International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 2831-2835

Received: 04-05-2020
Accepted: 06-06-2020

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Effect of processing treatments on nutritional profile of garden cress (*Lepidium sativum* L.) seeds

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DOI: https://doi.org/10.22271/chemi.2020.v8.i4ah.10074

Abstract
Garden cress (*Lepidium sativum* L.) is a small perennial edible plant that belongs to family Brassicaceae and possesses nutritional as well as therapeutic properties. The bitterness and astringency of garden cress greatly reduces its acceptability to be incorporated in food products. So, to reduce the bitterness and thereby enhancing the acceptance, three treatments i.e. popping, roasting and germination were given to the seeds. The effect of these treatments on the nutritional composition of garden cress seeds was evaluated. Processing treatments significantly increased the protein and crude fibre content in the seeds with germinated treatment indicating a significant per cent increase of 17.68 and 54.50 respectively. Significant effect of different processing treatments on iron, calcium and phosphorous content of garden cress seeds was recorded. Process of germination and popping influenced a significant per cent increase of 8.90 and 22.99 on iron values respectively.

Keywords: Garden cress, treatments, proximate composition, mineral profile

Introduction
Garden cress is a fast-growing, perennial edible plant, botanically related to mustard and water cress. It is cool season herb that is native to Egypt and West Asia but is widely cultivated in hot temperate climates throughout the world for various culinary and medicinal uses (Malleshi, 2004) [21]. It is grown in all parts of India and often used, most typically as a garnish or as a leaf vegetable due to its peppery, tangy flavour and aroma in the Indian cuisine (Divanji *et al*. 2012) [7]. Garden cress belongs to Family: Brassicaceae, Genus: Lepidium. Species: Sativum, Kingdom: Plantae, Division: Magnoliophyta, Class: Magnoliopsida and Order: Brassicales. Garden cress is commonly referred as common cress, garden pepper grass, pepper cress or pepperwort in English, *chansur* in Hindi and *chandshura* in Sanskrit (Prajapati and Dave, 2018) [14]. In native languages, it is pronounced as *haloyen* (Pahari), *holan* (Punjabi), and *haliv* (Marathi).

Garden cress seeds are small, smooth, oval-shaped, pointed and triangular at one end, about 3-4 mm long, 1-2 mm wide and reddish brown in color. Seed coat covers 12–17% and the innermost structure embryo is surrounded by the endosperm. Endosperm is composed of thick walled polygonal cells and accounts for 80–85% of the seeds (Mathews *et al*. 1993) [13]. While the seed coat is of brick red to cream coloured, the endosperm has yellow colour.

Garden cress seeds are categorized under oilseeds and are enriched with macro and micronutrients. The seeds are high in calories (454 kcal) having 25 gm protein, 24 gm fat, 3 gm dietary fiber and 33gm of carbohydrates per 100gm and also has significant amount of minerals viz. 377 mg of calcium, 723 mg of phosphorous and 430 mg magnesium and sufficient amount of vitamins, mainly thiamine (0.59 mg), riboflavin (0.61 mg) and niacin (14.3 mg) per 100g seeds (Chaudhary *et al*. 2017) [17]. It is the highest iron containing plant source ever known with better bioavailability (Chand *et al*, 2010). 100 mg/100g of iron is present in garden cress seeds that makes it an excellent source of this important micro mineral and is therefore also known as *raktabija* in Sanskrit.

Protein of seed is of good quality, containing essential amino acids, including lysine and phenylalanine. The major fatty acids are oleic (30.6%), linolenic acid (30.2%), with low amount of erucic acid (3.9%). Garden cress oil has balanced amount of polyunsaturated fatty acid (46.8%) and monounsaturated fatty acid in (37.6%) and also contain natural antioxidants

viz., tocopherols and carotenoids which protect the oil from rancidity (Diwakar *et al*., 2010) [4]. Major fatty acids found in garden cress seeds are oleic acid (30.6%), linolenic acid (29.3%) and minor fatty acids are palmitic acid (9.4%), linoleic acid (7.6%), erucic acid (3.0%), stearic acid (2.8%), and arachidic acid (2.3%) and hence because of the presence of essential fatty acids, it acts as memory booster (Sharma and Agarwal, 2011) [1].

