good source of folic acid, it helps in synthesis of different non-essential amino acids. The well documented antioxidant and phytochemical properties of this amazing plant make it a chemopreventive agent[14]. The functional properties of GCS suggest that the regular consumption can greatly help to boost one's immunity and overcome to gamut of diseases. It acts as a

general tonic and can also help to increase the libido naturally. As it is a good source of carotene, which is the precursor of vitamin A, it is good for the eyes. Therefore, it is advisable to add it raw to salads, sandwiches, and chutneys, or to simply use it as a garnishing agent along with coriander leaves for any food item in order to utilize these health benefits.

Side-effects of garden cress seed

It is an abortifacient, if had in excess. Because of its hot and bitter nature due to presence of galactogogue pregnant women should avoid taking Garden Cress in any form[38]. It contains goitrogens that prevent iodine absorption in thyroids and hence can lead to hypothyroidism. If large quantities of garden cress are consumed, may cause digestive difficulties in some people. The oil derived from Garden Cress seeds is edible and can therefore be used as a cooking medium; however, some people may experience symptoms of indigestion due to its excess use[39]. Such individuals should discontinue using this oil or mix it with some other edible oil, so as to dilute it and reduce its adverse effects.

Fortification by garden cress for the development of new food products

Due to high nutritional and functional properties garden cress can be used for the fortification with many drinks and foods. The fortified garden cress products are discussed as under:

Development of garden cress fortified dahiwala bread

Food product dahiwala bread was developed by Agarwal and Sharma using processed garden cress seeds[39]. It results in the development of the products with increased amount of protein, fat, calcium, iron and phosphorous. Processing of the GCS helps in a significant decrease of antinutritional components like oxalate and total cyanogens, while phytic acid reduces to a small extent. The developed food product was checked for its acceptability by semi trained panels. Whole garden cress seed flour incorporated product was acceptable as standard. The developed food products using garden cress seeds could be beneficial for masses as nourishing as well as therapeutic agents due to the presence of various therapeutic properties like hypoglycaemic, hypotensive, fracture healing, anticancerous, etc[39], those at risk or suffering from anaemia, fractures, diabetes mellitus and other chronic degenerative diseases to pursue prevention and management of these diseases.

Development of omega-3 fatty acid rich biscuits

GCSO is rich source of α-linolenic acid (ALA), thus it is highly prone for auto-oxidation. This problem overcome with microencapsulation of GCSO was prepared in whey protein concentrate with oil/protein ratio of 0.4, by spray-drying method. Microencapsulated GCO powder (MGCO) contained 25 g of GCSO/100 g with microencapsulation efficiency of 64.8 % and particle size of 15.4±9.1 µ. Biscuits were prepared by supplementing MGCSO at 20 g/100 g or GCO at 5.0 g/100 g by replacing flour and fat or fat in biscuit formula[40]. ALA content was found to be 1.02 g and 1.05 g/100 g, respectively in MGCSO and GCSO supplemented biscuits. Biscuits were packed in metalized PET film (MPET) pouches, stored at three different storage conditions, viz. 90 % RH/38 ºC for 3 months, 30-40 % RH/38-40 ºC for 4 months and 65 % RH/27 ºC for 5 months. Biscuits stored at 90 % RH/38 ºC had one month shelf- life, whereas at 30-40 % RH/38-40 ºC and 65 % RH/27 ºC, they lasted 4 and 5 months, respectively. However, in all the three storage conditions oxidation rate of ALA was high in GCSO-supplemented biscuits compared to MGCSO biscuits indicating that the encapsulation prevented oxidation of ALA in biscuits. Sensory evaluation results showed that MGCSO-supplemented biscuit were acceptable.

Improvement of dough rheology and quality parameters in rice-wheat bread

Bahareh Sahraiyan and coworkers have evaluated the effect of hydrocolloid of GCS and guar gum in improving dough rheology and quality parameters in composite rice-wheat bread[41]. It was reported that the rheological properties of GCS and guar gum seeds improved the quality of rice wheat bread[42]. Guar (G) and GCS (L) hydrocolloids were added to the flour at four different composition (0, 0.3, 0.6, and 1 %) w/w flour basis. Combinations of these levels were performed in order to obtain the following samples (the sub Index indicates the gum level): G0L0, G0L0.3, G0L0.6, G0L1, G0.3L0, G0.3L0.3, G0.3L0.6, G0.3L1, G0.6L0, G0.6L0.3, G0.6L0.6, G0.6L1, G1L0, G1L0.3, G1L0.6 and G1L1. This study revealed that the effects of guar, GCS and guar-*L. sativum* L. seed gum in order to substitute gluten in composite rice wheat flour recipes. GCS used as a novel gum that increased water absorption, dough development time, dough stability and viscosity alone or in combination. The effects of GCS gum on the mixing tolerance index and gelatinization temperature

were more than guar gum although these parameters decreased by addition of both hydrocolloids. The extensibility value for guar and GCS gum incorporated dough increased with increasing hydrocolloids concentrations from 0.3 to 0.6 % and then decreased at 1 %. Crumb firmness decreased with increasing hydrocolloids concentration and increased with longer storage time although the effect of GCS gum on crumb firmness reduction was more than guar gum. It was concluded that GCS gum can be a novel and useful gluten substitute for composite bread baking purposes. These properties may be useful in preparation of several functional food preparations that overcome the milk secretion related problems and anemic condition in women.

