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Effect of processing on selected nutrient profile of garden cress seeds and development of garden cress seed based muffin

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Abstract
Lepidium sativum L. commonly known as Garden cress is a member of the Brassicaceae family. It has been considered as an important nutritional and medicinal plant in India since the Vedic era. In this study, the Cress seeds were subjected to different processing methods- roasting and germination and their impact on nutrient profile were analysed. A common bakery product- Muffin was developed with incorporation of roasted and germinated garden cress seed flour at 5%, 10% and 15% levels. The organoleptic attributes of GC incorporated Muffin prepared was evaluated. The sensory scores revealed that 5% incorporation of Garden Cress seed powder was more acceptable in the product irrespective of the pre-treatments. The pre-treatments not only improved the nutrient profile, but also had well acceptable sensory attributes.

Keywords: garden cress, roasting, germination, nutrient profile, functional ingredient

1. Introduction
One of the underexplored and underutilized crops that our nature has gifted us is garden cress. It is an annual, herbaceous edible plant, native to Egypt and South west Asia and was referred to over many centuries ago in Western Europe. It is cultivated in India, as culinary vegetable. The seeds, leaves and roots of garden cress have economic value but its crop is mainly cultivated for its seeds (Agarwal and Sharma (2013) [1] Garden cress is commonly known as "Chandrashoor" in various Ayurvedic text of medieval India. The most reputed formulations which are commercially available are "*Chaturbuja*" which claims to possess a number of therapeutic properties including anti-inflammatory activities (Shail *et al*, 2016). [2] The *Lepidium sativum* was used as antidiabetic (Eddouks *et al*, 2008) [3], anti-asthmatic, diuretic, hypotensive (Maghrani *et al*, 2005) [4], anticarcinogenic (Kassie *et al*, 2002) [5], and antibacterial (Aburjai *et al*, 2001) [6] agent. The paste of Garden cress seeds is applied in rheumatic joints to relieve the pain and swelling (Gupta *et al*, 2010) [7]. Ethanolic extracts of Garden cress seed were effective in treating inflammatory bowel disease. Traditional sweets for lactating mothers are prepared from the Garden cress seeds (Mandal *et al*, 2008) [8].

It is rich in proteins, vitamins, minerals, especially calcium and iron. GC seeds contain 24 % fat in which 34.5 % of total fatty acids is α-linolenic acid (ALA, 18:3) Gill and Macleod, 1980 [9]; Maier *et al*, 1998 [10]. The phenolic compounds, alkaloids, flavonoids, glycosides, glucosinolates, sterols, tannins, and triterpene are important phytochemical constituents, which impart pharmacological characteristics to garden cress seed (Ghante *et al*, 2011) [11].

The current study was undertaken to study the impact of processing - dry roasting and germination on selected nutrient profile of Garden Cress seeds and to optimize the use of garden cress seeds in the preparation of muffin to tap its nutraceutical and health benefits.

2. Methodology
2.1 Procurement of ingredients
Garden cress seeds used in the present study were procured from local super market. After cleaning, the seeds were subjected to different processing methods such as roasting and germination and were used for further research.

2.2 Processing of Garden Cress Seeds
2.2.1 Untreated garden cress seed powder
Garden cress seeds were sun dried and hand sorted to remove impurities and foreign particles. Then, they were ground in a mixer and stored in an airtight container

2.2.2 Roasted garden cress seed powder
Garden cress seed were roasted in a griddle and ground in a mixer. Then, this powder is stored in an air sealed container.

2.2.3 Germinated garden cress seed powder
Garden cress seeds were sorted and cleaned to remove impurities. The seeds were spread on damp muslin cloth and were kept at room temperature (32-35 ºc) for 48 hours till seeds get germinated. These fresh germinated seeds were then sun dried and ground in a mixer. Then, this powder is stored in an air sealed container.

2.3 Experimental Analysis
The following tests were carried out for the plain, roasted and germinated garden cress flours: Moisture, Ash, Crude Fibre, Protein, Fat, Vitamin C, Iron, Calcium, Phosphorus **(**AOAC, 2000), [12] Total carbohydrates (FAO, 2003), [13] Total Calorie (James, 1995), [14] Total Tannins (Polshettiwar, 2007) [15] and

Total phenols (Singleton and Slinkard, 1977) [16]

2.4 Formulation of Muffin: Baked product Muffin was formulated with incorporation of Garden Cress seed flour (Untreated, Roasted & Germinated) at 5%, 10% and 15% levels.