Nowadays, garden cress is more popular in consumers and producers because of its peppery taste and presence of health promoting substances such as glucosinolates and sterols (Tuncay *et al*. 2011) [22]. Presence of high carbohydrates, macro and micro elements and antioxidant properties enhances its utilization to be used as food supplement in human diet. Its high nutritive value, therapeutic properties and low price makes it possible for people of all sections of the society to include them in their diets and enhance the nutritive quality of their meals. Garden cress seeds have great potential both as foodstuff and as nutraceutical. Despite this, it has not received due attention and has remained an under-utilized crop altogether, cultivated and utilized, to a lesser extent in Himachal Pradesh. The slight bitterness and astringency of garden cress greatly reduces its acceptability to be incorporated in food products. With this backdrop, cress seeds were given different processing treatments and the effect of these treatments was assessed on proximate and mineral composition of seeds.

Methods and Materials

Garden cress seeds used for analysis were procured from the local market which were cleaned manually for removing adhering dirt, dust and foreign particles along with shrunken and broken seeds. To reduce the peppery and tangy taste of garden cress seeds and enhancing its palatability and acceptability attributes, three treatments viz. popping, roasting and germination were given to selected samples.

1. Processing of garden cress seeds

a. Roasting

The seeds were roasted in a preheated iron skillet at a temperature of 128 °C for 2.5minutes leading to loss of raw flavour and production of a prominent aroma. Roasted seeds were taken out from the skillet and spread on a tray for rapid cooling.

b. Popping

Garden cress seeds were conditioned by soaking overnight in water (0.5mg water/g of seeds) in a covered container to gain optimum moisture content. Popping was carried out by dropping the soaked seeds in preheated sand taken in a skillet at 180 °C and stirring them continuously with the help of wooden spatula until the seeds were properly popped. The average time calculated was 1.15minutes the popped seeds were quickly separated from the sand using metallic strainer and cooled to room temperature.

c. Germination

Garden cress seeds were spread on a damp muslin cloth and were kept at room temperature (32°- 35 °C). Regular sprinkling of water was carried out to keep the seeds moist. Seeds took 48 hrs for germination (about 1 – 1.5 cm long). Germinated seeds were then dried in tray drier at 55 °C for 12 hrs.

After giving the above treatments, the processed seeds as well as raw garden cress seeds were ground into a fine powder with the help of stainless steel grinder and stored in airtight containers at room temperature for further analysis.

2. Proximate composition

The effect of the above processing treatments on proximate composition was analysed. The proximate analysis of raw as well as processed cress seeds for moisture, crude protein, crude fat, crude fibre and total ash was carried out in triplicate according to the standard methods of Association of Official Analytical Chemists (AOAC, 2010) [3]. Nitrogen was determined by the micro Kjeldahl method and was multiplied by the factor of 6.25 for converting it in to crude protein. Total carbohydrates content was determined by difference method.

3. Mineral composition

The organic matter present in the sample was wet digested with diacid mixture. The digested samples for minerals were analysed for determination of calcium and iron using atomic absorption spectrophotometer (Model: Perkin–Elmer 3100) while phosphorous was measured spectrophotometrically (Singh *et al*. 2005) [20].

All the analysis work was carried out in triplicate so as to reduce the experimental error and subjected to statistical analysis for one way analysis of variance (ANOVA) in a completely randomized design at 5 per cent level of probability using statistical software (Sheoran *et al*. 1998) [19]. The values obtained have been reported as mean and standard deviation. Per cent deviation i.e. the effect of treatment on the parameter was also assessed and reported in the selected tables.

