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Utilization of germinated garden cress (*lpidium sativum* L.) seeds as untraditional functional food

Amal M. El- Bastawesy; Aziza T. Gamal*

Address:

Horticultural Crops Research Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt.

*Corresponding author: ***Amal El- Bastawesy.*** email: ghazy68@yahoomail.com

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ABSTRACT

Garden cress (*Lpidium sativum* L.) is an underutilized crop with high nutritional potential. Its application in food products remains limited due to antinutritional factors and sensory challenges. Therefore, this study aimed to explore garden cress seeds' nutritional and bioactive enhancements after germination proces and utilize as main sources of high nutritional and bioactive compounds to improve and produce some untraditional and nutraceutical sweet potato puree with good nutrient balance and more palatable for consumers. The results demonstrated that the germination proces significantly enhances the nutritional and functional properties of garden cress seeds by increasing protein, phenol contents, and antioxidant activity, as well as reducing antinutritional components as phytic acid. Increasing the germination period increased the percent ratio of minerals, especially calcium and potassium that recorded the most significant increases from 590.58 to 660.85 and 82.34 to 112.33 mg/100g, respectively. Pyrogallol was the most common phenolic compound found in germinated seeds (227.58 mg/100 g), which dramatically increased after the germination period by more than 72-folds. Moreover, the germination process had a positive effect on raising the flavonoids, isoflavone compound contents, B-complex and fat-soluble vitamins, especially vitamin K, the predominant fat-soluble vitamin found in raw garden cress seeds, which increased fourfold after the germination process, being 78.89 mg/100g. Optimum incorporation of germinated garden cress seeds powder (10–20%) into sweet potato puree blends with orange juice improved the sensory palatability and recorded the highest scores comparing with the control blend. These findings demonstrate that germinated garden cress seeds are a potent functional ingredient for nutritional enhancement and health promotion of food products, supporting their application in developing value-added foods with favorable consumer acceptance.

Keywords: Germination, Bioactive Compounds, Antinutritional Factors, Garden cress seeds

INTRODUCTION

Underutilized crops are plant species cultivated for years and centuries for their nutritional, fodder, fibers, and medicinal characteristics, although their significance has diminished over time due to public unawareness (Bhatia, 2024). Garden cress (*Lepidium sativum*) is a highly and versatile plant with high nutrient value. It is a rich source of protein and important fatty acids, including arachidic and linoleic acids (Khalid *et al*., 2025). It is also rich in vitamins, minerals (iron, calcium, and magnesium) and bioactive compounds such as kaempferol glucuronide, gallic, protocatechuic, coumaric and caffeic acids, as well as, others having anticarcinogenic, antihypertensive, laxative, antidiabetic, and antioxidant activities (Azene *et al*., 2022; Tufail *et al*., 2024). Moreover, it is used to improve vitamin C deficiency, strengthen the immune system and bone healing (Abdallah *et al*., 2020).

Germination and sprouting, lead to physiological changes in legumes and seeds, enhancing their nutritional value and reducing antinutritional components (López-Martínez *et al*., 2017). Germination of seeds increased their antioxidant capacity by increasing phenolic and flavonoid components, (Chen *et al*., 2019). Germination represents a critical developmental process that occurs at a crucial point in the life cycle of plants. It is a biological process in which a seed transitions from a dormant to an active, vital form. During germination, vitamins and other beneficial substances, often regarded as antioxidants, undergo substantial changes (El-Dardiry and El-Rhmany, 2022).

Fruits and vegetables are excellent sources of vitamins and minerals, but they often lack in protein and fat contents. Garden cress extract or powder may serve as a substitute for these components. Phenolic compounds, the most effective natural antioxidants, are abundant in garden cress seeds and contribute to their antioxidant activity (Tufail *et al*., 2024). Furthermore, (Abdel-Aty *et al*. , 2019) recommended consuming garden cress sprouts as a rich source of health-promoting antioxidants. Sweet potatoes contain β-carotene, vitamins, minerals, and nutrients such

as carbohydrates and fibers (Alam, 2021), whereas, orange juice is rich in vitamins, polyphenols, and other natural nutrients. The nutritional benefits of drinking orange juice include reducing the risk of obesity, reducing total cholesterol levels, increasing total antioxidant status, reducing the risk of urinary calculi, and increasing vitamin C intake (Nishad *et al*., 2018; Pontifex *et al*., 2021).

Despite their advantages, there is limited utilization of germinated garden cress seeds in food product development, and there are limited studies on their combination with nutritionally rich ingredients such as sweet potatoes and orange juice to develop enhanced functional foods. Therefore, the current study aimed to utilize germinated garden cress seeds powder, as main sources of high nutritional and bioactive compounds, to improve and produce some untraditional and nutraceutical puree with good nutrient balance and more palatable among different consumers.

