Chapter 14

The Potential of Garden Cress (*Lepidium sativum* L.) Seeds for Development of Functional Foods

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Additional information is available at the end of the chapter

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Abstract

Garden cress (*Lepidium sativum* L.) belonging to Cruciferae family is widely grown in India, Europe, and United States. It has been used as an important medicinal plant since the Vedic era. 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 (GCSs). The seed of garden cress was used in the fortification of different food items but due to the lack of their physicochemical properties and medicinal value, the exploration of the potential of garden cress seed was limited. In the present review, we discuss the proximate chemical composition, physicochemical, medicinal properties, and the food product development with garden cress seed. The functional properties of garden cress seed stimulate us to review its different valuable properties and the fortified products developed by incorporating garden cress seeds.

Keywords: garden cress seed, galactogogue, natural antioxidants, functional foods, fortification

1. Introduction

Garden cress (*Lepidium sativum* L.) is a fast growing annual herb that is native to Egypt and west of Asia, and presently it is cultivated in 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 (**Figure 1**). 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

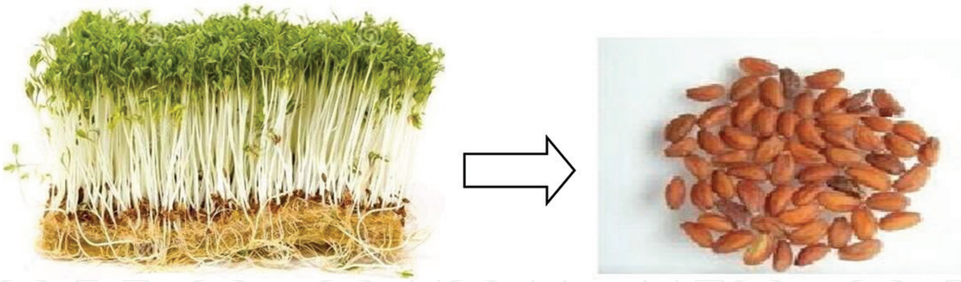

Figure 1. Garden cress plants and seeds.

can be sown and harvested several times throughout the year, the January, February, and November are the most suitable months of the year to sow in a Mediterranean climate [2]. Garden cress seed (GCS) possesses several of pharmacological properties like anti-anemic, antioxidant, galactogogues, 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 such as asthma, coughs with expectoration, diarrhea, 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 postnatal period and also recommended for the treatment of diarrhea 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 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 [4, 11]. GCSO contain high concentrations of γ-(1422 ppm) and α (356 ppm) tocopherols.

The 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].

2. 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 the 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 nonessential 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. Glutamic acid is an important excitatory neurotransmitter, and it plays a vital role in the metabolism of sugars and fats [17]. The body uses methionine to derive the brain food and 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 neurotransmitter and 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 1236.51 mg/100 g, while zinc and manganese contents are low. GCS is a good source of calcium, phosphorus, and magnesium. GCS has the 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 the development of a number of supplementary food products.

Fatty acid composition (**Table 1**) reveals 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 the 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

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
Nonessential 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

Amino acid profile (g/100 g protein)	
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. [4] and Zia-Ul-Haq et al. [14].

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

higher contents of unsaturated fatty acids; especially, it is rich in omega-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.

3. Physicochemical properties of garden cress seed oil

Physicochemical parameters provide important information regarding storage, stability, and quality of the product. The physicochemical properties of garden cress seed oil (GCSO) extracted by the different methods are presented in **Table 2** [21]. Extracted oil by solvent extracted, supercritical CO_2, and cold expression were 21.54, 18.15, and 12.60%, respectively. The Soxhlet method yields the maximum oil content (21.54%). Oil yield of GCS is low when compared to the other oil seeds of Cruciferae family like mustard (25–40%), rapeseed (40–45%),

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]The direct pycnometer determination at 33°C.

[3]Viscosity determined at 25°C MPa s^{-1}. Data compiled from: Diwakar et al. [21].

Table 2. Physicochemical properties of garden cress seeds extracted by various extraction methods.

and camelina or false flax (40–45%) [22]. The pungency of GCSO and mustard oil are similar, while the content is lower. The physicochemical properties of GCSO as summarized in **Table 2** establish the potential of garden cress for the development of novel products with several functional properties.

3.1. Physical properties of garden cress seed oil

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

3.1.1. Color

Color of any oil determines the attraction of consumer and acceptability of the product. Garden cress oil color is dirty yellow due to the presence of chlorophyll and carotenoids pigments, which are unintentionally co-extracted during the oil extraction [23].

3.1.2. Viscosity

Viscosity of the GCSO ranges from 53.8 to 64.3 (**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* extract. It decides the flow behavior of the products and is considered much during the formulation of any liquid or semisolid products.

3.1.3. Refractive index

High refractive index value (1.47 ± 0.03) is the indication of substantial unsaturation and the 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.

3.1.4. 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].

3.2. 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.