Results and Discussion

Proximate characteristics

Proximate composition provides an estimation of nutrients and forms the basis for food analysis. It includes moisture, ash, crude protein, crude fat, crude fibre and total carbohydrates content. These food components are important in the food industry for product development, quality control or regulatory purposes. Homogeneous and representative samples of the treatments along with the raw garden cress seeds were analyzed for proximate composition and the results have been reported on dry weight basis

Moisture

Moisture content influences the weight, appearance, taste, texture and shelf life of foodstuff and has a great bearing on composition of other nutrients. The per cent moisture content of raw whole seeds was calculated as 5.46 which decreased with the different processing treatments given and is clear from the per cent deviation calculated for the different treatments in comparison with the unprocessed seeds as shown in Table 1. Among the treated seeds, minimum moisture content of garden cress seeds, roasted at a temperature of 128 °C for 2.5 minutes, dropped to 1.54%, recording a fall of 71.79%. Hassan and Rahman (2019) [12] studied the influence of dry roasting process on nutritional properties of garden cress seeds flour and found that the moisture content of raw garden cress whole flour was 8.47%, which fell significantly (P<0.05) to 3.51%, 1.85%, 1.40% after roasting for 5, 10 and 15 min. respectively. Garden cress seeds were soaked overnight in water to gain optimum moisture content before popping. The bran of cress seeds has high water holding capacity and therefore forms and gets coated by transparent mucilage when soaked in water. Hence,

the popped seeds recorded a moisture content of 3.48%. Higher moisture content (4.54%) in germinated seeds among processed variants may be attributed to production of mucilage during soaking and sprinkling process and its retention later on after drying. All the treatments differed significantly when statistically compared at 5 per cent probability level. A high significant difference was calculated between raw and roasted garden cress seeds. Agarwal and Sharma (2013) [16] studied garden cress seeds and quantitatively analyzed whole, husk removed, husk, roasted and microwave processed forms for proximate principles. Their results reported that moisture content was highest in husked garden cress seeds powder i.e. 6.01 per cent, protein and fat content was highest in dehusked garden cress seeds powder i.e. 27.61 per cent and 25 per cent respectively. Ash (6.50%) and total carbohydrates (38.11%) were found highest in micro waved processed garden cress seeds powder while fibre was found to be highest (15.11%) in roasted garden cress seeds powder.

Ash

The ash content is a measure of the total amount of minerals present within a food. As clear from the Table 1, the effect of processing had a little influence on ash content except the popped seeds which recorded a higher value of 5.53% among the treatments. This value on ascending side may be due to the process methodology in which the seeds were popped in preheated sand which may have contributed to this increase. Hence, a significant difference was calculated when popped treatment was compared with the other three treatments. The ash content of raw, roasted and germinated garden cress seed powder was at par with values of 4.93, 4.90 and 4.93 per cent respectively.

Crude protein

Raw, unprocessed garden cress seeds contained 21.38% crude protein content. Processing treatments significantly increased the protein content in the seeds recording values of 24.08%, 24.76% and 25.16% in popped, roasted and germinated treatments thereby indicating a significant per cent increase of 12.62, 15.80, and 17.68 respectively. Germination is a biochemical process which involves transition of a seed from dormant state to vital active state. Many research studies have reported an increase in protein content in germinated seeds/legumes (Mugendi *et al*. 2010, James and Jayasena, 2012, Joshi and Verma, 2016) [15, 18, 10] which was reflected in the present study also. The increase in protein in germinated seeds may be due to synthesis of some amino acids during germination. Mathew *et al* (1993) [13] reported 24.3% protein content in garden cress seeds whereas Doke and Guha (2014) analysed 22.47% protein content in cress seeds.

Crude fat

Crude fat content analyzed by soxhlet method revealed per cent values of 22.80, 24.56, 25.00 and 25.57 in roasted, germinated, popped and raw cress seeds respectively. When statistically compared, significant difference was calculated between raw garden cress in comparison to roasted and germinated seeds and it was at par with popped seeds. A significant decrease (p<0.05) of 10.83% was observed for roasted cress powder and of 3.9% and 2.22% for germinated and popped variants respectively.