MATERIALS AND METHODS

Materials

Raw materials: Garden cress (*L. sativum*) seeds were obtained from Field Crops Res. Inst., Agricultural Research Center, Giza, Egypt. Potato tubers (*Ipomoea batatas*) and orange fruits (*Citrus sinensis*), Baladi variety were purchased from the local market at Giza city, Egypt.

Chemicals and reagents: Folin-Ciocalteu reagent, 2, 2'-Diphenyl-1-picrylhydrazyl (DPPH) and all other chemicals were purchased from EL Gomhoria Comp. Giza, Egypt and Sigma-Aldrich (USA). All chemicals used were of analytical reagent grade.

Methods

Preparation of raw materials

Garden cress seeds were cleaned to remove impurities and stored in an air-tight plastic container. The seeds were washed and soaked in tap water (1:2 w/v) at room temperature for 8 hrs. The seeds were spread on a wet surface at 25^{o}C for 4-5 days in dark and were sprayed until they germinated. Afterwards, the seeds were dried at 55 ^{o}C to stop germination. Sprouts were milled using a Moulinex mill machine (LM207125, French) to a particle size of less than 80 mesh to obtain the germinated seeds powder. Sweet potato tubers were washed, peeled, then cut into thin slices (1-1.5 cm) and steam blanched for 15 min . After that, the slices were oven- dried at 50 ^{o}C for 6 hours, and the dried potato was milled using a Moulinex mill machine to a particle size of less than 80 mesh to obtain potato powder.

Analytical methods

Chemical analysis

- Moisture, protein, crude fibers, ash, and mineral contents were determined according to the methods of the (AOAC, 2023), while mineral elements were detected using an Atomic Absorption Spectrometer (Perkin-Elmer, Model 3300, USA).
- Total soluble solids (TSS), total and reducing sugars, titratable acidity, and pH values were determined according to the methods of the (AOAC, 2023).
- Ascorbic acid was determined using the 2,6-dichlorophenolindophenol titration method (Ranganna, 1979).
- Total phenols and flavonoids contents were measured using standardized colorimetric assays. Total phenols content was determined using the Folin-Ciocalteu method (Zheng and Wang, 2001), using a UV-Vis Spectrophotometer, Labomed Inc., (USA) and expressed as mg gallic acid equivalents (GAE)/g. Whereas, total flavonoids content was determined according to the method of (Zhishen *et al*. ,1999) and expressed as mg catechin equivalents (CE)/g.
- The antioxidant activity of the samples was measured using the DPPH radical scavenging method (Scherer and Godoy, 2009), and the percentage inhibition of the DPPH radical was calculated as:

****Inhibition% = [(A0– A1) / A0] × 100**

Where:

A0: is the absorbance of the control reaction.

A1: is the absorbance in the presence of the tested samples, and

A1 = the sample absorbance at time =30 minutes.

Tests were done in triplicate.

- Phytic acid was assayed according to the method described by (Mohamed *et al*., 1986).
- Total carotenoids were determined according to the methods described by (Lichtenthaler and wellburn, 1983).
- Phenolic acids, flavonoids, and iso flavanone compounds of garden cress methanolic extracts were fractionated and identified using an Agilent 1200 series HPLC system (Hewlett-Packard 1050) equipped with a quaternary pump and

autosampler according to the methods described by (Goupy *et al*. , 1999; Mattila *et al*. , 2000; Mantovani *et al*., 2011). Column temperature was maintained at 25±1°C, with the detection of phenolic compounds at specific wavelengths: 280 nm for phenolic acids, 330 nm for flavonoids, and 254 nm for isoflavones. The analysis was performed at the Food Technology Research Institute, Agricultural Research Center, Giza, Egypt.

- B-complex vitamins were analyzed by HPLC (Agilent 100 series) using a variable wavelength detector (280 nm) and an ODS column at 35°C (Batifoulier *et al*., 2005). While fat-soluble vitamins (A, E, D, and K) were analyzed using HPLC (Agilent 1200) with a C18 column (30°C) and a variable wavelength detector (325 nm for V.A, 295 nm for V.E, 266 nm for V.D, and 280 nm for V.K) according to the method of (Rizzolo *and Polesello*, 2012).

- Fatty acids methyl esters were prepared from total lipids using a rapid method according to ISO 12966-2 (2011). Also, fatty acids and fatty acid methyl esters were injected into the Gas-Liquid Chromatography (GLC) (HP 6890 series GC) apparatus provided with a DB-23 column (60×0.32 mm ×25 µm) at the Food Technology Research Institute, ARC, Giza, Egypt.

Sensory evaluation

Sensory attributes (color, taste, odor, consistency, palatability, and overall palatability) of the potato puree with different ratios of germinated seeds powder (10, 15, 20, and 25%) were evaluated directly after rehydration with orange juice by more than ten panelists' (chosen randomly) at Food Technology. Res. Inst. according to the method of (Stone and Vermeulen, 2016).