3.2.1. 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**). The FFA content of supercritical CO_2 extracted GCSO is higher than the oil extracted by cold pressed and Soxhlet extraction. The acid value of oils depends upon the oil extraction methods apply. Lower the FFA, higher the stability of oil at room temperature (25 ± 2°C). The content of FFA of GCSO (**Table 2**) is in limit with the specifications of vegetable oils (1–7% of oleic acid). The high PV in Soxhlet extracted oil could be due to the exposure of the oil to high temperature (60–80°C) during extraction. The low PV of cold-pressed GCSO indicates that it is less prone to oxidative rancidity at room temperature.

3.2.2. Iodine value

The unsaturation of an oil or fat is measured by the iodine value (IV). IV depends on the unsaturated fatty acids present in the oil or fat. The IV of oil extracted by cold-pressed and supercritical fluid extracted of GCSO was relatively lower than solvent extracted (**Table 2**). The IV of the oil is affected due to the presence of many long chain unsaturated components like olefins, including carotenoids and squalenes [26]. The solvent-extracted oil contained a significantly higher amount of total carotenoids than the cold-pressed oil. Thus, the higher carotenoid content might be responsible for a high IV in solvent-extracted GCSO.

3.2.3. Saponification value

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

3.2.4. Unsaponifiable matter

Unsaponifiable matter (USM) shows the pigments, chlorophyll, and other heterocyclic compounds present in the oil. The USM content in GCSO extracted by different method varied from 1.16 to 1.65 g/100 g (**Table 2**). The USM content was higher in GCSO than in 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) oil [28]. The presence of lignan (29.4%), crude fiber (16.5%), protein (24.3%), and minerals (5.4%) in GC seeds the USM contents was high [29].

3.3. Functional properties and other health benefits of garden cress seeds

3.3.1. As antioxidants: free radical scavenging activity

The antioxidant properties depend on the phenolic compounds present 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.

3.3.2. 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 promote 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].

3.3.3. As gastrointestinal tract cleansing agent

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

3.3.4. As haematic agent

The GCS is the rich source of iron, which is easily absorbed in intestine and helps to increase the hemoglobin level in blood. The bioavailability of iron content in GCS beneficial for anemia

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when taken daily. Vitamin C taking half an hour after consumption of these seeds enhances the 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].

3.4. Other health benefits

Garden cress seeds are considered as a memory booster due to the presence of arachidic and linoleic acids. They help to increase 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 helps in strengthening of hair. The leaves are mildly stimulant and diuretic, useful in scorbutic (related to or resembling scurvy) diseases, and liver complaints. 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 nonessential amino acids. The well-documented antioxidant and phytochemical properties of this amazing plant make it a chemopreventive agent. The functional properties contained by 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.

3.5. Side effects of garden cress seed

It is an abortifacient (substance that induces abortion), if had in excess. Pregnant women should avoid taking garden cress in any form because it has the ability to induce uterine contractions and thereby trigger spontaneous abortion. It contains goitrogens that prevent iodine absorption in thyroids and hence can lead to hypothyroidism. Hence, it may not be suitable for patients suffering from hypothyroidism. If large quantities of garden cress are consumed, may cause digestive difficulties in some people. The oil extracted from GCS is edible and is used as a cooking medium; however, some people may experience symptoms of indigestion due to its use. To overcome these problems, people should discontinue using this oil or mix it with some other edible oil, so as to dilute it and reduce its adverse effects.

3.6. Fortification by garden cress for the development of new food products

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

3.6.1. Development of garden cress fortified dahiwala bread

Food product dahiwala bread was developed by Agarwal and Sharma using processed garden cress seeds [37]. 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 was reduced 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 hypoglycemic, hypotensive, fracture healing, anticancerous, etc. [37]. The developed food product will benefit all age group individuals for nourishment and those at risk or suffering from anemia, fractures, diabetes mellitus, and the other chronic degenerative diseases to pursue prevention and management of these diseases.

3.6.2. 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. Microencapsulation of GCSO was difficult in spray drying method for preparation of whey protein concentrate with oil/protein ratio of 0.4. 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 microns. Omega-3 fatty acid–rich biscuits were prepared by adding MGCSO at 20 g/100 g or GCO at 5.0 g/100 g by replacing flour and fat or fat in biscuit formula [38]. In MGCSO- and GCSO-supplemented biscuits, the ALA content was found to be 1.02 g and 1.05 g/100 g, respectively. Metalized PET film (MPET) pouches are used for packaging and stored at three different storage conditions, viz., 90% RH/38°C for 3 months, 30–40% RH/38–40°C for 4 months, and 65%RH/27°C for 5 months. Prepared biscuits stored at 30–40% RH/38–40°C had 1 month shelf-life, whereas at 90% RH/38°C and 65% RH/27°C, they lasted after 4 and 5 months, respectively. The oxidation rate of ALA was high in GCSO-supplemented biscuits compared to MGCSO biscuits resulting the effect of GCO which prevent the oxidation of ALA. MGCSO-supplemented biscuit were acceptable by testing the sensory evaluation results of the panel.

