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Chemical, Rheological and Physical properties of Germinated Wheat and Naked Barley

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Abstract : The effect of germination on chemical composition, dough raising capacity, gluten changes and folic acid of wheat" variety Gammeza 7" and naked barley "variety Giza 131" were investigated. Crude protein ranged from 9.08 to 11.70% in germinated barley and wheat. Barley was the highest in ether extract and ash. Wheat was the highest in crude fiber. Flour extract (82%) was the highest in carbohydrate. Wheat was the highest in Na, K, Fe, and Ca. Dough raising capacity was highest in 75% germinated wheat flour. Wet, dry gluten in flour extracted (82%) have the highest percentages. While 75% substituted germinated wheat for flour 72% extraction was the highest in wet and dry gluten. Fresh germinated wheat and barley were higher in folic content than other treatments. Germination seems to be a natural and sustainable way to improving nutritional quality and functional food compound in wheat and barley.
Key words: folic acid, gluten, naked barley, nutritive value and wheat.

Introduction

Cereals are the most important contributor to the human diet worldwide. Globally, the most important species grown are wheat, rice, maize, barley, and sorghum. Other species like rye, millets, oats, and others more are of minor or more regional importance. They all belong to the family poaceae of the monocotyledonic branch of the plant family. Cereals are commonly seen as a good source of energy, protein, dietary fiber, and minerals **Slavin *et al.*** [1]. Wheat (*Triticum aestivum* L.) is a cereal, a major source of dietary energy and protein for people whom daily diet is composed of cereal products. It is the world most important crop in terms of production and consumption **FAO** [2].

Barley (*Hordeum vulgare* L.), is a cereal, ranks fourth globally in both quantity produced and cultivation area **Zhou**[3]. Historically, barley has been an important food source in many parts of the world, including the Middle East, North Africa and Northern and Eastern Europe (Iran, Morocco, Ethiopia, Finland, England, Denmark, Russia and Poland) and in Asia (Japan, India, Tibet and Korea) **Baik and Ullrich**[4].

Sprout is a source of soluble sugars, protein and amylases in the dough and promotes the activity of yeast resulting in good bread texture and bigger loaf volume, good flavor and color to the finished baked products. Further applications of sprout products are for non-fermented bakery products, for example, crackers, cookies and muffins. Sprout barley is rich in enzymes and is also used for bakery products as a source of amylases to compensate the low alpha amylase activity in bread wheat flours **Arif *et al*** [5].

Due to the increased interest in healthy nutrition, there has been an increased interest in other bioactive compounds which can be found in cereal grains, such as tocopherols, phytosterols, lignans, phenolic acids, and folates **Slavin *et al.*** [1]. The intake of whole grain cereal products has been connected with a number of positive health effects including decreased risk of certain types of cancer, lowering of blood cholesterol, and risk of coronary heart disease **Dykes and Rooney**[6].

Germination has a strong influence on the nutritional quality of cereal grains and can be used as a tool to improve the nutritional value. However, some compounds deemed beneficial, such as beta-glucans, might be degraded during germination material and adapt the germination process for the respective purpose **Hubner and Arendt** [7]. Whole grain cereals have been found to be a good source of nutritionally valuable substances, such as antioxidants, minerals, vitamins, and dietary fiber. A wide range of these compounds is affected by germination. While some compounds, such as beta-glucans are degraded, others, like vitamins can be increased by means of malting. Therefore, germination of cereals is a way to produce ingredients enriched with health promoting compounds **Hubner and Arendt**[7].

However, some whole grain cereals (e.g., wheat, rye and oats) are an important source of folates, while other important grains only contain small amounts **Belitz *et al.*** [8].