Statistical analysis

The statistical assessment was conducted using a one-way variance assessment (ANOVA) at a substantial rate of 0.05 for the whole results using the statistical program CoStat (Ver. 6.400), according to (Steel *et al*., 1997).

RESULTS

Effect of Germination Process on Chemical Composition and Bioactive Compound contents of Garden Cress Seeds

Data in (Table 1) show that a slight increase occurred in moisture and ash contents. After the germination process of garden cress seeds, the protein content (24.83%) was highly increased to 32.17%, while crude fat and total carbohydrates decreased from 26.62 to 24.96% and 41.26 to 32.95 %, respectively (Table 1). Concerning bioactive compounds content, data in the same table show also that the total phenols (14.17mg/g) increased more than four folds being 52.85 mg/g after the germination period. Whereas, total flavonoids had slightly increased from 0.016 to 0.037 mg/g, resulting in an improvement in antioxidant activity from 89.85 to 93.41%. Moreover, phytic acid, a well-known antinutritional factor, had significantly reduced from 440.33 to 236.16 mg/100g.

Regarding minerals content, potassium, magnesium, calcium, and iron significantly elevated after the germination process, while calcium and potassium recorded the most significant increase from 590.58 to 660.85 and 82.34 to 112.33 mg/100g, respectively (Table 1).

Effect of germination process on bioactive compounds of garden cress seeds

1-Fractionation and identification of phenolic compounds

Fourteen phenolic compounds were identified in raw and germinated garden cress seeds, demonstrated a significant compositional changes during germination (Table 2). In raw seeds, Catechin (12.25 mg/100 g) and Ferulic acid (10.40 mg/100 g) were the predominant phenolic compounds, and both of them nearly doubled after germination, being 22.33 and 21.12 mg/100 g, respectively. Pyrogallol was the most common phenolic compound found in germinated seeds (227.58 mg/100 g), which dramatically increased after the germination by more than 72-folds. Other compounds, including Gallic, 4-aminobenzoic, P-hydroxybenzoic, Chlorogenic acids, Caffeine, and Coumarin, were initially present in trace amounts, but their concentrations showed substantial increased by more than 2-7 folds after the germination process. In contrast, Ellagic acid was not detected after germination.

2- Fractionation and identification of flavonoids and isoflavone compounds

As recorded in (Table 3), thirteen flavonoids and five isoflavone compounds were separated and identified after the germination process of garden cress seeds. Apigenin 6-arabinose 8-glucose (97.99 mg/100g) was the predominant flavonoid in raw seeds, and its concentration slightly increased to 103.88 mg/100g after the germination period. Naringinin, Quercetin, Kaempferol, and Apigenin, were initially found in trace amounts but exhibited significant increase which could be attributed to the effect of the germination process. Additionally, other compounds namely, Luteolin 7-glucose (2.65 mg/100 g), Rutin (2.21 mg/100g), and Kaempferol 3-2-p-coumoroyl glucose (3.63 mg/100 g) were also detected in moderate amounts and highly increased after the germination process. Interestingly, Naringin,

Table 1. Effect of germination process on chemical composition and bioactive compounds of garden cress seeds

Samples / *Constituents (%)	Raw seeds±SD	Germinated seeds±SD	LSD at 0.05
Moisture	6.26 ^{b} ±0.01	8.26^{a} ±0.01	0.029
Protein	24.81^{b} ±0.01	32.17^{a} ±0.01	0.040
Fat	26.62^{a} ±0.01	24.96^{b} ±0.01	0.047
Ash	1.05^{b} ±0.01	1.66^{a} ±0.01	0.029
Crude fibers	24.42^{a} ±0.01	24.02^{b} ±0.01	0.029
Total carbohydrate**	41.26^{a} ±0.02	32.95^{b} ±0.02	0.045
Total phenols (mg GAE/g)	14.17^{b} ±0.01	52.85^{a} ±0.01	0.065
Total flavonoids (mg CE/g)	0.016 ^{b} ±0.001	0.037^{a} ±0.002	0.040.
Antioxidant activity by DPPH (%)	89.85^{b} ±0.02	93.41^{a} ±0.01	0.003
Phytic acid (mg/100g)	440.33^{a} ±2.52	236.16^{a} ±1.62	0.059
Minerals (mg/100g)			
K	82.34	112.33	-
Mg	267.0	298.82	-
Na	133.04	148.87	-
P	40.51	45.33	-
Mn	3.03	3.39	-
Cu	0.80	0.89	-
Ca	590.58	660.85	-
Fe	9.52	10.55	-
Zn	3.01	3.37	-

Means within a raw showing the same letters (a, b) are not significantly different (P>0.05).
*On dry weight basis ** Total carbohydrate calculated by difference

