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Impact of grain germination on *in vitro* antioxidative properties, nutrients digestibility, and functional attributes of brown rice flour

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ABSTRACT

Brown rice was germinated for different times (12, 24, 36, and 48 h) at different temperatures (25, 30, and 35 °C) with the aim to improve the *in vitro* digestibility and antioxidant potential of the flour made from it. Results showed that increase in germination time and temperature increased *in vitro* digestibility of starch and protein during germination of brown rice owing to depolymerisation of starch and protein molecules by enzymatic activity. After germination under varying conditions, antioxidant activity increased from 50.19 to 95.58%, total phenolic and flavonoid contents from 0.88 to 2.02 mg GAE/g and 34.06–62.94 mg QE/100g, respectively. Germination at elevated temperature (35 °C) for prolonged time (48 h) also increased the reducing power by 60.49% and metal chelating activity by 114.50% as a result of structural breakdown of bound phenolics. Increased activity of hydrolytic enzymes with progress in the germination time and temperature also results in continuous reduction in the pasting properties and lightness values (L), while increasing a* and b* values of the flour of germinated brown rice. Tailored germination, therefore, can be offered as a tool to increase nutrient digestibility and bioactive potential of brown rice as compared to non-germinated brown rice, thus, producing naturally modified flour with enhanced functionality.

KEYWORDS

germination, brown rice, *in vitro* digestibility, antioxidant activity, pasting properties

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1. INTRODUCTION

Brown rice, obtained from paddy after dehusking is rich in nutritional as well as bio-functional components. It is a rich source of tocopherol, tocotrienol, oryzanol, ferulic acid, phytosterols, phenolic compounds, and γ-aminobutyric acid (GABA) as bran and embryo contain numerous nutritional and bioactive components (Singh et al., 2017). Germination activates dormant enzymes such α-amylase, β-amylase, β-glucanase, pentosan, invertase, maltase, cellulose, and proteases (Zhang et al., 2014). Enzyme activation during germination softens the outer bran layer through breakdown of starch and protein in the grain, resulting in improved texture and a sweet flavour (Gujral et al., 2012). Degradation of starch and protein during germination by action of various hydrolytic enzymes also results in improving the *in vitro* starch and protein digestibility and absorption characteristics compared to non-germinated ones (Zhang et al., 2014). Biochemical activities taking place during germination result in synthesis/accumulation of secondary metabolites with health-promoting properties, such as vitamin C, tocopherols, flavonoids, tocotrienols, γ-aminobutyric acid (GABA), γ-oryzanol, and phenolic compounds, thus resulting in an increase of antioxidant and biological activity of the grains (Kim et al., 2015). Germinated grains have various health beneficial components, and their free radical scavenging properties showed protective effects against various oxidative stress-induced diseases (Cáceres et al., 2014).

Studies have reported that the content of accumulated bioactive compounds and changes in protein and starch digestibility and functionality of flour were strongly influenced by time and temperature during germination (Singh et al., 2018; Sharma et al., 2019). Influence of different germination temperatures of 25, 30, and 35 °C for short term germination (12, 24, 36, and 48 h) was not studied properly for the combined effect on the *in vitro* nutrient digestibility, bioactive compounds, antioxidant activities, pasting properties, and colour characteristics. Hence, the present study was targeted to fulfil this research gap and to examine the combined effect of different germination conditions on the functionality of brown rice for optimisation of germination condition for germinated brown rice flour.

2. MATERIALS AND METHODS

2.1. Preparation of brown rice and germinated brown rice

Paddy (cultivar PR 123) was processed using rubber roll Sheller (Stake Rice Mill, Japan). The obtained brown rice was soaked (10 h/25 °C), then it was spread onto and covered with double layer of damped cloth. Grains were then allowed to germinate for 12, 24, 36, and 48 h at 25, 30, and 35 °C (85% relative humidity) followed by drying as per method earlier described by Singh et al. (2017, 2018).

2.2. *In vitro* nutrient digestibility

In vitro starch digestibility and protein digestibility of non-germinated and germinated brown rice samples were determined by the method earlier described by Singh et al. (2019). Starch digestibility was assessed by employing pancreatic amylase and then measuring maltose liberated by dinitrosalicylic acid reagent. A two-step enzymatic proteolysis was carried out using pepsin and pancreatin under controlled conditions to assess protein digestibility.