Table 1: Composition of Muffin Mix with GC Seed flour incorporation

Ingredients	Quantity (per 200g)
All-purpose flour	150g
Sugar	83g
Baking powder	9g
Salt	0.5g
Nutmeg powder	0.25g
Cinnamon powder	0.50g
Milk (To be added while preparation)	80-100 ml
Egg (To be added while preparation)	1
Processed Garden Cress seed powder (Untreated, Roasted and Germinated) are incorporated at 5%, 10% and 15% levels.	

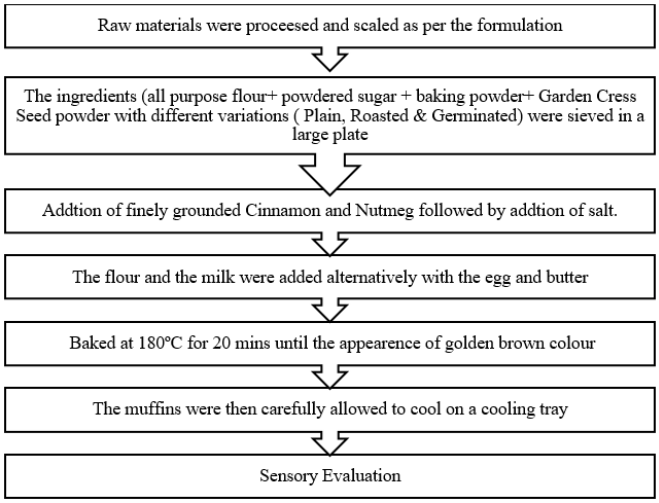

Fig 1: Preparation process of Instant Muffin Mix

2.5 Sensory analysis

Sensory evaluation was carried out for all the variations of the muffin prepared on a 9 - point hedonic scale rated by 15 semi-trained panellists. Each panellist was given a sensory evaluation sheet and the muffin prepared was evaluated for parameters such as colour, flavour, sponginess, taste, mouth feel, after taste and overall acceptability (Peryam and Pilgrim, 1957) [17].

2.6 Processing and analysis of data

All the experimental analysis was carried out in triplicates. Data were reported as mean and standard deviation. Paired t test was carried out to compare the significant difference between the plain flour and the germinated flour and also between plain flour and dry roasted. One way ANOVA was carried out to validate if there was any significant difference in the sensory attributes of muffins prepared. Data analysis was done using SPSS version 20.0.

3. Results & discussion

Moisture Content

The low moisture content is an index of stability, quality and increased shelf life of seeds. Marangoni *et al*, (1988) [18] The moisture content of untreated, roasted and germinated GC seed powders are 5.25±0.17%, 3.53±0.41% and 4.89±0.07% respectively. In a study by Agarwal and Sharma, (2013) [1], the moisture content of garden cress seed was found to be 5.83±0.28g/100g.There was a 32.76% and 6.85% decrease in moisture content on dry roasting and germination respectively.

Table 2: Proximate composition of processed garden cress seed powder

Sample/ Parameters	Untreated Garden Cress	Roasted Garden Cress	Germinated Garden Cress
Moisture (%)	5.27±1.0	3.77±1.0 ^{NS} (-28.46)^{1}	4.49±0.63 ^{NS} (-14.80)^{1} (+19.09)^{2}
Total Ash (%)	5.03±0.5	4.99±0.39 ^{NS} (-0.79)^{1}	4.80±0.37 ^{NS} (-4.52)^{1} (-3.80)^{2}

Total Fat (%)	20.92±0.60	16.31±0.41* (-22.03)[1]	5.57±0.43** (-73.37)[1] (-65.84)[2]
Total Fibre content (g/100g)	2.16±0.25	2.06±0.78NS (-4.62)[1]	3.00±0.02** (+38.88)[1] (+45.63)[2]
Protein (g/100g)	22.21±0.54	25.00±0.69* (+12.56)[1]	25.42±0.53** (+14.45)[1] (+1.68)[2]
Total Carbohydrate (g/100g)	50.15±0.20	53.25±0.56* (+6.18)[1]	60.47±0.49** (+20.57)[1] (+13.55)[2]
Vitamin C (mg/100g)	57.35±0.42	77.22±0.36* (+34.64)[1]	137.05±0.31** (+138.97)[1] (+77.47)[2]
Iron (mg/100g)	16.37±0.40	21.41±0.30* (+30.78)[1]	33.55±0.31** (+56.70)[1] (+104.94)[2]

