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ORIGINAL ARTICLE

Influence of Germination on Nutraceutical, Nutritional, Anti-Nutritional and Functional Characteristics of Foxtail Millet

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ABSTRACT
The present investigation entitled "Influence of germination on nutraceutical, nutritional, anti-nutritional and functional characteristics of foxtail millet " was carried out in the Division of Food Science and Technology, SKUAST Kashmir, Shalimar and department of food technology RIMT university Punjab. The goal of the current study was to investigate how germination affected the functional, anti-nutritional, and nutraceutical properties of foxtail millet. Foxtail millet seeds were soaked all night and allowed to germinate for 48 hours at a temperature of 25°± 2°C.After germination samples were analyzed for physicochemical composition, functional, nutraceutical, anti-nutritional properties .The results revealed that the germination significantly (p≤0.05) decreased crude fat from 4.43±0.015% to 4.16±0.015%, carbohydrate from 60.94±0.036% to 59.47±0.037% and ash content from 2.97±0.094% to 2.53±0.032% while a significant (p≤0.05) increase was noticed in crude protein content from 12.31±0.01% to 14.58±0.015% and crude fiber from 7.51±0.011% to 7.73±0.018%. Further, nutraceutical characteristics were improved on germination. The results revealed that total phenolic content, total flavonoids and antioxidant activity - DPPH increased from 33.33±0.017mg/g to 86.42±0.012mg/g, 24.14±0.007mg/g to 53.74±0.015mg/g and 50.33±0.014% to 61.63±0.001% respectively after 48 hours of germination. A significant (p≤0.05) decrease in anti-nutritional components (tannins- 2.71 ± 0.003mg/g to 0.90±0.004mg/g and phytic acid- 0.45±0.003mg/g to 0.19±0.002mg/g) was found after germination for 48 hours. The functional properties were also improved upon germination. The results revealed that the values of water absorption capacity, water solubility index, emulsifying capacity, oil absorption capacity and foaming capacity increased significantly from 145.40 ± 0.119ml/g to 154.66 ± 0.48ml/g, 3.82 ± 0.02% to 6.72 ± 0.08%, 49.22 ± 0.009 to 66.52 ± 0.01, 78.53±0.088ml/g to 96.13±0.021ml/g and 6.76 ±0.088% *to* 9.167±0.145 *% respectively after 48 hours germination.*
Keywords : Foxtail millet, Germination, Physicochemical analysis

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INTRODUCTION

Millets are a crucial crop for ensuring food security in semi-arid regions and have long been considered one of the staple foods [1]. Millets were once thought to be a staple of the lower socioeconomic classes [2]. Recent health claims, such as low glycemic index, gluten-free, and high levels of dietary fibre and minerals, have, nevertheless, classified them as functional foods [3]. Millets are also a natural way to maintain the productivity of drylands due to their climate-friendly characteristics, such as their need for little to no irrigation, capacity to thrive in poor soil, and resilience to insects and pests [4].

According to [5]., foxtail millet (*Setaria italica* L.), which has the sixth highest yield of any millet variety, is a significant millet in terms of global production. In the approximately 29 million tonnes of millet produced globally (during the 2015–16 season), foxtail millet comes in second place. China is the world's top producer of foxtail millet, accounting for 80% of global production, followed by India with 10% [6]. It is native to the Yellow River Basin country. One of the earliest cereal grains to be domesticated is foxtail millet, which is a member of the Setaria genus and the Poaceae family and subfamily.

Foxtail millet grains have layers of husk and bran, just like other millet grains. Due to its medicinal qualities and antioxidant capacity, it is recommended for usage in several nutritional and health foods. Additionally, foxtail millet have shown lot of health benefits shown to have a number of health benefits which includes ability to lower blood sugar and cholesterol levels and prevent cancer. Due to its non-glutinous and non-acid-generating characteristics, foxtail millet can be considered a readily digestible grain in 2015, similar to buckwheat and quinoa.

Like the majority of millets, foxtail millet promotes bowl movement, aids in digestion, and is a good source of crude fibre. It has a laxative effect as a result, which is advantageous for a healthy digestive system. The protein and mineral content of foxtail millet seeds is higher [7]. Due to its high lysine content, it can be used as a supplemental protein source and potential functional food element in the majority of cereals. To lessen the anti-nutritional elements and improve the digestibility of finger millet, germination is a major and practical method [8]. Grain that is still germination can be dried to a lower moisture content for additional processing and storage. The chemical composition, usable characteristics, and mineral content of the grains alter during germination [9].