2.3. Bioactive components

Antioxidant activity (AOA) in terms of DPPH radical scavenging activity was measured by the method of Gujral et al. (2012) using acidified methanol extract and measuring the absorbance at 515 nm. Spectrophotometric method was used to determine the total phenolic content (TPC) (Sharma and Gujral, 2011). Briefly, the aliquot was mixed with freshly diluted (10-fold) Folin–Ciocalteu reagent, which was then equilibrated and mixed with saturated sodium bicarbonate solution followed by 2 h incubation at room temperature. The absorbance of reaction mixture was read at 765 nm, and the results were expressed as mg of gallic acid equivalents (GAE)/g. Total flavanoid content was determined according to the method described in brief by Sharma et al. (2019), using 100 µl of aluminium chloride and potassium acetate solution followed by absorbance measurement at 415 nm after 30 min of reaction. The results were expressed as mg quercetin equivalent (QE)/100 g of sample. Reducing power was measured by mixing the extract with phosphate buffer and potassium ferricyanide solution, followed by incubation and addition of trichloroacetic acid solution and then centrifugation. The upper layer of supernatant was then mixed with equal proportion of water and ferric chloride solution, and absorbance of the reaction mixture was read at 700 nm. The results were expressed as µg of ascorbic acid equivalent (AAE)/g (Sharma and Gujral, 2011). Metal (Fe^{+2}) chelating activity of brown rice samples was measured by the procedure of Sharma and Gujral (2011), which follows the mixing of the sample extract with ferrous chloride solution and 80% methanol, followed by addition of ferrozine solution and measuring absorbance at 562 nm.

2.4. Pasting properties and colour characteristics

Pasting properties of samples were evaluated using Rapid Visco Analyzer (RVA) (Newport Scientific, Warrie Wood, Australia) according to the methodology earlier described by Singh et al. (2019). The colour analysis of the samples was done by using Hunter lab colorimeter (CR-300 Minolta Camera, Japan), and results were recorded as L (lightness), a^* (redness), and b^* (yellowness).

2.5. Statistical analysis

The data collected was subjected to analysis of variance (ANOVA), and Tukey's posthoc test was employed to check difference in means ($P < 0.05$) using SPSS statistical software version 16.0.

3. RESULTS AND DISCUSSION

3.1. *In vitro* starch digestibility

In vitro digestibility of starch from non-germinated brown rice was 20.96% and it increased from 23.16 to 28.56% under different germination conditions (Table 1). Results also showed that both germination time and temperature significantly increased the *in vitro* digestibility of starch. Germination induces metabolic and structural changes of starch both in molecules and in crystallites form, and the residual components after germination show increased susceptibility to enzymatic attack, which results in enhanced starch digestibility of germinated brown rice (Singh et al., 2018). Similar results for increase in *in vitro* digestibility of starch due to degradation of starch chains by the amylolytic enzymes were also observed by Xu et al. (2012).

Table 1. Effect of germination conditions on *in vitro* digestibility of nutrients in germinated brown rice flour

Germination temperature (°C)	Germination time (h)	*In vitro* nutrient digestibility	
		Starch digestibility (%)	Protein digestibility (%)
Control		20.96 ± 0.28^{g}	61.83 ± 0.40^{h}
Soaked 25 °C 10 h		21.56 ± 0.00^{g}	62.85 ± 0.56^{h}
25	12	23.16 ± 0.00^{Qf}	65.73 ± 0.73^{Rg}
	24	23.76 ± 0.28^{Qef}	67.81 ± 0.42^{QRfg}
	36	24.56 ± 0.28^{PQde}	68.83 ± 1.01^{Qf}
	48	25.56 ± 0.57^{Pcd}	72.04 ± 0.24^{Pe}
30	12	24.56 ± 0.28^{Rde}	68.89 ± 0.62^{Sf}
	24	26.16 ± 0.28^{Qbc}	72.50 ± 0.53^{Re}
	36	26.96 ± 0.28^{PQb}	75.98 ± 0.62^{Qd}
	48	27.16 ± 0.57^{Pb}	79.96 ± 0.59^{Pc}
35	12	24.76 ± 0.00^{Sde}	76.79 ± 0.45^{Sd}
	24	26.36 ± 0.00^{Rbc}	80.03 ± 0.69^{Rc}
	36	27.36 ± 0.28^{Qab}	84.03 ± 0.40^{Qb}
	48	28.56 ± 0.28^{Pa}	88.05 ± 0.72^{Pa}

Values represent mean ± standard deviation; Values having different superscripts from a, b, c to l differ significantly ($P < 0.05$) from each other in each column separately among different treatments; Values having different superscripts P, Q, R, and S show significant ($P < 0.05$) differences during different germination time at each germination temperature.