Table 2. Fractionation and identification of phenolic compounds of garden cress seeds

Samples / Phenolic compounds (mg/100g)	Raw seeds	Germinated seeds
Pyrogallol	3.18	227.58
Gallic acid	0.13	1.35
Catechol	0.69	0.50
4-Aminobenzoic acid	0.91	2.40
Catechin	12.25	22.33
Chlorogenic acid	7.56	26.89
Benzoic acid	Nd*	27.86
P-OH-benzoic acid	0.64	12.35
Vanillic acid	3.77	13.01
Caffeine	1.96	23.47
Ferulic acid	10.40	21.12
Salicylic acid	4.37	10.48
Ellagic acid	1.70	Nd*
Coumarin	0.77	5.72

Nd* not detected

present at 2.02 mg/100g in raw seeds, and disappeared after the germination process, while Apigenin 7-glucose and Hesperidin, appeared in high levels in germinated seeds.

Regarding isoflavone compounds, it could be noticed that the germination process had a positive effect on raising the isoflavone compounds' content in garden cress seeds. Isorhamntin (99.10 mg/100g) was the predominant isoflavone compound detected in garden cress seeds, and the most notable change was observed in its level, that increased to more than double being 201.16 mg/100g after the germination process. Similarly, Daidazein elevated from 5.01 to 7.41 mg/100g, after the germination process.

Table 3. Fractionation and identification of flavonoid and isoflavone compounds of raw and germinated garden cress seeds

Samples / Flavonoid compounds (mg/100g)	Raw seeds	Germinated seeds
Apiening 6-arbinose 8-glucose	97.99	103.88
Luteolin7 glucose	2.65	9.35
Rosmarinnic	2.05	1.67
Rutin	2.21	6.81
Hespirdin	Nd*	34.81
Quercetin	12.64	8.83
Apigenin 7 glucose	Nd*	19.21
Naringin	2.02	Nd*
Naringenin	0.42	5.58
Quercetin	0.79	4.89
Kaempferol 3-2-p-coumoroyl glucose	3.63	9.24
Kaempferol	0.47	5.91
Apigenin	0.17	3.63
Isoflavone compounds (mg/100g)		
Biochainin	0.53	0.55
Genistein	0.75	2.10
Isorhamtine	99.10	201.16
Daidazein	5.01	7.41
Isoformentin	0.12	1.60

***Not detected

3-B-Complex and fat-soluble vitamins fractions of garden cress seeds:

B-complex and fat-soluble vitamins were fractionated and identified using HPLC and the results are presented in (Table 4). Thiamin (B1) and Cobalamin (B12) were the most abundant B-complex vitamins in raw garden cress seeds, and their levels increased being 378.8 and 124.21 mg/100 g, respectively after the germination process. Pyridoxine (B6) and folic acid were initially present in lower amounts (7.33 and 0.17 mg/100g, respectively) then increased dramatically after germination process, reaching 91.80 and 9.28 mg/100g, respectively.

Regarding fat-soluble vitamins, vitamin K (20.70 mg/100g) was the predominant fat-soluble vitamin found in raw garden cress seeds, which increased fourfold after the germination process being, 78.89 mg/100g. Vitamin A (0.09 mg/100g) and vitamin D (0.02 mg/100g) were presented in small amounts in raw seeds and increased dramatically after the germination, reaching 20.20 and 0.71 mg/100g, respectively.

Table 4. Effect of germination process on b-complex and fat-soluble vitamins fractions of garden cress seeds

Samples / Vitamins (mg/100g)	Raw seeds	Germinated seeds
Pyridoxine (B6)	7.33	91.80
Thiamin (B1)	101.37	378.80
(B12) Cobalamin	63.34	124.21
Folic acid	0.17	9.28
Riboflavin(B2)	10.93	6.09
Fat-soluble vitamins (mg/100g)		
A	0.09	20.20
D	0.02	0.71
E	0.04	0.12
K	20.70	78.89

*On a dry weight basis

Effect of germination process on fatty acids composition of garden cress seeds

Germination significantly changes the fatty acids composition of garden cress seeds, as revealed in (Table 5). There is a notable reduction in some saturated fatty acids, such as Palmitic acid (C16:0) from 9.09 to 8.27%, Stearic acid (C18:0) from 3.24 to 2.65%, and Arachidic acid (C20:0) from 3.75 to 1.26%. On the other hand, some unsaturated

fatty acids increased after the germination process, such as, Oleic acid (C18:1) from 22.62 to 25.22% and Linoleic acid (C18:2) from 11.50 to 12.27%. However, ALpha-linolenic acid (C18:3n^3) declined from 31.99 to 28.81%. The total saturated fatty acids (16.37%) slightly decreased to 15.44%, while the total unsaturated fatty acids (83.63%) remained nearly constant after the germination process. Additionally, new minor components and unknown fatty acids are noticed only after the germination process.