Sprouts are outstanding sources of protein, vitamins and minerals and they contain such in the respect of health-maintaining important nutrients like glucosinolates, phenolic and selenium. As the sprouts are consumed at the beginning of the growing phase their nutrient concentration remains very high. In the sprouts besides the nutrients phytochemicals, vitamins, minerals enzymes and amino acids are of the most importance as these are the most useful in the respect of the human health **Finley**[9]. However, germination has been repeatedly reported as way to improve folate content in wheat **Koehler *et al.*** [10], Also, **Walker *et al.***[11], found that a decrease in folate content in kilned germinated cereal in comparison to green cereal, indicating temperature sensitivity of the folates. Biofortification of folates in staple foods by metabolic engineering is seen as an important measure of fighting folate deficiencies **Bekaert et al.**[12]. Moreover, in the short run, germination of cereals and other seeds might be an easy way to increase the uptake of folates. Also, **Hubner and Arendt**[7] and **Koehler *et al*** [10] proved the effects of germination whole grain on the chemical composition, mineral content, and folat content. Malnutrition causes a great deal of human suffering and is associated with more than half of all deaths of children worldwide. Thus nutrition plays an important role in the reproduction of poverty from one. Therefore, the objective of this research was to investigate the influence of germination of wheat and barley on proximate analysis, mineral content, gluten and folic acid.

Materials and Methods

Materials

Wheat grain (*Triticum aestivum* L.), Gammeza-7 variety and Barley grain (*Hordeum vulgara* L.) Giza 131 (naked barley) were purchased from Field crops Department, Agricultural Research Center, Ministry of Agriculture, Giza. Wheat flour (72%) and (82%) extraction rate were obtained from Al-Salam- Company for milling and baking.

Methods

Preparation of Samples

Germinated grains

The germination procedure of grains as follows: Washed the grain with 0.7% sodium hypochlorite, soaked in distilled water at room temperature for 12 hours (1 part of grain: 4 parts of water), and shaken every 30 min. The water drained off, and the grain transferred and spread on trays which were covered by muslin cloths. The muslin cloths allowed oxygen to enter for the germinated grain while minimizing contamination. The grain germinated at 25±3° C, for 72 hours and grain sprayed daily with distilled water in order to maintain an adequate hydration level. The grains weighed prior to soaking, and after soaking before the germination operation. The germinated seeds were dried at 55- 60 ºC; milled to obtained whole grain sprout flour and stored in refrigerator after raped in polyethylene until used **Juana *et al.*** [13].

Preparation of blends

Different addition levels of sprout whole grain barley, wheat, and blends at 25, 50, 75, and 100% to wheat flour 82 and 72% extraction rate for bread and biscuits making.

Analytical Methods

Proximate analysis

Moisture, protein, oils, crude fiber, and ash contents of the raw material and treatments were determined according to the methods of **A.O.A.C.**[14]. Total carbohydrate was calculated by difference. The estimated parameters were related to the untreated and treated wheat and barley.

Determination of dietary fiber

Total dietary fiber was determined according to the method **described by Prosky *et al.***[15]

Determination of minerals

Two gram of sample was weighed and heated at 550 ºC. Then the ashes were dissolved with 100 ml 1M HCl. Dissolved ash was analyzed for zinc, iron, calcium, potassium, sodium and magnesium contents by using methods of **A.O.A.C.**[14]. Perkin Elmer (Model 3300, USA) Atomic Absorption Spectrophotometer was used to determine these minerals.

Determination of dough-rising capacity

Cylinder test was used to determine the fermentation capacity according to the method described **by Fernandes *et al.* (1985)** [16].

Determination of wet and dry gluten and gluten index

Wet and dry gluten and gluten index of wheat flour were determined using (Glutomatic perten instruments AB type 2200 No.005092, Huddling, Sweden) as described by **Perten**[17] the obtained fraction calculated as dry gluten.