According to [10] discovered that through causing the activation of latent enzymes, germination has the power to significantly modify the biochemical, nutritional, and sensory aspects of seeds. Germination (sprouting) is the most practical and economical method for improving the nutraceutical value of cereals, pseudo-cereals, and legumes. Functional components like polyphenols and flavonoids are found in nutritive and functional meals, and they have the power to delay or block the oxidative process, thereby preventing oxidation and cellular damage. One of the reasons that sprout ingestion is considered to be a key component in lowering human diseases linked to oxidative stresses is because germination can boost the antioxidant activity of these chemicals [11].

Keeping into view the above points the present study is therefore, proposed with the following objectives:

To study the influence of germination on nutraceutical, nutritional, anti-nutritional and functional characteristics of foxtail millet.

MATERIAL AND METHODS

The present investigation entitled "influence of germination on nutraceutical, nutritional, anti-nutritional and functional characteristics of foxtail millet" was carried out at the Division of FST, SKUAST-Kashmir Shalimar J&K and department of food technology RIMT University Punjab. Below is an overview of the particular instruments and techniques used during the research process.

MATERIALS

Raw materials

Some of raw ingredients such as foxtail millets were procured from the fields of Bhaderwah.

Chemicals

The ultrapure grade chemicals used for the current studies were bought from reputable manufacturers, such as sulfuric acid, NaoH, copper sulphate, potassium sulphate, solventdiethyl ether, boric acid, bromo-cresol green, methyl red, NaCl, ammonium bicarbonate, sodium bicarbonate Merck India, Hi-Media and Sigma.

CHEMICAL ANALYSIS

Moisture content

Pre-weighed samples (2 g) of each flour were dried for an hour at 130°C in a hot air oven (make: Tanco India Ltd.); the moisture content in percent was then determined from the weight loss [12].

$$\textit{Moisture content (\%)} = \frac{\text{Weight of original sample (g)} - \text{weight of dried sample (g)}}{\text{Weight of original sample (g)}} \times 100$$

Ash content

In a silica crucible that had already been pre-weighed, one gram of moisture-free sample was recovered. By gradually heating over a flame, preliminary ash was produced, allowing fat to be smoked off without being burned. The sample was burned for eight hours at 600 °C in a muffle furnace after it stopped smoking. The crucibles were taken out, weighed, and allowed to cool in a desiccator before being returned. The weight in difference of the crucible wand was used to compute the ash content, which was then represented as a percentage.

$$Ash\ Per\ cent = \frac{Weiht\ of\ ash\ (g)}{Weight\ of\ Sample\ (g)} \times 100$$

Crude protein

In order to convert nitrogen content to crude protein using the micro-Kjeldahl method, a ratio of 6.25 was utilized.In a Kjeldahl digestion flask, combined sulphuric acid (20 ml) and digestion mixture (10.0 g) are used to break down a 1.0 gram weighted sample. Before being transferred to a 250 mL volumetric flask, the ingredients were chilled. With distilled water, the volume was raised to the required level and then mixed. A predetermined amount was put into a distillation flask, and then 40.0 percent sodium hydroxide was added to it. A condenser was used to obtain ammonium borate, which was then placed in a flask with 10 ml of a 4 percent boric acid solution. A 0.1 N sulfuric acid titration was performed on the distillate. Along with the sample, a blank sample was also collected.

$$\text{Nitrogen \%} = \frac{\text{Titre value X 0.00014 X volume made}}{\text{Aliquottaken (g) X Weight of sample (g)}} \times 100$$

Crude fat:

To evaluate crude fat, the soxhlet extraction technique was performed. The sample's fat content was simply extracted into petroleum ether, an organic solvent, between 60 and 80 degrees Celsius, and then refluxed for six hours. The proportion of fat content was calculated using the formula.

$$\text{Crude fat percent} = \frac{\text{Ether extract amount (g)}}{\text{Weight of Sample (g)}} \times 100$$

$$= \frac{W2-W1}{W} \times 100$$

Sample Weight = W (g)
Empty Beaker Weight = W1 (g)
Empty Beaker weight+ content fat (ether extract) W2 (g)

Crude fiber

Applying the AOAC [12] standard method, crude fibre was calculated. 200ml of 125 percent sulphuric acid was added to a two-gram sample that had been removed from moisture and fat. Beaker boiled for 30 minutes after being placed on a digestion device with a previously controlled hot plate.