3.2. *In vitro* protein digestibility

Non germinated brown rice shows an *in vitro* protein digestibility value of 61.83%, which increased from 65.73 to 88.05% as germination time increased from 12 to 48 h and temperature from 25 to 35 °C. During germination process, proteins were denatured by action of endogenous protease enzymes, which expose the sites of denatured protein and make it more susceptible to enzymatic hydrolysis resulting in increased *in vitro* protein digestibility (Sharma et al., 2019). A similar result for increase of *in vitro* protein digestibility due to proteolysis and partial solubilisation of nitrogenous compounds, which occurs during germination, was also observed in sorghum (Singh et al., 2019).

3.3. Antioxidant activity (DPPH radical scavenging activity)

Statistically significant ($P < 0.05$) difference was observed in antioxidant activity (DPPH scavenging ability) of non-germinated and soaked and germinated brown rice samples (Table 2). Antioxidant activity of brown rice prior to soaking was 41.54% and it increased marginally to 46.92% after 10 h of soaking at 25 °C. However, 48 h germination of brown rice at 25, 30, and 35 °C resulted in increasing the antioxidant activity of brown rice to 70.00, 90.38, and 95.58%, respectively. It was observed that as the germination time increased from 12 to 48 h and temperature from 25 to 35 °C, the antioxidant activity in germinated brown rice samples increased significantly. During germination, various hydrolytic enzymes were activated that

Table 2. Effect of germination conditions on the antioxidative properties of germinated brown rice flour

Germination temperature (°C)	Germination time (h)	Antioxidant activity (% DPPH inhibition)	Total phenolic content (mg GAE/g)	Total flavanoid content (mg QE/100g)	Reducing power (μg AAE/g)	Metal chelating activity (%)
Control		41.54 ± 1.09^{h}	0.65 ± 0.05^{j}	32.78 ± 1.13^{k}	19.85 ± 0.07^{l}	23.91 ± 0.31^{i}
Soaked 25 °C 10 h		46.92 ± 1.63^{gh}	0.46 ± 0.03^{k}	26.67 ± 1.57^{l}	20.59 ± 0.05^{k}	24.67 ± 0.77^{i}
25	12	50.19 ± 0.82^{Sfg}	0.88 ± 0.06^{Shi}	34.06 ± 0.55^{Rjk}	22.68 ± 0.06^{Sj}	28.48 ± 1.23^{Rh}
	24	54.81 ± 1.36^{Rf}	1.10 ± 0.15^{Rfg}	37.78 ± 0.44^{Qhi}	24.02 ± 0.22^{Ri}	30.54 ± 0.15^{Qgh}
	36	65.96 ± 1.90^{Qe}	1.22 ± 0.00^{Qde}	41.44 ± 1.57^{Pefg}	26.90 ± 0.15^{Qg}	31.96 ± 0.61^{Qg}
	48	70.00 ± 2.18^{Pe}	1.32 ± 0.15^{Pcd}	43.59 ± 0.79^{Pef}	30.90 ± 0.21^{Pe}	38.04 ± 1.23^{Pde}
30	12	77.88 ± 1.90^{Sd}	0.92 ± 0.15^{Sh}	36.39 ± 0.94^{Rhij}	23.45 ± 0.27^{Si}	33.15 ± 1.08^{Sfg}
	24	82.31 ± 2.72^{Rd}	1.16 ± 0.15^{Ref}	38.89 ± 0.79^{QRgh}	29.66 ± 0.07^{Rf}	40.87 ± 0.61^{Rd}
	36	87.50 ± 0.82^{Qc}	1.29 ± 0.08^{Qcd}	44.71 ± 0.85^{PQde}	32.17 ± 0.22^{Qd}	45.11 ± 0.46^{Qc}
	48	90.38 ± 0.54^{Pab}	1.60 ± 0.15^{Pb}	50.22 ± 0.63^{Pc}	33.90 ± 0.16^{Pc}	55.54 ± 1.08^{Pb}
35	12	88.08 ± 1.63^{Rbc}	1.02 ± 0.29^{Rgh}	40.21 ± 0.80^{Sfgh}	25.02 ± 0.00^{Sh}	35.65 ± 0.61^{Sef}
	24	90.58 ± 1.90^{QRab}	1.10 ± 0.09^{Rfg}	47.93 ± 0.54^{Rcd}	29.88 ± 0.06^{Rf}	46.85 ± 1.08^{Rc}
	36	92.88 ± 0.27^{Qab}	1.72 ± 0.15^{Qb}	57.87 ± 0.45^{Qb}	34.73 ± 0.15^{Qb}	54.89 ± 0.46^{Qb}
	48	95.58 ± 0.82^{Pa}	2.02 ± 0.00^{Pa}	62.94 ± 0.79^{Pa}	36.40 ± 0.30^{Pa}	61.09 ± 0.61^{Pa}