Crude fibre

Significant variations in crude fibre content were visible when processing treatments were given to garden cress seeds. Raw, unprocessed seeds had crude fibre content of 8.33% that increased subsequently in roasted (9.91%), popped (11.80%) and germinated (12.87%) leading to a per cent increment of 18.96, 41.65 and 54.50 respectively. As discussed earlier, the bran of the cress seeds has high water holding capacity and high dietary fibre (Sharma and Agarwal, 2011) [1]. When the seeds are soaked in water, they absorb the water rapidly, the mucilage on the seed coat swells and encloses the whole seed with a transparent, colourless covering. The mucilage consists of a mixture of cellulose and uronic acid containing polysaccharides. So, overnight soaking of seeds before popping increased the crude fibre content. Further, soaking and sprinkling of seeds and their subsequent germination also elevated their crude fibre content to a highest level among the treatments.

Total carbohydrates

Total carbohydrates content was worked out by difference method and was calculated as 27.92, 30.10, 34.13 and 36.07 percent respectively in germinated, popped, raw and roasted samples. Significant influence of the process treatments was visible on all the analysed proximate parameters when compared statistically at 5 per cent probability level.

Mineral composition

Knowledge of concentration and type of specific minerals present in food products is often important in the food industry viz. for nutritional labelling, quality aspects, microbiological stability and for processing purposes. Unprocessed and processed garden cress seeds were analysed for their mineral composition viz. phosphorous, calcium and iron and the results calculated on dry weight basis have been reported in Table 2 and presented in Figure 1.

Phosphorous content of garden cress seeds was analysed by spectrophotometric method in values of ascending order of 511.321, 567.367, 609.534 and 611.386 mg/100 g in popped, roasted, raw and germinated cress seeds respectively. As per analysis of variance, significant statistical relationship was derived for the evaluated treatments.

Significant effect of different processing treatments on calcium content of garden cress seeds was recorded. Raw, unprocessed seeds had calcium content of 267.880 mg/100 g that decreased subsequently in popped, roasted and germinated to values of 260.630, 250.250 and 240.320 mg/100 g, respectively. Amare *et al*. (2016) [2] also evaluated a significant decrease (p<0.05) in calcium content (8%) in *Amaranthus caudatus* grains when they were popped in hot clay pan for 10–15 seconds. The result data showed by Kasabe *et al*. (2012) [11] suggested that prolonged soaking decreased the Ca^{2+}concentration in the garden cress samples. This may be the reason of reduced calcium level in germinated seeds in present study. The decrease in calcium content in germinated seeds may be due to mobility of calcium to growing axis and leaching of calcium from the testa (Ferguson and Bollard 1976) [9].

For iron content, significant difference was calculated when different treatments were compared with each other. As clear from the table, popped seeds recorded higher iron content of 128.453mg/100 g among the treatments with per cent increment of 22.99. As discussed earlier, this value on ascending side may be due to the process methodology in which the seeds were popped in preheated sand which may have contributed to this increase. Roasted garden cress seeds recorded a decrease in this micro mineral that reduced to value of 89.227 from 98.920 mg analysed for untreated seeds.

Hassan and Rahman (2019) [12] also evaluated an inverse proportional decrease in iron content with time of roasting treatment. Germinated seeds had 107.733 mg of iron content in 100 g of seeds.

Garden cress seeds were found to be a rich source of iron (100mg/100g) along with being a good source of calcium(377mg/100g) and phosphorous (723 mg/100g) and thus can be used in as a viable supplement, as medicinal formulations and inhuman food as a ready source of dietary minerals to fight various diseases (Agarwal and Sharma, 2011) [1]. Agarwal and Sharma (2013) [16] quantitatively analyzed whole, husk removed, husk, roasted and microwave processed garden cress seeds for mineral composition. Their results reported that phosphorous was highest in husked removed powder (675.33±6.11 mg) while calcium content was highest in whole garden cress seeds powder (347.50 ±2.17 mg). Roasted garden cress seeds powder had 127.1±2.53 mg of iron. Chaudhary (2017) [17] analyzed mineral composition of whole and treated (soaked, dried and roasted) garden cress seeds. Results showed that phosphorous (613.17 mg) and calcium (391.27 mg) content were high in whole garden cress seeds while iron content was high in treated garden cress seeds (138 ±37 mg). Mineral composition of garden cress seeds reported by Reeta *et al.* (2015) [6] indicated presence of appreciable amount of phosphorous 608.63 mg/100g and calcium 266.35 mg/100g.