Table 5. Effect of germination process on fatty acids composition of garden cress seeds

Samples / Fatty acids (%)	Raw seeds	Germinated seeds
C12:0	Nd	0.18
C14:0	0.11	0.27
C16:0	9.09	8.27
C16:1	0.20	0.28
C17:0	0.05	0.05
C17:1	0.32	0.05
C18:0	3.24	2.65
C18:1	22.62	25.22
C18:2	11.50	12.27
C18:3n^3	31.99	28.81
C18:4	Nd	0.74
C20:0	3.75	1.26
C20:1	12.27	10.89
Unknown	Nd	0.56
Unknown	Nd	0.52
C22:0	0.13	0.92
C22:1	5.12	5.22
Total unknown	---	1.08
Total saturated fatty acids	16.37	15.44
Total unsaturated fatty acids	83.63	83.48

Chemical constituents of fresh orange juice

Fresh orange juice was analyzed and its chemical composition is presented in (Table 6). Orange juice contains a considerable amount of total soluble solids (12.61 %), which is primarily attributed to dissolved sugars, organic acids, and other soluble nutrients that influence taste and nutritional value. Meanwhile, the sugar content comprised 10.31 % including 7.78 % of reducing sugars and 2.48 % of non-reducing sugars. Moreover, orange juice contains high levels (66.28 mg/100g) of ascorbic acid (vitamin C), while exhibiting a total acidity of 1.37 mg/100g as citric acid, with a pH value of 3.61, which indicates its acidic nature. From the above, table it can be also seen that orange juice is a rich source of bioactive compounds, with a high total phenols content (126.78 mg GAE/100g) and moderate amount of total flavonoids (15.52 mg CE/100g). The antioxidant activity was 52.29 % that indicating a significant potential source for neutralizing frees radicals.

Proximate chemical composition of sweet potato powder

As revealed in (Table 7), the proximate chemical composition of sweet potato powder shows that the moisture content was 8.10% and total solids 91.90%, with moderate ash content. Sweet potato powder had high carbohydrates content (74.78 %) and total sugars (22.80%). Moreover, it is also considered as a good source of ascorbic acid (68.90 mg/100g). Additionally, sweet potato was found to be notable sources of total phenols (31.20 mg GAE/100 g), flavonoids (24.50mg CE/100 g), and the antioxidant activity recorded 54.82%. Furthermore, it exhibited high total carotenoid content (33.60 mg/100 g).

Organolyptic evaluation of sweet potato and germinated garden cress seeds puree rehydrated by orange juice

Sensory evaluation results of sweet potato powder and germinated garden cress seeds puree that rehydrated by orange juice are presented in (Table 8). Blend 2 (15% germinated seeds powder and orange juice) exhibited the highest overall palatability scores (42.9) comparing with control one. Similarly, blends 1, 3 which contain 10 and 20% . germinated seeds powder and rehydrated by orange juice recorded the same overall palatability scores, 42.7 and 42.4, respectively. The sensory evaluation of sweet potato puree blends that fortified with germinated garden cress seeds and orange juice were organoleptically acceptable up to 20%. Meanwhile, increasing germinated garden cress seeds level than 20 % led to statistically significant declines ($p < 0.05$) in mean sensory scores for all sensory parame.

Table 6. Mean chemical constituents of fresh orange juice

*Constituents (%)	**Orange juice**±SD
Moisture content	85.32 ± 0.049
Total solids (TS)	14.63 ± 0.009
Total soluble solids (TSS)	12.61 ± 0.020
Crude fibers	2.07 ± 0.0082
Fat	0.15 ± 0.0115
Protein	0.19 ± 0.0082
Ash	0.42 ± 0.025
Total sugars	10.31 ± 0.015
Reducing sugars	7.78 ± 0.025
Non-reducing sugars	2.48 ± 0.015
Total acidity (mg/100g as citric acid)	1.37 ± 0.010
pH value	3.61 ± 0.016
Ascorbic acid (mg/100g)	66.28 ± 0.147
Total phenols (mg GAE /100g)	126.78 ± 1.041
Total Flavonoid (mg CE /100g)	15.52 ± 0.284
Antioxidant activity by DPPH	52.29 ± 0.271

(on fresh weight basis)

Table 7. Mean a proximate Chemical Composition of Sweet Potato Powder

*Constituents (%)	**Sweet potato powder**±SD
Moisture content	8.10 ± 0.20
Total solids (TS)	91.90 ± 0.16
Crude fibers	8.52± 0.15
Protein	7.48± 0.25
Fat	1.12±0.12
Ash	2.99 ± 0.25
****Total carbohydrates**	74.78 ± 0.40
Total sugars	22.80 ± 0.50
Reducing sugars	16.24±0.31
Non-reducing sugars	6.56±0.24
Ascorbic acid (mg/100g)	68.90 ± 0.50
Total carotenoids (mg/100g)	33.60 ± 0.20
Total phenols (mg GAE/100g)	31.20 ± 0.18
Total flavonoids (mg CE /100g)	24.50 ± 0.28
Antioxidant activity using DPPH	54.82±0.36