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

Sahraiyan et al. have evaluated the effect of hydrocolloid of GCS and guar gum in improving dough rheology and quality parameters in composite rice-wheat bread [39]. It was reported that the rheological properties of GCS and guar gum seeds improved the quality of rice-wheat bread [40]. Four different composition (0, 0.3, 0.6, and 1%) of w/w Guar (G) and GCS (L) hydrocolloids were added to the flour. The levels of different combination were tested in order to obtain the following samples (the sub Index indicates the gum level): G0 L0, G0 L0.3, G0 L0.6, G0 L1, G0.3 L0, G0.3 L0.3, G0.3 L0.6, G0.3 L1, G0.6 L0, G0.6 L0.3, G0.6 L0.6, G0.6 L1, G1 L0, G1 L0.3, G1 L0.6, and G1 L1. The results of this research revealed that the effects of guar, GCS, and guar-*L. sativum* seed gum in order to substitute gluten in composite rice-wheat flour recipes. The properties of water absorption, dough development time, dough stability, and viscosity were increased by GCS. GCS gum highly affected the mixing tolerance index and gelatinization temperature as guar gum while these parameters decreased by addition of both hydrocolloids. The extensibility value dough increased with increasing hydrocolloid concentrations from 0.3 to 0.6%, and then decreased at the level of 1%. Crumb firmness decreased with increasing hydrocolloid 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 the preparation of several functional food preparations that overcome the milk secretion–related problems and anemic condition in women.

3.6.4. Development of iron-rich biscuits

Iron-rich biscuit was prepared by combining garden cress and rice flakes to prevent the anemia in adolescent girls from urban, rural, and tribal areas of Marathwada region of Maharashtra state [41]. The sensory properties of iron-rich biscuits were tested by sensory panel members. The high score sample were tested for proximate composition. The hemoglobin value of selected adolescent girls was found in the range of 8.7–10.96 mg/100 g. By comparing these values, they found the least value of hemoglobin 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 score ranged from 1.80 to 4.20. The mean values of different sensory characters reported that color scored maximum followed by taste and texture. Low scores were noted for flavor and overall appearance.

3.6.5. 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%),

Particulars	Nutrient content	
	Iron-rich biscuit [40]	Milk-based health drink [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 gm)	17.63	127.20
Phosphorus (mg/100 gm)	15.48	106.20
Iron (mg/100 gm)	12.00	2.90
Carbohydrate (%)	–	10.30
Energy (kcal/100 gm)	–	65.63

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

it can be used as health drink with milk as its base. By keeping this thing in mind, a health drink was developed with processed garden cress seeds that contain 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 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 provides the entire essential factor that is needed by these people [42]. This type of finding help to develop many types of functional and fortified food products. The chemical composition of milk-based health drink prepared by Mohite et al. is presented in **Table 3** [13]. This type of drink helps to prevent nutrient deficiency and promotes lean muscle developments in persons doing regular exercise. Therefore, it is essential that the food prepared in such a way to meets the requirement of modern consumers. At the same time, it should appeal to the senses of the consumers by having pleasant organoleptic qualities.

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

Earlier finding of researcher concludes that the intake of high n-6 PUFAs in diet has change the physiological conditions like prothrombotic and proaggregatory, characterized by increase in blood viscosity, vasospasm, and vasoconstriction and decrease in bleeding time [40]. Atopic dermatitis, rheumatoid arthritis, asthma, ulcerative colitis, and cancer were caused by the deficiency of n-3 PUFA. However, sufficient intake of n-3 PUFAs alters membrane fluidity, downregulates inflammatory genes and lipid synthesis, and stimulates fatty acid degradation [43]. Humans cannot synthesize PUFAs like n-3 and n-6, which are essential fatty acids; therefore, they need to be supplemented through food. The eating of vegetable oils in diet (sunflower, corn oil, safflower oil, 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 [44, 45].

Umesha and Naidu developed a blended vegetable oil and studied its modulatory effects on lipid metabolism [46]. For the development of blended vegetable oil, different ratios of GCSO were blended with sunflower oil (SFO), rice bran oil (RBO), and sesame oil (SESO) to obtain n-6/n-3 PUFA ratio of 2.3–2.6 for the assessment of its modulatory effect on lipid metabolism. Wistar rats fed to Native and GCSO blended oils at 10% level in the diet for 60 days. Serum and liver lipids showed significant decrease in total cholesterol (TC), triglyceride (TG), and LDL-C levels in GCSO blended oil fed rats compared to native oil fed rats. In the GCSO blended oils fed rats, the ALA, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) contents were significantly increased, whereas linoleic acid (LA) and arachidonic acid (AA) levels decreased. The lipid profile of rats effectively modulated with blending of vegetable oils with GCSO by increasing the ALA and decreasing n-6 to n-3 PUFA ratio.

4. Conclusion

The content of biologically active compounds, as well as the antioxidant capacity of *L. sativum* 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 plant, seed as well as oil present us with wide scope for further investigations for their potential preventive effects toward chronic diseases and also as interesting ingredients for new functional food formulations.

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