Table 1: Proximate composition of unprocessed and processed garden cress seeds (% DW basis)

Parameters	Treatments				Mean	C.D *(p≤0.05)*
	Raw	Roasted	Popped	Germinated		
Moisture	5.46±0.03	1.54±0.037 (-71.79)	3.48±0.042 (-36.26)	4.54± 0.072 (-16.84)	3.75± 0.04	0.161
Ash	4.93±0.05	4.90±0.05 (-0.60)	5.53±0.03 (+12.17)	4.93±0.03 (0)	5.07±0.04	0.135
Crude protein	21.38±0.04	24.76±0.02 (+15.80)	24.08±0.01 (+12.62)	25.16±0.01 (+17.68)	23.84±0.02	0.084
Crude fat	25.57±0.18	22.80±0.28 (-10.83)	25.00±0.20 (-2.22)	24.56±0.04 (-3.94)	24.48±0.19	0.656
Crude fibre	8.33±0.05	9.91±0.01 (+18.96)	11.80±0.39 (+41.65)	12.87±0.12 (+54.50)	10.72±0.21	0.700
Total carbohydrates	34.13±0.00	36.07±0.00 (+5.68)	30.11±0.00 (-11.77)	27.92±0.00 (-18.19)	32.05±0.00	0.022

Data are expressed as the mean ± standard deviation. Data in parenthesis shows per cent deviation

Table 2: Mineral composition of unprocessed and processed garden cress seeds (mg/100 g, DW basis)

Minerals	Treatments				Mean	C.D *(p≤0.05)*
	Raw	Roasted	Popped	Germinated		
Phosphorous	609.534±0.273	567.367±0.280 (-6.91)	511.321±0.305 (-16.11)	611.386±0.241 (+0.30)	574.927±0.278	0.922
Calcium	267.880±0.320	250.250±0.006 (-6.58)	260.630±0.006 (-2.70)	240.320±0.008 (-10.28)	254±0.161	0.534
Iron	98.920±0.193	89.227±0.263 (-9.79)	128.453±0.109 (+22.99)	107.733±0.607 (+8.90)	114.083±0.348	1.153

Data are expressed as the mean ± standard deviation. Data in parenthesis shows per cent deviation

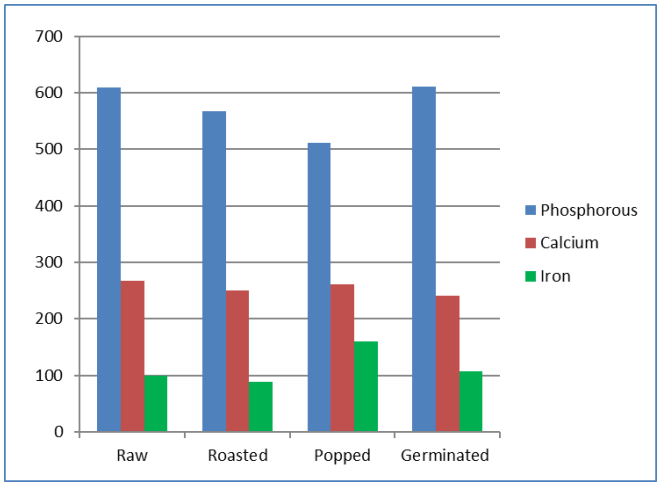

Fig 1: Mineral composition of unprocessed and processed garden cress seeds

Conclusion

Processed garden cress seeds were analyzed for its nutritional composition in order to attain the best processed form of seeds for better utilization. From the present study it can be concluded that processing treatments can substantially improve the proximate and mineral profile of garden cress seeds. Popped garden cress seeds had high amount of total ash and iron content. Germinated treatment was analysed for higher crude protein (25.16%) and crude fibre (12.87%). This treatment also had higher phosphorous content of 611.386 mg/100 g.

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