[1] depicts the percent increase or decrease between Untreated and Roasted Garden cress powder and between Untreated and Germinated garden cress powder.
[2] depicts the percent increase or decrease between Roasted and germinated Garden Cress powder
* Significant difference ($p<0.05$) on comparing Untreated and dry roasted Garden cress seed flour
** Significant difference ($p<0.05$) on comparing Untreated and germinated Garden cress seed flour
NS Depicts no significant difference

Ash Content

The ash content of untreated, roasted and germinated garden cress seed powder were 5.03±0.54%, 4.99±0.39% & 4.80±0.37% respectively. Agarwal and Sharma (2013) [1], reported the ash content of garden cress seed powder and roasted garden cress seed powder to be 5.93% and 6.40% respectively. Higher amounts of ash contents indicate that the garden cress seeds are good source of minerals. There was a 0.79% decrease in ash content after roasting and a 4.52% decrease after germination when compared with untreated garden cress seed powder. However, the decrease is not statistically significant. The decrease in the ash content on germination can be attributed to the loss of minerals in soaking water.

Fat Content

The fat content of untreated, roasted, germinated GC seed powders was found to be 20.92±0.60%, 16.31±0.41% and 5.57±0.43% respectively. There was a significant decrease ($p<0.05$) of 22.03% and 73.37% in fat content on dry roasting and germination respectively. The fat content of the germinated garden cress seed was 84% lesser than the dry roasted GC powder. The decrease in fat content could be due to increased activities of lipolytic enzymes during germination which hydrolyses fat component into fatty acids and glycerol. (Chiemela *et al*, 2009) [19].

Protein Content

Garden cress seeds are found to contain high amount of protein. The protein content of GC is reported in the range of 22-25g/100g. All essential amino acids; expect sulphur containing and tryptophan are present in high amounts (Agarwal and Sharma 2013) [1]. High protein indicates that garden cress seeds have high food energy (Marangoni *et al*, 1988) [18].

The protein content of untreated, roasted and germinated garden cress seed powder were 22.21%, 25% and 25.42% respectively. Mathew *et al*, (1993) [20] reported 24.3% protein content in garden cress seeds. Doke and Guha, (2014) [21] reported the protein content of garden cress seed to be 22.47%.

Germination is a biochemical process which involves transition of a seed from dormant state to vital active state. It is a simple technique that has been reported to improve the nutritive value of foods. Several studies on the effect of germination on legumes have found that germination can increase protein content and dietary fiber (Limbachiya and Amin, 2015) [22]. There was significant ($p<0.05$) 14.45 % increase in the protein content of garden cress seed on germination.

Roasting technology resulted in the increase in the protein content of the garden cress seed. In the current study, there was a significant ($p<0.05$) increase by 12.56% in the protein content of garden cress seeds on dry roasting.

Total Carbohydrate

The total carbohydrate content of garden cress seed powder were 50.15±0.20%, 53.25±0.56% & 60.47±0.49% respectively. There was a significant ($p<0.05$) 6.18% and 20.57% increase in the total carbohydrate content of the garden cress seed on roasting and germination respectively.

Carbohydrates especially starch, represent the major reserve substance in most seeds (Bewley and Black, 1994) [23]. During early germination, mobilization of storage carbohydrates occurs, once the high molecular weight carbohydrates are mobilized, they are converted into soluble forms, (i.e.) Sucrose, glucose, and fructose that are readily transportable to sites where they are required for growth (Mayer and Poljakoff- Mayber, 1975) [24]. The increase in the total carbohydrate content on germination can be attributed to the above discussed concept.

Crude Fibre Content

The total fibre content of untreated, roasted and germinated

garden cress seed powders were 2.16±0.25%, 2.06±0.30% and 3.00±0.02% respectively. Mohite *et al*, (2012) [25] reported the crude fibre content of garden cress seeds to be 12%. Gokavi *et al*, (2004) [26] reported the crude fibre content of garden cress seeds to be 7%. In the current study a lower value of fibre content in the range of 2-3% is recorded. There was no significant difference in the crude fibre content of untreated and dry roasted garden cress seeds, whereas there was a significant difference in the crude fibre content of germinated garden cress seed powder. On germination, the crude fibre content has significantly ($p<0.05$) increased by 38%. The same trend of an increase in the crude fibre on germination in mung bean, peas and lentil seeds were recorded by El-adway *et al*, (2003) [27].