Wet gluten content (%) = (Wet gluten weight)/10 × 100

Dry gluten content (%) = (Dry gluten weight)/10 × 100

Gluten index = (Remained gluten on cassette (g))/ (Total gluten) × 100

Water binding in wet gluten = (Wet gluten-Dry gluten)/ (Dry gluten) × 100

Determination folic acid

According to **Batifoulier *et al.*** [18] one gram of samples was homogenized in 7 ml of $HClO_4$ 0.4M using a polyton disintegrator (Bioblock, Switzerland). The suspension was then centrifuged at 8000 g for 10 min and aliquots of the supernatant were immediately used for derivatization. Potassium hexacyanoferrate (20µl; 30.4 mM in NaOH 15%) was added to 200 µl of perchloric extract, mixed by vortex during 10 s and left to stand exactly during 60 sand then 5 µl of NaOH (15%) was added. The linearity of the standards (T, TMP, and TDP) was assayed at points 0.31, 0.63, 1.25, 2.5, 5, 0 and 50 µmol/l. This range concentration corresponded to the concentration found in the different samples. To verif extraction recovery, the same standard solution was analyzed with and without extraction.

Chromatographic conditions:

The liquid chromatography system consisted of an Al-liance 2690 separation Module (Waters, Saint Quentin en Yvelines, France) with a Multi λ fluorescence detector (Waters 2475). The column (15 cm × 4 mm) were packed with a RP-amide C16 stationary phase with a particule size of 5µm (supelco, USA). The column and the guard column were placed in an oven at 30 ^{o}C. The mobile phase was potassium phosphate buffer (50 mM and pH 6) methanol (80/20; v/v) delivered at flow rate of 1ml/min. The injection volume was 20µl and the duration of the analytical run was 10 min λ Fluorescence detection was operated at 366 nm excitation and 435 nm emissions.

Statistical analysis

Data were statically analyzed using MSTAT-C v.2.1 (Michigan State University, Michigan, USA) and mean comparisons were based on the least significant difference (LSD at 5%) test according to **Maxwell and Delaney** [19].

Results and Discussion

Protein content

Crude protein content in Gammeza wheat; Barley (naked barley) before and after germination are presented in Table (1). Protein content of Gammeza wheat; Barley (naked barley) before and after germination ranged from 11.70±0.25 to 10.15±0.31% for wheat; 10.41±0.14 to 9.08±0.65% for barley. Protein was significantly higher in "Gammeza wheat" while "Germinated barley" was the lowest one. The results are in agreement with **Wanasundara *et al.*** [20], **Donkor *et al.*** [21] who found that crude protein content in whole wheat flour 11.56, while **Montanuci *et al.*** [22] reported that barley protein content is ranged from 9.55% to 10.56%. The crude protein was decreased after germination compared with whole grain flour. The same results findings **by Abdallah and Abo El-Naga**[23] who reported that effect of sprouting in protein content of whole wheat grain flour, naked barley flour compared to wheat flour 72% extraction rate 13.20%, 9.41% and 11.37% respectively. Furthermore, **Donkor *et al.*** [21], **Uwaegbute *et al.*** [24] showed that after germination of wheat and naked barley.

Protein was increased in germinated flour and could be attributed to synthesis of enzymes during germination which might have resulted in the production of some amino acids during protein synthesis. While, **Hung *et al.*** [25] showed that during 48 h of germination, the protein of germinated waxy wheat was not significantly different from those of the control.

Oil content

Results in Table (1) indicated that the oil content of Gammeza wheat and barley before and after germination. Oil content ranged from 3.30±0.06 to 1.71±0.01% for wheat; 3.52±0.05 to 3.16±0.07% for barley respectively and "naked barley" variety represents the highest value. These results are in line with **Theodoulou and Eastmond** [26], **Chauhan *et al.***[27]. The oil content decreased in germinated seed. However, **Donkor *et al.*** [21] showed that oil contents in wheat germination decreased about oil contents in wheat (1.95±0.14 and 1.81±0.22, respectively) while in germinated barley, it was higher than barley non-germination (3.01±0.69 and 2.37±0.22, respectively).