*(on dry weight basis) ** Total carbohydrate calculated by difference

Table 8. Organoleptic evaluation of sweet potato puree blends fortified with germinated garden cress seeds powder and orange juice

Properties / *Blends	**Taste (10)** ±SD	**Flavor (10)** ±SD	**Color (10)** ±SD	**Texture (10)** ±SD	**Palatability (10)** ±SD	**Overall Σ 50**
Control	6.6^{d}±0.70	6.3^{c}±0.69	6.8^{c}±0.89	7.3^{b}±0.69	6.6^{a}±0.98	34.1
Blend1 (10%)	8.7^{a}±0.48	8.6^{a}±0.50	8.3^{a}±0.44	8.1^{a}±0	8.8^{a}±0.44	42.7
Blend2 (15%)	8.5^{b}±0.32	8.4^{a}±0.58	8.3^{a}±0.50	8.2^{a}±0.32	8.9^{a}±0.32	42.9
Blend3 (20%)	8.5^{ab}±0.56	8.3^{a}±0.56	8.5^{a}±0.53	8.1^{a}±0.22	8.70^{a}±0.35	42.4
Blend4 (25%)	7.2^{c}±0.42	7.4^{b}±0.42	7.45^{b}±0.50	7.65^{b}±0.62	7.25^{c}±0.26	37.05
LSD at 0.05	0.086	0.114	0.135	0.01	0.108	--

Means within a column showing the same letters (a, b ,c) are not significantly different (P>0.05).

Control: Sweet potato powder + 10% germinated garden cress seeds rehydrated with water.

Blend (1): Sweet potato powder + 10% germinated garden cress seeds rehydrated with orange juice.

Blend (2): Sweet potato powder + 15% germinated garden cress seeds rehydrated with orange juice

Blend (3): Sweet potato powder + 20% germinated garden cress seeds rehydrated with orange juice

Blend (4): Sweet potato powder + 25% germinated garden rehydrated with orange juice

DISCUSSION

The slightly high moisture content indicates water absorption, which is necessary for enzyme activity and metabolic activities during germination, whereas higher ash content indicates enhanced minerals mobilization and availability (Maleki Farahani *et al*., 2025).

Germination process of garden cress seeds had a positive effect to increase the protein content, while crude fat and total carbohydrates decreased. These results are in agreement with those reported by (Limbachiya and Amin, 2015), who found that the germination process could increase the protein content of legumes due to photolytic enzymes breaking down proteins into simpler ones, making them more accessible for seedling growth. Furthermore, the decrease in lipid content probably results partly from lipase-catalyzed degradation of triglycerides to free fatty acids (FFA) and glycerol and the further oxidation of the FFA into non-lipid products (El-Safy *et al*., 2013).

Total phenols showed a rise of more than four folds after the germination period, whereas total flavonoids had slightly increased which resulted in an improvement in antioxidant activity. These results are in agreement with those reported by (Abd-Aty *et al.*, 2019), who stated that the germination process increased the bioactive components and antioxidant activity of garden cress seeds to the maximum levels on 7-day sprouts. Biochemical and physiological changes during garden cress seeds germination increased total phenols, flavonoids contents, as well as antioxidant activity due to phenylalanine ammonia-lyase (PAL) stimulation, which promotes the biosynthesis and releases of phenolics and flavonoids. The plant produces these compounds to combat oxidative stress and environmental factors such as light, moisture, and temperature (Bhatia, 2024).

The Germination proces had a significantly reduced the phytic acid content of garden cress seeds and this reduction could be attributed to an increase in phytase activity as germination progressed, which leads to the breakdown of phytic acid, resulting in a marked decrease in its content within the seed. Reduced antinutritional compounds during germination increase bioavailability and antioxidant capacity (Abdel-Aty *et al*., 2021). These changes demonstrate the plant's adaptive response to oxidative stress during germination and increase its nutritional and functional properties (Malhotra *et al*., 2023).

Calcium and potassium recorded the most significant increases from 590.58 to 660.85 and 82.34 to 112.33 mg/100g, respectively. Increasing the germination period increased the minerals, content of garden cress seeds due to phytase activity on phytate, which liberates the minerals from phytates complexes in a free mod. These results are in agreement with those reported by (Dobrowolska-Iwanek *et al*., 2022) who found that the significant increase in mineral content can be attributed to the elevation of phytase activity during germination, which significantly improved the bioavailability of minerals such as calcium and iron due to the degradation of phytates during germination, which is a key factor in this enhancement.