Iron Content

Garden cress seeds are found to be a rich source of iron. The iron content of untreated, roasted and the germinated GC were 16.37±0.40mg/100g, 21.41±0.30mg/100g and 33.55±0.31mg/100g respectively. The result is in accordance with the value reported (17.30mg/100g) by Longvah *et al* (2017) [28].

There was a significant ($p<0.05$) 30.78% and 56.7% increase in iron content of garden cress seed powder on dry roasting and germination respectively.

Incorporation of garden cress in foods have shown marked increase in the iron and protein content (Nathiya *et al*, 2014) [29]. Gigi Elizabeth *et al*,(2014) [30] showed 5 to 30 g of garden cress incorporated cookies meet 100% required iron of adolescent girls.

Vitamin C

The vitamin C content of untreated, roasted and germinated garden cress seed powders were 57.35±0.42mg/100g, 77.22±0.36mg/100g & 137.05±0.31mg/100g respectively. There was a 34.64% increase in the Vitamin C content in the garden cress seed on dry roasting, which was statistically significant ($p<0.05$).

Germination is reported to be associated with increase of vitamin concentrations and bioavailability of trace elements and mineral found that germination improves ascorbic acid content. (Dipika *et al*, 2013) [31]. The vitamin C content of germinated garden cress was twice the value of untreated garden cress seed powder. It has recorded a significant ($p<0.05$) 138.97% increase in the vitamin C content after germination.

Phytonutrients

Table 3: Phytonutrient of processed garden cress seed powder

Sample/ Parameters	Untreated GC	Roasted GC	Germinated GC
Total Tannin Content (mg/100g)	0.24	0.27	0.33
Total Phenolic Compounds (mg/100g)	43.17	45.76	51.44

Total tannin content

The total tannin content of untreated, roasted and germinated garden cress seed powders were 0.24mg/100g, 0.27mg/100g and 0.33mg/100g respectively. According to Hanif *et al*, (2008) [32] tannin content of garden cress seed was found as 0.5- 1mg/g. Hussian *et al*, (2011**)** [33] found 0.61% tannins in garden cress seeds. Differences in the reports could be because of the differences in procedure and variety of the seeds used.

There was a 12.5% and 37.5% increase in the tannin content of the garden cress seed powder on dry roasting and germination respectively. Increase in the tannin contents may be due to the degradation of high molecular weight insoluble polymer into a low molecular weight soluble polymer while popping. The increase in the tannin contents during processing was also reported by other investigators Ahmed *et al*, 1996 [34]; Osman, 2007 [35]. In a study by Panwar and Guha (2014) [36] the tannin contents of the garden cress seed extracts increased (6.81%) while popping whereas it decreased (20.45%) during germination as compared to the native GCS extract.

Total phenolic compounds

Polyphenols are well known to be important nutraceuticals having antioxidant properties. The total phenolic content of the untreated, roasted and germinated garden cress seed powder were found to be 43.17 (mg/100g, GAE), 45.76 (mg/100g,GAE) and 51.44(mg/100g, GAE)

There was a 5.99 % increase in the total phenolic content of the garden cress seed powder on dry roasting. Increase in total phenolic content on roasting maybe due to increase in the extractability of bound phenolics by the thermal degradation of cellular constituents.

There was a 19.15% increase in the total phenolic content of the garden cress seed powder on germination. During seed sprouting a multitude of biochemical processes takes place, leading to radical changes in primary and secondary metabolites composition which could result in change of intrinsic phenolic compounds profile, and antioxidant activity (Jian *et al*, 2009) [37].

Roasting and germination improve the nutraceutical property of Garden Cress Seeds by increasing its content in phenolic compounds and also its antioxidant activities

Sensory Parameters

Sensory evaluation brings valuable information on quality characteristics. The comparison of the sensory attributes-appearance, colour, texture, taste, flavor, mouth feel, sponginess, after taste and overall acceptability were made among the untreated and processed (roasted & germinated) garden cress incorporated muffins.