Ash and total dietary fiber content

Concerning ash content of wheat and barley before and after germination, results in Table (1) showed that ash content ranged from 1.90±0.09 to1.90±0.02 % for wheat; 2.54±0.07 to1.90±0.01% for barley respectively. These results are in agreement with **Montanuci *et al.*** [22] who reported that ash content for varieties barley ranged from 1.73% to 2.47%; BRs 195 and BRs GRETA varieties. In addition, **Hung *et al.*** [25] found that the ash content of waxy wheat (18.0%±0.02 g/kg, 18.60%±0.2 g kg-1) did not change significantly during the first 36 h of germination. However the ash content of 48 h germinated wheat (19.40%±0.1 g kg-1 db) was significantly higher than that of the control. Also, **Donkor *et al.***[21] showed that ash content of barley, wheat before and after germination as (2.16%±0.06), (2.33 %±0.1), (1.85%±0.05) (2.18% ±0.04) respectively.

Total dietary fiber for wheat and barley before and after germinated showed in Table (1). Gammeza wheat grain before and after germinated process had significantly different during germination. It was 26.49±0.00 and 23.31±0.58% for wheat before and after germination and was 38.60±0.00 and 38.92±0.00% for barley before and after germination. These results are in agreement with **Koehler *et al.*** [10] who found that the concentration of total dietary fiber decreased in the first 48 h of germination and the effect was more pronounced at low temperatures (15 and 20 ^{o}C) than at high temperatures (25 and 30 ^{o}C) particularly at high temperatures adistinct increase of the total dietary fiber concentration was present after 102 h of germination. However, **Hung *et al.*** [25] reported that an increase in total dietary fiber was clearly observed for the 48 h germinated wheat.

Crude fiber

Results in Table (1) demonstrate that crude fiber contents in wheat, barley before and after germinated was7.83±0.02, 6.77±0.04% for wheat; 5.21±0.11, 4.84±0.13% for barley respectively. It was gemmeza wheat represents the highest value and significantly different the other raw material. Supporting results finding by **Koehler *et al.*** [10] who reported changes in fiber content may attribute to the fact that part of the seed fiber may be solubilized enzymatically during seed germination.

Carbohydrate contents

Table (1) showed that carbohydrates content in gammeza wheat and barley before and after germination ranged from 75.28±0.39 to 79.48±0.32% for wheat; 78.32±0.11 to 81.02±0.67% for barley, respectively. The decrease in carbohydrates in germinated grains may be attributed to increase in alph-amylase activity which breakdown complex carbohydrates into simpler and more absorbable sugars **Hung *et al.***[25]. The amount of starch was decreased significantly in control and after germination for 12 h (624%±5 and 617%±4 g kg^{-1}) respectively. The loss of starch due to germination probably meant that the weight of grain decreased. Moreover, **Chauhan *et al.*** [27] showed that there was significant difference ($P \leq 0.05$) in carbohydrate content among amaranth before and after germinated flours (62.41%±0.03 and 60.7% ± 0.02, respectively).

Also, in Table (1) the chemical components contents in wheat flour of 72% extraction rate contained 0.47±0.00, 10.55±0.08, 0.71±0.06, 0.47±0.00, 87.80±0.05 and 25.55±0.00% ash, crude protein, ether extract, crude fiber, carbohydrate, and total dietary fiber, respectively, while wheat flour of 82% extraction rate contained 0.99±0.01, 10.94±0.06, 2.06±0.01, 2.04±0.01, 83.97±0.07 and 19.97±0.00% for the same components, respectively.

Elementary analysis

Table (2) showed minerals contents, magnesium (Mg), sodium (Na), potassium (K), iron (Fe), calcium (Ca), zinc (Zn) in Gammeza wheat and naked barley before and after germination. Result indicated that germinated Gammeza wheat (G.G.W) and germinated naked barley (G.n.B) have the highest contents in Mg and Zn (24.14±0.09, 16.66±0.05) (0.83±0.03, and 0.34±0.01 mg $100g^{-1}$), respectively.