Fourteen phenolic compounds were identified in raw and germinated garden cress seeds, demonstrating a compositional changes during germination. The changes in polyphenol concentrations may be attributed to the action of endogenous seed enzymes, which increase during germination (Duenas *et al*., 2009). These results are in agreement with those reported by (Abdel-Aty *et al*., 2021), who found that the concentration of phenolic compounds increased several-fold in the 7-day chia sprouts compared to the chia dry seeds, such as P-hydroxybenzoic, Apigenin, and a new phenolic acid appeared after germination, such as P-coumaric acid and Kaempferol. Additionally, Pyrogallol, Catechin, and Sinapic were the major phenolic compounds in raw garden cress seeds. Pyrogallol dramatically increased 247-fold on day 6 of garden cress sprouts, which had strong antibacterial, antifungal, and anticancer activity (Abdel-Aty *et al*., 2019; AL-Sayed *et al*., 2019). The germination process had a positive effect on raising the flavonoids and isoflavone compounds, content in garden cress seeds and the results are in agreement with those reported by (AL-Sayed *et al*., 2019) who found that Apigenin, Naringenin, and Rosmarinic were the predominant flavonoid compounds detected in raw garden cress seeds.

Germination process caused notable changes in the profiles of flavonoids and isoflavones of germinated garden cress seeds, showing markedly higher levels than raw ones .The elevation of flavonoid and isoflavone compounds following the germination process could be ascribed to the fact that the germination process involves water uptake, activation of metabolic enzymes, and mobilization of nutrient reserves, which improve the biosynthesis of phenolic compounds, including flavonoids and isoflavones (Tufail *et al*., 2024), as well as the activation of enzymes that convert precursor molecules into these flavonoids or release them from complex forms during seed metabolism (Bhatia, 2024). Data of B-complex and fat-soluble vitamins recorded that the germination process had a positive effect on raising the content of both B-complex and fat-soluble vitamins in garden cress seeds. The increase in vitamin B complex levels could be due to the fact that seeds synthesize vitamins during the germination process for their

development. These results align with those of (Kong *et al*., 2022), who reported that the content of vitamin E (a fat-soluble vitamin) rose during the germination of brown rice.

These results clearly demonstrate that germination significantly enhances the content of both B-complex and fat-soluble vitamins in garden cress seeds, which can be attributed to the increased enzymatic and metabolic activities during the germination process, which not only boosts vitamin biosynthesis but also promotes the hydrolysis of macromolecules and favors the synthesis of vitamins for growth and development (Guzmán -Ortiz *et al.,* 2014). Furthermore, these enzymes promote a greater availability of nutrients and prevent the formation of complexes, making proteins more accessible for hydrolysis (Lakshmipathy *et al*., 2024).

It be clearly seen that germination significantly changes the fatty acids composition of garden cress seeds. These results are in agreement with those reported by (Vaishnavi, 2020), who reported that germination significantly alters the fatty acids content of garden cress seeds. During germination, lipolytic enzyme activity increases, breaking down stored triacylglycerol's into monoacylglycerols and free fatty acids, thereby altering the quantity and type of fatty acids present. This process often results in a reduction in total fat content and a change in the balance of specific fatty acids. The data of fresh orange juice are in agreement with (Agbaje *et al*., 2020), who reported that the physicochemical properties of orange juice show the following range of values for acidity (1.06%), total soluble solids (8.20%), total sugars (9.56%), moisture content (88.20%) and Vit.C (27.18%). Furthermore, (Saad, 2017) found that the bioactive compound of orange juice was 56.63 % for antioxidant activity, 80.34 mg/100ml for total phenols, and 17.93 mg/100ml for total flavonoid contents.

The results of sweet potato powder are in agreement with the results reported by (Zhao *et al*., 2024), who found that sweet potato is a nutrient-dense tuber widely recognized for its rich content of carbohydrates, dietary fibers, and bioactive compounds such as β-carotene and phenolic contents. (Ji *et al*., 2015) mentioned that total phenols contents in sweet potato cultivars ranged from 9.6 to 54.3 mg/g dry weight and antioxidant capacity between 43.3 and 81.2 mg/g. Moreover, a comparative study found sweet potato vitamin C content ranged from 8.17 to 66.09 mg/100g, total polyphenols from 0.32 to 13.82 µg/g, and total carotenoids from 0.22 to 559.70 µg/g (Xi-You *et al*., 2024). Blend 2 (15% germinated seeds powder and orange juice) exhibited the highest overall palatability scores (42.9) comparing with control one. These findings are consistent with previous research, which has shown that moderate levels of germinated garden cress seeds are well accepted in food products, but higher levels can lead to a decline in sensory scores, likely due to the seeds' distinct flavor and textural impact (Sharma, 2015). Using orange juice as a rehydration medium enhances sensory qualities, possibly by masking any bitterness and improving overall sensory attributes especially, flavor and color.