Carbohydrate (%):

The difference method was used to calculate the amount of carbohydrates. It was obtained by deducting 100 from the sum of the percentages of moisture, fat, protein, fibre, and ash.

Carbohydrate (%) =100- (moisture % + fat %+ protein % + ash%+ fiber %).

Calorific value

It was estimated based on the contents of crude protein (N × 6.25), fats and carbohydrates using the Atwater factors of 4.0, 9.10 and 4.2 K Cal/g of each component, respectively [12].

Phytic acid

The assay of phytic acid is based on modified colorimetric method. The detailed method is given below

Requirements: Beakers, test tubes, 0.2 N HCl buffer, Wade reagent (0.03% FeCl3.6H2O + 0.3% sulfosalicylic acid), double distilled water (ddH2O), centrifuge, spectrophotometer,

Procedure:

The 30 mg of ground seed sample was used for extraction of phytic acid in 0.2 N HCl buffer and kept overnight. Crude acid extracts were shifted to fresh tubes containing 20 mg NaCl. The contents were of tubes were shaken at 350 rpm for 20 min to dissolve the salt present in solution and were allowed to rest at 20°C for 20 min. The mixture was then centrifuged at 8000 rpm for 20 min at 10°C and clear supernatant was diluted 25 times by mixing with distilled water. Then, 750 µl of this diluted sample was combined with 250 µl of modified Wade reagent (0.03% FeCl3.6H2O + 0.3% sulfosalicylic acid) in a eppendorf tube, thoroughly mixed on a vortex, and centrifuged at 8000 rpm at 10°C for 10 min. A series of calibration standards containing 0, 0.5, 1, 1.5, 2, 3, 4, 5, 7.5, 10 and 12 µg ml−1 phytic acid-P were prepared from sodium phytate (Sigma-Aldrich). Absorbance of color reaction products for both samples and standards wereread at 500 nm on a UV-Vis spectrophotometer (Labtronics), and calculation of phytic acid-P content was estimated by the method.

Total Phenolic contents

The total phenolic content was determined by using Folin-Ciocalteu reagent following a slightly modified method. Gallic acid was used as a reference standard for plotting calibration curve. A volume of 0.5 mL of the plant extract (100 µg/mL) was mixed with 2 mL of the Folin-Ciocalteu reagent (diluted 1:10 with de-

ionized water) and were neutralized with 4 mL of sodium carbonate solution (7.5%, w/v). The reaction mixture was incubated at room temperature for 30 min with intermittent shaking for color development. Using a microprocessor visible spectrophotometer (711- SNV), the absorbance of the resulting blue colour was determined at 765 nm. The total phenolic contents were determined using a standard curve created using gallic acid and its linear equation. a dry extract's total phenol content is expressed as milligrams per gram of gallic acid equivalent (GAE).

Total flavonoid content

The total flavonoid content of millet extracts was determined using [13] technique. 0.1 ml of acidified methanolic extract was added to 4.9 ml of distilled water. At time zero, 0.3 ml of (5% w/v) NaNO2 was added. 0.3 ml of 10% w/v AlCl3 and 2 ml of 1 M NaOH were added after waiting for 5 minutes. Then, 10 cc of distilled water were added to the capacity to make it larger. The mixture was shaken vigorously before the absorbance at 510 nm was recorded. A calibration curve was generated using a standard catechin solution (R2 = 0.999). The results were expressed as mg catechin equivalents (CEQ)/100 g of material (dry basis).

Tannin content

The millet extracts' tannin content was evaluated using the modified vanillin-HCl method (Price, Van Scoyoc, & Butter, 1978). 5 ml of the Vanillin-HCl reagent were added right away to 0.1 ml of the acidified methanolic extract after it had been diluted to 1 ml with distilled water. The tubes underwent a test to determine the colour obtained at 500 nm after 20 minutes of standing at room temperature (30 C). A calibration curve was generated using a standard catechin solution (R2 = 0.998). The results were expressed as mg catechin equivalents (CEQ)/100 g of material (dry basis).