Development of iron rich biscuits

Iron rich biscuit was prepared by combining garden cress and rice flakes to prevent the anaemia in adolescent girls from urban, rural and tribal areas of Marathwada region of Maharashtra state[43]. The sensory properties of iron rich biscuits were tested by sensory panel members. The high score samples were tested for proximate composition. The haemoglobin value of selected adolescent girls was found in the range of 8.7 to 10.96 mg/100 g. By comparing these values they found that there is least value of haemoglobin content in tribal and low income group girls. The proximate composition of selected biscuits which was highly accepted for all sensory attributes is given in Table 3. It is evident from the study that the acceptability scored ranged from 1.80 to 4.20. The mean values of different sensory characters reported showed that colour scored maximum followed by taste and texture. Low scores were noted for flavor and overall appearance.

Table 3— Chemical composition of garden cress seeds fortified iron rich biscuit and milk based health drink

Particulars	Nutrient content	
	Iron rich biscuit (Varsha and Rohini, 2007)[40]	Milk based health drink (Mohite *et al* 2012)[13]
Moisture %	14.87	84.10
Ash %	6.11	0.85
Fat %	29.61	1.22
Fiber %	0.99	-
Protein %	2.80	3.44
Calcium (mg/100 g)	17.63	127.20
Phosphorus (mg/100 g)	15.48	106.20
Iron (mg/100 g)	12.00	2.90
Carbohydrate %	-	10.30
Energy (kcal/100 g)	-	65.63

Processed garden cress seeds fortified health drinks

The edible whole seeds are known to have health promoting properties hence it was assumed that these seeds can serve as raw materials for functional foods contributing its peppery, tangy flavor and aroma. Since it is rich in proteins, carbohydrates and certain essential minerals like calcium, iron and phosphorous along with crude dietary fiber (7.6 %) it can be used as health drink with milk as its base. Considering this, a health drink was developed with processed garden cress seeds containing excess amount of minerals and nutrients[13]. The composition of health drink developed by adding 5 % sugar (w/v) in skimmed milk with 1 % fat and 3 % of processed garden cress seeds powder had 8.75 as overall consumer acceptability.

The health drink is considered as a type of fortified functional foods mainly needed for growing children, the aged and the invalids and also certain convalescent patients. It enhances the nutritional properties of milk and also providing the entire essential factor that are needed by these people[44]. This type of finding help in developing many types of functional and fortified food products. The chemical composition of milk based health drink is presented in Table 3. These drinks helps to prevent nutrients deficiency and promotes lean muscle developments in persons doing regular exercise. Therefore, it is essential that the food prepared in such a way that meet the requirement of these consumers, at the same time it should appeal to the senses of the consumers by having pleasant organoleptic qualities.

Vegetable oil blends with α-linolenic acid rich garden cress oil

Studies indicated that intake of high n-6 PUFAs in diet has shifted the physiological status to one that is pro-thrombotic and pro-aggregatory, characterized by increase in blood viscosity, vasospasm, and vasoconstriction and decrease in bleeding time[43]. Further, the deficiency of n-3 PUFAs has been implicated in inflammatory diseases, viz. atopic dermatitis, rheumatoid arthritis, asthma, ulcerative colitis and cancer. However, sufficient intake of n-3 PUFAs alters membrane fluidity, down-regulates inflammatory genes, lipid synthesis and stimulates fatty acid degradation[45]. In recent years, human dietary lipids intake shifted more towards polyunsaturated fatty acids (PUFAs) due to their cholesterol lowering

effect when compared to saturated lipids. PUFAs like n-3 and n-6 are essential fatty acids, since humans cannot synthesize them and therefore, they need to be supplemented through food. The increased consumption of vegetable oils (sunflower, corn, safflower and soybean oil) rich in n-6 PUFA has shifted the n-6 to n-3 PUFA ratio to 50:1 instead of a recommended ratio of 10:1 or 2:1[Ref. 46,47].

Umesha and Naidu developed a blended vegetable oil and studied its modulatory effects on lipid metabolism[48]. For development of blended vegetable oil, different ratios of GCSO was blended with Sunflower, Rice bran and Sesame oil to obtain n-6/n-3 PUFA ratio of 2.3–2.6 for the assessment of its modulatory effect on lipid metabolism. Native and GCSO blended oils were fed to Wistar rats at 10 % level in the diet for 60 days. Serum and liver lipids showed significant decrease in Total cholesterol, Triglyceride, LDL-C levels in GCSO blended oil fed rats compared to native oil fed rats. ALA, eicosapentaenoic acid, docosahexaenoic acid contents were significantly increased while linoleic acid, arachidonic acid levels decreased in different tissues of GCSO blended oils fed rats. Blending of vegetable oils with GCSO increased ALA, decreased n-6 to n-3 PUFA ratio and beneficially modulated the lipid profile of rats.

Conclusion

The content of biologically active compounds, as well as the antioxidant capacity of *L. sativum* L. has been investigated by several researchers and their findings indicated that seeds of garden cress plants are good source of amino acids, minerals, fatty acids and have the ability to act as *in vivo* as well as *in vitro* antioxidants due to their high content of phenolic compounds. The functional health benefits of GCS may be exploited by incorporating it in several food formulations and health drink preparations. Therefore, garden cress seed as well as oil present a wide scope for further investigations for their potential preventive effects towards chronic diseases and also as interesting ingredients for new functional food formulations.

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