From Table (2), it could be noticed the Mg content and Zn increased by germination, these findings are in agreement with those findings of **Hubner and Arendt** [7] who reported that Mg and Zn content increased by germination for 3 day in barley (106, 112, 2.00 and 2.50 mg 100g-1). Also, **Plaza *et al.*** [28] reported that Mg and Zn content increased by germination in wheat (0.78±0.02 to 0.84±0.01 and 19.69± 1.61 to 56.24±1.31 mg 100g-1, respectively). While, contents of K and Fe were decreased by germination, these findings are in agreement with those findings of **Hubner *et al.*** [29] who showed that Fe content in barley decreased by germination (3.7 to 2.8 mg 100g-1). In contrast, **Plaza *et al.*** [28] reported that K and Fe content increased by germination for wheat (0.81±0.14, 1.43±0.15 mg 100g-1) for K content (26.21±1.53, 30.44±16.27 mg100g-1 for Fe content). On other hand, **Platel *et al.*** [30] showed that iron (Fe) and zinc (Zn) content was increased in malted barley than barley. While, calcium (Ca), copper (Cu), and manganese (Mn) decreased with malted barley than barley. Also, zinc (Zn), calcium (Ca) and copper (Cu) content decreased by germination for wheat.

Minerals content of flour 82% and 72% extraction rate were presented in the same Table (2). Magnesium (Mg), Sodium (Na), Potassium (K), Iron (Fe), Calcium (Ca), and Zinc (Zn) of 72% were 8.74±0.01 ,7.28±0.00 ,0.47±0.01 ,0.10±0.01 , 2.05±0.07 and 0.21±0.01, respectively, while wheat flour 82% extraction rate was 10.65±0.01, 4.55±0.19, 0.79±0.01, 0.74±0.00, 1.73±0.03 and 0.18±0.01, respectively. **Abd- El Hamid**

[31] found that minerals contents of commercial wheat flour 72% was Mg 30.20, Na 4.51, Zn 0.89, Mn 0.33, Fe 2.46, Ca 34.20, K 160.30, and Cu 0.40 mg $100g^{-1}$ flour. While, **Osman** [32] reported that minerals contents of wheat flour (82% extraction) was Na 23.31, K 122.57, Ca 17.86, P 144.12, Mg 118.15, Mn 0.94, Fe 1.16, Zn 0.82, and Cu 0.25. While, wheat flour 72% extraction was Na 26.78, K 135.70, Ca 14.62, P 139.25, Mg 137.25, Mn 1.65, Fe 0.65, Zn 0.39, and Cu 0.28.

Dough raising capacity

Table (3 A and B) showed the dough raising capacity (mm) of fermented dough made using wheat flour (82% extraction rate) and substituted with germinated wheat flour (G.W.f), germinated barley flour (G.B.f) and germinated wheat and barley flour (G.W.B. f). It could be noticed that substituted with 75% (G.W.f) higher raising capacity (mm) for fermented dough than control after120 min fermentation time (212±0.00mm, 202.00±1.16 mm), respectively. This result may be due to increase in amlyolytic and proteolytic activity and resulted to increased components as well as sugars, amino acid and resulted in yeast activity. Also, cereals are good substrate for the growth of the relevant bacteria, as they contain higher levels of certain essential minerals, higher contents of dietary fibre, but lower levels of fermentable sugars **Charalampopoulos *et al.*** [33 &34] and **Kaur *et al*.**[35].

Table (1): Proximate analysis for raw materials (as basis DM%)

Treatment	Ash	Crud Protein	Ether extract	Crud fiber	Carbohydrate z	Moisture	Total dietary fiber
Gamaza Wheat	1.90± 0.09 b	11.70± 0.25a	3.30± 0.06 b	7.83± 0.02 a	75.28± 0.39 e	7.16 ±0.09d	26.49 ± 0.00 b
Germinated Gamaza Wheaty	1.90± 0.02 b	10.15± 0.31 bc	1.71±0.01 d	6.77± 0.04 b	79.48± 0.32 d	8.97± 0.17 c	23.31 ± 0.58d
Barely	2.54± 0.07 a	10.41± 0.14b	3.52± 0.05 a	5.21± 0.11 c	78.32 ±0.11d	8.68 ±0.14c	38.60 ± 0.00a
germinated Barley	1.90± 0.01 b	9.08 ±0.65c	3.16± 0.07 b	4.84± 0.13 d	81.02 ±0.67c	6.26± 0.05 e	38.92± 0.00 a
Flour 72%	0.47± 0.00 d	10.55± 0.08 b	0.71± 0.06 e	0.47± 0.00 f	87.80± 0.05 a	11.89 ±0.28b	25.55± 0.00 c
Flour 82%	0.99±0.01 c	10.94± 0.06 ab	2.06± 0.01 c	2.04 ±0.01 e	83.97± 0.07 b	13.18± 0.06 a	19.97 ± 0.00e
L.S.D $_{0.05}$	0.13	1.09	0.17	0.23	1.216	0.52	0.51