Values represent mean ± standard deviation; values having different superscripts from a, b, c to l differ significantly ($P < 0.05$) from each other in each column separately among different treatments; values having different superscripts P, Q, R, and S show significant ($P < 0.05$) differences during different germination time at each germination temperature.

hydrolyse the constituents of brown rice and liberate free phenolics compounds with more effective antioxidant activities (Tian et al., 2004). A similar result was reported by Cáceres et al. (2014), who found higher antioxidant activity in brown rice germinated for 96 h at 34 °C compared to 28 °C.

3.4. Total phenolic content (TPC)

TPC of non-germinated brown rice was 0.65 mg g^{-1} GAE, which after soaking of 10 h at 25 °C was reduced to 0.46 mg g^{-1} GAE, due to leaching or solubilisation of phenolic compounds during steeping. Germination of brown rice brought an appreciable increase in TPC, and this increase was time and temperature dependent (Table 2). Total phenolic content of 0.92, 1.16, 1.29, and 1.60 mg GAE/g was observed after germination of brown rice at 30 °C for 12, 24, 36, and 48 h, respectively. Brown rice germinated for 48 h at 25 °C showed total phenolic content of 1.32 mg GAE/g, which increased to 1.60 and 2.02 mg GAE/g when germinated at 30 and 35 °C, respectively. Similar observations were also recorded by Cáceres et al. (2014). According to their study, brown rice germinated for 48 h at 34 °C displayed a higher TPC content than those germinated at 28 °C in four Ecuadorian brown rice cultivars. During germination, saccharolytic enzymes hydrolyse the constituents of brown rice to release the bound phenolic compounds and thus increasing the TPC (Tian et al., 2004).

3.5. Total flavonoids content

The total flavonoids content of non-germinated brown rice was 32.78 mg QE/100 g, and it increased significantly ($P < 0.05$) from 34.06 to 62.94 mg QE/100 g as the germination time increased from 12 to 48 h and temperature from 25 to 35 °C, respectively. After 48 h of germination, the highest TFC (62.94 mg QE/100g) was observed in brown rice germinated at 35 °C and the lowest (34.06 mg QE/100 g) at 25 °C. During germination, flavonoids were biosynthesised by activation of the metabolic phenylpropanoid pathway, in which acetyl coenzyme A esters (CoA) were generated by the intermediates, which were further converted to flavonoids (Sharma et al., 2019). Similar results for increase in total flavonoids content were also reported in brown rice by Ti et al. (2014).

3.6. Reducing power

Reducing power of brown rice significantly ($P < 0.05$) increased as germination time increased from 12 to 48 h and temperature from 25 to 35 °C (Table 2). Non germinated brown rice had a reducing power of 19.85 μg AAE/g, which after germination for 12 and 48 h at 25 and 35 °C increased significantly ($P < 0.05$) from 22.68 to 36.40 μg AAE/g, respectively. Among different germination conditions, the highest reducing power was reported after 48 h of germination at each germination temperature. Reducing power value of brown rice increased significantly to 30.90, 33.90, and 36.40 μg AAE/g after 48 h of germination at 25, 30, and 35 °C, respectively. During germination, some compounds of brown rice donate electron to free radicals that helps to terminate or stabilise radical chain reactions, which in return results in higher reducing power (Sharma and Gujral, 2011). Similar results for increase in reducing power with increase in germination time and temperature were also reported by Lin et al. (2015). They reported that the reducing power of two rice cultivars increased significantly as germination time increased from

24 to 72 h. Also highest reducing power was observed in brown rice germinated at 36 °C compared to 26 °C.