One way ANOVA analysis for the sensory attributes of the garden cress muffins prepared with untreated, roasted and germinated GC powder with 5%, 10% and 15% incorporation revealed that there was a significant difference ($p<0.05$) among the experimental samples.

Among the muffin mix prepared from untreated, roasted and germinated garden cress, the overall acceptability ranked highest for germinated garden cress(5%) incorporated muffin (GGM1) with a mean score of 8.26±0.45, followed by roasted (RGM1)garden cress muffin with a score of 7.73±0.55 and untreated (UGM1)garden cress muffin with a score of 7.53±0.45.

Table 4: Product code for garden cress incorporated instant muffin mix

CM	Control Muffin (Without Garden cress incorporation)
UTM1	Muffin incorporated with 5% untreated GCS powder
UTM2	Muffin incorporated with 10% untreated GCS powder
UTM3	Muffin incorporated with 15% untreated GCS powder
RGM1	Muffin incorporated with 5% roasted GCS powder
RGM2	Muffin incorporated with 10% roasted GCS powder
RGM3	Muffin incorporated with 15% roasted GCS powder
GGM1	Muffin incorporated with 5% germinated GCS powder
GGM2	Muffin incorporated with 10% germinated GCS powder
GGM3	Muffin incorporated with 15% germinated GCS powder

Table 5: Mean scores for garden cress incorporated muffin

Parameters /Product code	CM	UGM1	UGM2	UGM3	RGM1	RGM2	RGM3	GGM1	GGM2	GGM3
Appearance	6.66±0.48	7.13±0.35	6.6±0.63	6.2± 0.41	7.8±0.41	6.66±0.61	6.26±0.45	8.2±0.56	6.73±0.59	6.30±0.48
Color	6.73±0.45	7.13±0.51	6.6±0.63	6.2± 0.41	7.8±0.41	6.6±0.63	6.2±0.41	8.2±0.56	6.73±0.59	6.33±0.48
Texture	6.25±0.45	7.18±0.56	6.6±0.72	6.12± 0.35	7.8±0.41	6.6±0.63	6.2±0.41	8.06±0.45	6.73±0.59	6.2±0.41
Taste	6.33±0.61	7.6±0.50	6.5±0.63	5.53± 0.74	7.53±0.63	6.6±0.63	6.2±0.67	8.2±0.86	6.6±0.63	5.93±0.59
Flavour	6.43±0.51	7.5±0.62	6.5±0.79	5.68± 0.50	7.4±0.70	6.73±0.81	6.33±0.51	8.2±0.777	6.4±0.63	6.0±0.84
Mouthfeel	6.6± 0.63	7.73±0.59	6.4±0.61	5.73±0.70	7.46±0.63	6.53±0.63	6.06±0.50	8.66±0.56	6.4±0.50	5.86±0.77
Sponginess	6.26±0.70	7.6±0.63	6.4±0.63	5.6± 0.50	7.8±0.56	6.6±0.50	5.8±0.77	8.4±0.50	6.66±0.48	5.93±0.79
After taste	6.13±0.74	7.46±0.63	6.6±0.56	5.8± 0.63	7.86±0.51	6.46±0.51	6.0±0.51	8.2±0.41	6.66±0.48	6.13±0.51
Overall acceptability	6.13±0.35	7.53±0.55	6.66± 0.72	6.06± 0.45	7.73±0.45	6.73±0.59	6.13±0.35	8.26±0.45	6.73±0.45	6.13±0.35

Values are Mean ± SD of 15 respondents

4. Conclusion

Medicinal plants are now more focused than ever because they have the capability of producing many benefits to society indeed to mankind. Garden cress (*Lepidium sativum* L.) is one such food stuff that abounds not only in nutrients but also in health enhancing phytochemicals. Hence the study, "Effect of Processing on Selected Nutrient Profile of Garden cress seeds and Optimization of Garden cress seed based Muffin" was undertaken. The pre-treatments dry roasting and germination not only improves the nutrient and phyto nutrient profile, but also has well acceptable sensory attributes. The study concludes that, Garden cress seeds can be dry roasted or germinated to have an enhanced nutrient profile. The functional health benefits of garden cress may be exploited by incorporating it in food formulations such as muffins at 5% level, which had good overall acceptance.

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