Antioxidant content

The amount of free radical scavenging activity was assessed using the DPPH (diphenylpicryl hydrazyl) technique. 25 mL of the sample's methanolic extract were added, and after holding the temperature at 200C for 30 minutes, 500 microliters of the 0.5 Mm DPPH solution and 2 ml of the 80 percent methanol aqueous solution were added. The absorbance was then measured using a 517 nm (80 percent methanol and tries buffer) wavelength. By contrasting the absorbance of the sample solution with that of a control solution made up entirely of distilled water, the sample solution's (free radical scavenging activity) was determined. [14].

$$\text{Radical scavenging activity (\%)} = \frac{\text{Control OD(0 min)} - \text{Sample OD(30 min)}}{\textit{Control OD (0 min)}} \times 100$$

Water activity

The water activity was measured using a water activity metre (AquaLab, Model 3TE, Decagon Devices Inc., Pullman, WA).

Water absorption capacity and water solubility index

The capacity of flour to absorb water was evaluated.3 g of flour was put to pre-weighed centrifuge tubes along with 25 mL of distilled water. The dispersion was stirred for 10 minutes before being centrifuged at 3000g for 25 minutes. The tube was left upside-down for ten minutes in order to drain off the supernatant. The supernatant was collected in dry, pre weighed Petri plates and dried for 24 hours at 105 °C in a hot air oven based on its ability to absorb water. Results were presented as a percentage-based water solubility index.

Oil absorption capacity

In a pre-weighed centrifugal tube, refined oil of 10ml (Soybean Refined Oil, Fortune Brand, India) and 0.5 g of flour were combined, and the mixture was vortexed for 10 minutes. For 25 minutes, the tubes were centrifuged at 3000g. The centrifuge tubes were weighed after being inverted for 10 minutes to drain the oil.

Emulsifying capacity

The Yasumatsu (1972) approach was utilised. To generate emulsions, 2 g of each sample were mixed with 20 ml of distilled water that was cold (40ºC), 20 ml of refined sunflower oil, and 50 ml in a centrifuge tube. After that, the samples were vortexed for a minute. The tubes were immediately spun at 4000 g for 10 minutes. The emulsified layer's height as a percentage of the material's overall height was used to calculate the emulsifying capacity using the calculation below:

$$\text{Emulsion activity} = \frac{\textit{height of emulsion layer}}{\textit{height of whole layer}} \times 100$$

Foaming capacity

The method developed by [15] was used to calculate the foam capacity. To determine the various foxtail millet samples' ability to produce foam, 2 g of the substance were combined in a typical electric mixing apparatus (Kenstar Supermix, Kenstar Company, Mumbai, India). The mixture was then stirred at 12,000 rpm for 6 minutes at 270 0C after 100 ml of distilled water had been added. The volume of the foam was rapidly calculated and quantitatively transferred to a measuring cylinder holding 250 ml [15].

RESULTS AND DISCUSSION

The experiments pertaining to the present investigation were carried out to study the impact of germination on nutritional characteristics of foxtail millet for the development of cookies.

The results of experiment obtained in the present investigation have been discussed here with their suitable reasoning.

Experiment 1: Evaluation of the effect of germination on nutraceutical, nutritional and functional characteristics of foxtail millet.

Germination of foxtail millet: The foxtail millet was germinated using the following condition:

Time : 48 hours

Temperature : 25 degree Celsius (Ambient).

Nutritional, nutraceutical and functional characteristics of germinated foxtail millet flour:

Both ungerminated and germinated millet flour was evaluated for the following parameters:

Proximate composition

The proximate composition of ungerminated as well as germinated millets was determined. Data pertaining to the proximate composition of millets is presented in the table no1.

Moisture content (%)

Moisture content of ungerminated foxtail millets (11.83±0.012%) was found to be significantly($p \leq 0.05$) higher than the germinated millets with moisture content of 11.51±0.012%.

Crude Protein (%)

Millets that had germinated were found to have a crude protein level that was substantially higher (p 0.05) than those that had not germinated, which had a protein content of 12.31±0.011. The biological production of additional amino acids, as well as the absorption and breakdown of other components during germination, may be responsible for the rise in protein concentration. These findings were consistent with earlier research that had been published [16].

Crude fat (%)

After 48 hours of germination, the crude fat level considerably reduced from 4.43±0.015% to 4.16±0.015%. According to [17], the oxidation of fat to fatty acids and water and consumption as a carbon source may be the reason for the reduction in fat content following germination.[17] reported that finger millet's crude fat content decreased 36 hours after germination. After seven days of germination, [18] showed a 10% drop in the crude fat of buckwheat.