3.7. Metal chelating activity

The metal chelating activity of brown rice was significantly ($P < 0.05$) enhanced by variation in germination temperature, and time and it ranged from 28.48 to 61.09% (Table 2). After germination of brown rice for 12, 24, and 48 h, the observed mean values for metal chelating activity were 32.42, 39.42, and 51.56%, respectively. Mean metal chelating activities of 32.25, 43.67, and 49.62% were observed, when brown rice was germinated at temperatures of 25, 30, and 35 °C, respectively. Increase in germination time and temperature may cause degradation and structure alteration of the phenolic compounds to different Millard reaction products that may act as antioxidants and resulting in higher metal chelating activity (Sharma et al., 2012).

3.8. Pasting properties

The pasting properties of brown rice germinated under different germination conditions differed significantly ($P < 0.05$) in comparison to non-germinated brown rice. Pasting temperature increased with increase in germination time and temperature, however, no pasting temperature was recorded after 48 h of germination at 30 and 35 °C, which indicates the resistance of starch to swelling. The values for all pasting characteristics (peak, hold, final viscosity) decreased significantly ($P < 0.05$) as germination time increased from 12 to 48 h and temperature from 25 to 35 °C (Table 3). After 12 h of germination at 25 °C, the peak viscosity of brown rice decreased to 2,633.0 cP, which declined to 244.5 cP after 48 h. It further decreased significantly ($P < 0.05$) to 11.5 cP, when brown rice was germinated for 48 h at 35 °C. The substantial decrease in viscosity with increasing germination time and temperature may be attributed to degradation of starch and proteins to simpler units, which was higher at elevated germination temperatures and durations (Chung et al., 2012a). Xu et al. (2012) also found decrease in viscosity as germination time increased.

3.9. Colour characteristics

Germination conditions significantly affected all colour characteristics of the germinated brown rice. Non-germinated brown rice showed L value of 87.30, a^* −1.90, and b^* 11.80. Lightness (L^*) value of brown rice decreased slightly as the germination time increased from 12 to 48 h and temperature increased from 25 to 35 °C. However, increase in germination time and temperature significantly increased the redness (a^*) and yellowness (b^*) values of the brown rice. The colour is one of the important physical properties of rice flours for its utilisation in a variety of products and its consumer acceptance. Studies of Chung et al. (2012b) also reported similar results for changes in lightness and yellowness values in germinated brown rice. They reported that GABA was also synthesized during germination of brown rice, which enhances pigment formation, thus reducing the L^* value.

4. CONCLUSIONS

Germination time and temperature had significant effect on the functionality of brown rice flour. At each germination temperature, maximum nutrient digestibility and amount of

Table 3. Effect of germination conditions on the pasting properties and colour characteristics of germinated brown rice flour