Finally, it could be concluded that sweet potato puree fortified with 10–20% germinated garden cress seeds and rehydrated by orange juice displayed the best balance of sensory attributes, overall acceptability and produce untraditional and nutraceutical puree with good nutrient balance and more palatable among different consumers.

CONCLUSION

Germinated garden cress seeds *(L. sativum*) represent a promising natural source of essential nutrients, particularly bioactive compounds, bioavailable iron, calcium, vitamins (A, C, and E), and beneficial oils. The germination process significantly enhances the nutritional profile and functional properties of the seeds, making them a potent ingredient for improving the health benefits of sweet potato puree blends and rehydrated with fresh orange juice improved sensory palatability and increased the bioavailability of iron and calcium contents. Their high iron content can aid in addressing iron-deficiency anemia, while the abundance of vitamins and unsaturated fatty acids contributes to antioxidant defense. Therefore, the fortification of germinated garden cress seeds powder into food formulations holds great potential for developing functional foods aimed at combating micronutrient deficiencies and supporting public health.

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الإستفاده من بذور حب الرشاد (*Ipidium sativum* L.) المنبته كغذاء وظيفى غير تقليدى

أمل محمد البسطويسى غازى* و عزيزة ثروت جمال مصطفى

قسم بحوث تكنولوجيا تصنيع الحاصلات البستانية- معهد بحوث تكنولوجيا الاغذية - مركز البحوث الزراعية

* بريد المؤلف المراسل: ghazy68@yahoomail.com

الملخص العربى

يعتبر حب الرشاد *(Lepidium sativum L.)* من المحاصيل قليلة الإستغلال رغم ما يتميز به من قيمة غذائية عالية، ولا يزال استخدامه في الصناعات الغذائية محدودًا نتيجة لإحتوائه على بعض العوامل المضادة للتغذية ومشكلات اخرى مرتبطة بالقبول الحسي. ولهذا هدف البحث الى دراسة التركيب الكيميائى والمركبات الحيوية النشطة في بذور حب الرشاد بعد إجراء عملية الإنبات لها ، وإستخدامه كمصدر رئيسى لإنتاج منتجات صحيه وغير تقليديه من بيوريه البطاطا الحلوة ذات قيمة غذائية وخصائص جودة عالية ولها قبول حسي عالى لدى للمستهلكين. وأظهرت النتائج المتحصل عليها أن عملية الإنبات أسهمت بفاعلية في تعزيز القيمة الغذائية والوظيفية لبذور حب الرشاد من خلال زيادة محتواها من البروتين والمركبات الفينولية والنشاط المضاد للأكسدة، إلى جانب خفض المكوّنات المضادة للتغذية وخاصتة حمض الفيتيك. كما أدت إطالة فترة الإنبات إلى ارتفاع ملحوظ في نسبة المعادن، وخاصة الكالسيوم والبوتاسيوم واللذان سجلا اعلى نسبة من 590.58 إلى 660.85 ملجم/100جم ومن 82.34 إلى 112.33 ملجم/100جم على الترتيب . ووجد ان البيروجالول هو المركب الفينولى السائد فى البذور المنبته (227.58 ملجم/100جم)، والذى ارتفعت نسبته اكثر من 72 ضعفًا عقب عملية الإنبات. لوحظ ان عملية الإنبات لها تاثير ايجابى على زيادة محتوى كلا" من مركبات الفلافونويدات والإيزوفلافونات ومجموعة فيتامين ب والفيتامينات الذائبة في الدهون وخاصة فيتامين K و الذى يعتبر الفيتامين السائد فى بذور حب الرشاد المنبته والذى تضاعفت نسبته اكثر من اربع اضعاف بعد عملية الإنبات ليصبح 78.89 ملجم/100جم.

وعامة أدت إضافة مسحوق بذور حب الرشاد المنبتة بنسبة 10–20% الى خلطات بيوريه البطاطا الحلوة الممزوجة بعصير البرتقال الطازج إلى تحسين الخصائص الحسية، حيث سجلت أعلى درجات التقييم الحسى مقارنة بالعينة الكنترول . وعموما اثبتت النتائج المتحصل عليها من الدراسه أن بذور حب الرشاد المنبتة تعتبر مكوّنًا غذائيًا وظيفيًا واعدًا لتطوير منتجات غذائية مبتكرة ذات قيمة مضافة، تجمع بين التوازن الغذائي العالي والفوائد الصحية وذات قبول حسى عالى لدى المستهلكين.

الكلمات المفتاحية: بذور حب الرشاد ، الإنبات، المركبات الحيوية النشطة، المواد الضارة غذائيا"