Crude fibre (%)

After 48 hours of germination, it noticed that the fibre content had substantially increased, going from 7.51±0.011% to 7.73±0.018%. The quick loss of starchy components could be the cause of the rise in crude fibre content. The amount of crude fibre can also be increased by the portions of roots and shoots that are still attached to millet grains after deculming. This may also be the result of changes made to the seeds' cell wall polysaccharides, which may have an impact on the tissue's histology's integrity and cause disruptions in the protein-carbohydrate interaction. The synthesis of novel food components was made possible by the requirement for a sizable quantity of cell wall biosynthesis [19]. Same results regarding how germination affects the dietary fibre in foxtail millet. For mung bean, pea, and lentil seeds that had already germination, [20] reported the same capacity for crude fibre.

Ash content (%)

Ash content was adversely affected by germination, falling considerably from an initial value of 2.97±0.044% to 2.53±0.032% after 48 hours. Reduced ash content is seen by [21]. The removal of the roots and shoots of germinated grains can abrasively remove the bran layer, which may also result in the loss of minerals. Similar findings have been found by [22].

Carbohydrate (%)

Ungerminated foxtail millets had a substantially higher carbohydrate content (60.94±0.036%) ($p \leq 0.05$) than germinated millets, which had a carbohydrate value of 59.47±0.037%. An increase in alpha amylase activity, which converts complex carbs into sugars that are simpler to digest, may be responsible for the decrease in carbohydrates seen in germinated grains.

Energy value

Energy value of ungerminated foxtail millets (332.90±0.18%) was found to be significantly($p \leq 0.05$) lower than the germinated millets with energy value of 333.71±0.21%.

Table no.1 Effect of germination on the physicochemical properties of foxtail millet.

S.no	Parameters	Ungerminated	Germinated
1	Moisture content	11.51±0.012a	11.83±0.012b
2	Water activity	0.45±0.008a	0.56±0.008b
3	Crude protein	12.31±0.011a	14.58±0.015b
4	Crude fat	4.43±0.015b	4.16±0.015a
5	Crude fibre	7.51±0.011a	7.73±0.018b
6	Ash	2.97±0.094b	2.53±0.032a
7	Carbohydrates	60.94±0.036b	59.47±0.037a
8	Energy value	332±0.182a	333.71±0.21b

Values are shown as the mean ± S.D values subscripted in the row differ significantly ($p \leq 0.05$).

Nutraceutical characteristics

Total phenolic content

The foxtail millet that has been germinated has a good amount of total phenols, as evidenced by its total phenolic content (86.42±0.012%). The total phenolic content of ungerminated foxtail millets was considerably (p 0.05) lower (33.33±0.017%). Cell wall-degrading enzymes became active during germination and altered the structure of the grain's cell wall, which led to a rise in the content of phenolic compounds in foxtail millet seeds. This is significant because associations like ester and ether bonds allow phenolic chemicals like hydroxycinnamates (such as ferulic and p-coumaric acids) to remain bonded to non-starch polysaccharides in grain cell walls. Cell wall-degrading enzymes, primarily esterase's, act on these bonds to release the bound phenolic chemicals. A rise in polyphenols during germination, however, might also be a result of a rise in the overall percentage of seed coat at later stages of germination due to the loss of carbohydrates. According to [23], the phenols are often contained in the seed coat (pericarp and aleurone layer) of the grains.

Total flavonoids

The germination process increased the results for the total flavonoid contents of foxtail millet substantially (p 0.05). Following germination, the total flavonoid content increased from 24.14±0.007 to 53.74±0.015mgRUE/g. This might be the result of the biochemical modifications that seeds go through during germination, which, as a result of enzyme activation, may have resulted in the formation of secondary plant metabolites, such as flavonoids, or the release of glycones from conjugated glycosides. During the thermal processing of Brazilian beans and oak acorns, respectively, a rise in the flavonoid contents was also noted [24].

Antioxidant activity – DPPH

The table below lists the total antioxidant capacity of foxtail millet flour's ungerminated and germinated polyphenolic extracts, given as mg AAE/100 g. According to the findings, foxtail millet extract's overall antioxidant capacity was considerably (p 0.05) impacted by the germination process. After germination, the total antioxidant capacity increased from 50.33±0.014 to 61.63±0.001 mgAAE/g. The increase could be related to the endogenous hydrolytic enzymes' increased production of polyphenolic chemicals as well as the glutamate decarboxylase enzyme's conversion of glutamate in the sample to -amino butyric acid [25].