Germination temp. (°C)	Germination time (h)	Pasting temp. (°C)	Paste viscosity (cP)			Colour characteristics		
			Peak	Hold	Final	L	a*	b*
Control		90.75 ± 0.07^{c}	$4{,}103.5 \pm 65.76^{a}$	$3{,}575.5 \pm 88.39^{a}$	$4{,}940.0 \pm 8.49^{a}$	87.30 ± 0.36^{a}	-1.90 ± 0.00^{gh}	11.80 ± 0.17^{efg}
Soaked 25 °C 10 h		89.45 ± 0.07^{de}	$3{,}977.5 \pm 21.92^{a}$	$3{,}440.0 \pm 72.12^{a}$	$4{,}183.0 \pm 25.46^{c}$	87.40 ± 0.17^{a}	-2.10 ± 0.00^{h}	11.23 ± 0.06^{g}
25	12	90.70 ± 0.00^{Rcd}	$2{,}633.0 \pm 28.28^{Pc}$	$2{,}175.0 \pm 50.91^{Pb}$	$3{,}323.0 \pm 76.3^{Pd}$	86.10 ± 0.40^{Qbcd}	-1.77 ± 0.15^{Qfg}	12.20 ± 0.26^{Qdef}
	24	90.15 ± 0.35^{Rcde}	$2{,}037.5 \pm 16.26^{Qe}$	$1{,}452.0 \pm 83.44^{Qd}$	$3{,}149.0 \pm 49.50^{Qe}$	86.90 ± 0.36^{Pab}	-1.67 ± 0.15^{Qefg}	12.27 ± 0.38^{Qde}
	36	92.55 ± 0.35^{Qb}	618.5 ± 6.36^{Rh}	292.5 ± 2.12^{Rf}	$1{,}865.0 \pm 26.87^{Rf}$	85.33 ± 0.12^{Rde}	-1.33 ± 0.06^{Pbcd}	13.07 ± 0.12^{Pabc}
	48	93.00 ± 0.14^{Pb}	244.5 ± 13.44^{Si}	120.5 ± 6.36^{Sg}	266.0 ± 8.49^{Sh}	84.43 ± 0.15^{Sf}	-1.20 ± 0.10^{Pabc}	13.57 ± 0.23^{Pa}
30	12	89.35 ± 0.21^{Re}	$2{,}903.0 \pm 55.15^{Pb}$	$2{,}178.0 \pm 36.77^{Pb}$	$4{,}379.0 \pm 7.07^{Pb}$	87.70 ± 0.26^{Pa}	-2.10 ± 0.17^{Rh}	11.17 ± 0.12^{Rg}
	24	91.05 ± 0.49^{Qc}	$1{,}541.0 \pm 2.83^{Qf}$	$1{,}205.0 \pm 21.21^{Qe}$	734.5 ± 6.36^{Qg}	86.33 ± 0.32^{Qbc}	-1.67 ± 0.12^{Qefg}	12.23 ± 0.12^{Qdef}
	36	95.00 ± 0.85^{Pa}	225.0 ± 15.56^{Ri}	152.5 ± 6.36^{Rfg}	278.0 ± 2.83^{Rh}	84.67 ± 0.51^{Ref}	-1.10 ± 0.10^{Pab}	13.13 ± 0.15^{Pabc}
	48	ND	$91.5 \pm 2.12d^{Sjk}$	59.0 ± 11.31^{Sg}	44.5 ± 0.71^{Si}	84.07 ± 0.15^{Rf}	-1.03 ± 0.06^{Pa}	13.30 ± 0.10^{Pab}
35	12	89.95 ± 0.07^{Rcde}	$2{,}498.0 \pm 69.30^{Pd}$	$1{,}850.0 \pm 33.94^{Pc}$	$4{,}113.0 \pm 35.36^{Pc}$	86.90 ± 0.10^{Pab}	-1.90 ± 0.00^{Rgh}	11.60 ± 0.36^{Qfg}
	24	92.65 ± 0.35^{Qb}	$1{,}315.0 \pm 8.49^{Qg}$	157.5 ± 4.95^{Qfg}	357.5 ± 16.26^{Qh}	86.23 ± 0.42^{PQbc}	-1.57 ± 0.12^{Qdef}	12.57 ± 0.35^{Pcd}
	36	95.90 ± 0.00^{Pa}	167.0 ± 0.00^{Rij}	73.0 ± 2.83^{Rg}	65.0 ± 2.83^{Ri}	85.97 ± 0.21^{Qcd}	-1.47 ± 0.06^{PQcdE}	12.60 ± 0.17^{Pcd}
	48	ND	11.5 ± 2.12^{Sk}	18.0 ± 4.24^{Sg}	6.5 ± 0.71^{Si}	84.93 ± 0.25^{Ref}	-1.37 ± 0.06^{Pbcd}	12.77 ± 0.12^{Pbcd}

ND: Not detectable; cP: centiPoise; values represent mean ± standard deviation; values having different superscripts from a, b, c to l differ significantly ($P < 0.05$) from each other in each column separately among different treatments; values having different superscripts P, Q, R, and S show significant ($P < 0.05$) differences during different germination time at each germination temperature.

bioactive compounds were observed after 48 h of germination compared to 12 h. Increase in germination time and temperature increases the extent of enzymatic activities in brown rice, resulting higher antioxidant activity, more bioactive compounds, and lower pasting viscosity. Germination of brown rice for 48 h at 35 °C results in enhanced nutrient digestibility with lower pasting viscosity and the highest accumulation of bioactive components. This germinated brown rice flour with reduced viscosity and increased amounts of bioactive compounds can be effectively used in the preparation of porridges, gruels, and infant formulations, providing low viscosity food with elevated nutritional profile.

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