Table No.2 Impact of germination on the nutraceutical properties of foxtail millet

S.No	Parameters	Ungerminated foxtail millet	Germinated foxtail millet
1	Total phenolic content	33.33±0.017a	86.42±0.012b
2	Total flavonoids	24.14±0.007a	53.74±0.015b
3	Antioxidant activity	50.33±0.014a	61.63±0.001b

Values are shown as the mean ± S.D values subscripted in the row differ significantly ($p \leq 0.05$).

Functional characteristics

Millets' functional characteristics are essential for the production of new products. During germination, these characteristics are transformed.

Water absorption capacity

The capacity to absorb water increased from 145.4± 0 0.119 to 154.66± 0.481 after 48 hours of germination. The increased ability to absorb water and oil is due to an increase of damaged starch and surface area. Damaged starch absorbs more water because it is more hygroscopic than native starch. [26] reported similar results for the germination of Amaranthus grains.

Water solubility index

After 48 hours of germination, WSI was found to have raised from 3.827±0.023 to 6.720±0.083, a substantial increase with longer germination times. The rise in WSI may be caused by the breakdown of starch into smaller granules and an increase in sugar content.

Oil absorption capacity

Oil absorption capacity increased from initial 78.53±0.088 to 96.13 ±0.021after 48 hours germination.

Foaming capacity

According to [27], the amount of protein, salts, carbohydrates, lipids, temperature, and pH all affect foaming capacity. After germination for 48 hours, foaming capacity increased from 6.76 ±0.088 to 9.16±0.145%.

Table No.3 Impact of germination on the functional properties of foxtail millet

S.No	Parameters	Ungerminated foxtail millet	Germinated foxtail millet
1	Water absorption capacity	145.40 ± 0.119a	154.66 ± 0.481b
2	Water solubility index	3.82 ± 0.023a	6.72 ± 0.083b
3	Emulsifying capacity	49.22 ± 0.009a	66.52 ± 0.01b
4	Oil absorption capacity	78.53±0.088a	96.13±0.021b
5	Foaming capacity	6.76 ±0.088b	9.167±0.145a

Values are shown as the mean ± S.D values subscripted in the row differ significantly (p≤0.05).

Antinutritional components:

With longer germination times, the antinutritional components considerably (p≤0.05) decreased. The results of antinutritional components are presented in table no. 4.

Tannins

The tannin concentration of foxtail millet that has been germinated is 0.90±0.004%, which is considerably (p≤0.05) greater than the tannin content of ungerminated millet, which is 2.71±0.003%. During soaking leaching of soluble tannin molecules occurs, a significant reduction in tannin content could be noticed throughout the germination phase, and this reduction continued during successive germination [28].

Phytic acid

Ungerminated foxtail millets had a much greater phytic acid level (0.45±0.003%) than germinated millets (0.193±0.002%), according to studies. The amount of phytic acid significantly decreased as germination time increased because of the enzyme phytase's increased hydrolytic activity [29]. Phytase activity during germination assists in lowering the concentration of phytic acid by hydrolyzing phytate phosphorus into inositol monophosphate.

Table No.4 Impact of germination on the anti nutritional characteristics of foxtail millet

S.NO	Parameters	Ungerminated foxtail millet	Germinated foxtail millet
1	Tannins	2.71 ± 0.003b	0.90±0.004a
2	Phytic acid	0.45±0.003b	0.19±0.002a

Values are shown as the mean ± S.D values subscripted in the row differ significantly (p≤0.05)

CONCLUSION

The germination had a major effect on the nutritional attributes, nutraceutical characteristics, functional attributes, and antinutritional components, according to the results. Moisture content, crude protein content, and crude fat content all significantly increase after germination (p ≤0.05). After germination, the amount of crude fat, carbohydrates, and ash considerably (p≤0.05) reduced. After 48 hours of germination, the total phenolic, flavonoid, and antioxidant contents all considerably (p≤ 0.05) increased. Values for tannin and phytic acid decreased significantly (p≤0.05). Germination, water absorption, water solubility index, oil absorption, emulsifying capacity, and foaming capability all enhanced after 48 hours.

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Conflict of interest

No conflict of interest exists among authors.

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