Values are mean of three replicates ±SE, number in the same column followed by the same letter are not significantly different at P ≤ 0.05 level.
DM: Dry Matter

Table (2): Minerals contents (mg/100g) of wheat, barley and their flour (raw materials)

Raw materials	Mg	Na	K	Fe	Ca	Zn
Gammeza wheat (G.W)	23.46± 0.01b	13.28± 0.01 a	1.73± 0.01 a	0.84± 0.03 a	2.38± 0.06 a	0.69± 0.02 b
Germinated Gammeza Wheat (G.G.W)	24.14± 0.09 a	4.46± 0.04 c	1.48± 0.02 c	0.39± 0.01 d	1.68± 0.01 c	0.83± 0.03 a
Barley (B)	16.17 ± 0.01d	1.14± 0.00 e	1.62± 0.00 b	0.57 ±0.02c	1.30± 0.01 e	0.30 ±0.01c
Germinated Barley (G.B)	16.66± 0.05 c	3.52± 1.00 d	1.36± 0.06 d	0.31± 0.01 e	1.52± 0.04 d	0.34± 0.01 c
Flour (72%)	8.74± 0.01 f	7.28± 0.00 b	0.47 ±0.01e	0.10± 0.01 f	2.05± 0.07 b	0.21± 0.01 d
Flour (82%)	10.65± 0.01 e	4.55± 0.19 c	0.79 ±0.01e	0.74± 0.00 b	1.73± 0.03 c	0.18 ±0.01d
L.S.D $_{0.05}$	0.13	0.25	0.08	0.06	0.14	0.06

Values are mean of three replicates ±SE, number in the same column followed by the same letter are not significantly different at P ≤ 0.05 level.

Table (3A): Dough raising capacity (mm) fermented for flour extract (82%) and substituted with germinated grain flour in frist stage.

Sources of flour (z)	High of dough (mm)				
	Fermentated Time (mm)				
	zero time	15	30	45	60
Flour (82%)	80	94.00±0.58 cd	146.00±1.16 b	152.00±1.16 bc	162.00±2.31 b
Substituted with (G.W.f)					
25% WG	80	82.00±1.16 e	110.00±0.00 h	120.00±2.89 h	134.00±2.31 g
50%WG	80	114.00±2.31 a	148.00±1.16 b	150.00±0.00 cd	160.00 ±0.00 c
75%WG	80	115.00±0.00 a	150.00±2.89 b	155.00±0.00 b	162.00±4.05 b
100%WG	80	100.00±2.89 b	115.00±2.89 g	120.00±2.89 h	130.00±2.89 g
Substituted with (G.B.f)					
25%BG	80	94.00±2.31 cd	125.00±0.00 cd	144.00±2.31 e	152.00±1.16 de
50%BG	80	95.00 ±2.89 cd	116.00±0.58 fg	136.00±0.58 g	144.00±2.31 f
75%BG	80	98.00±1.16 bc	120.00±2.89 f	138.00 ±1.16 fg	148.00±0.00 ef
100%BG	80	92.00±1.16 d	115.00±0.00 g	136.00±.00 g	136.00±2.31 g
Substituted with (G.W.B.f)					
25%WBG	80	118.00±1.73 a	156.00±0.58 a	168.00±1.73 a	182.00±1.16 a
50%WBG	80	94.00±2.31 cd	132.00 ±0.00 d	142.00±0.00 ef	154.00±2.31 cde
75%WBG	80	96.00±2.31 bcd	138.00±0.00 c	146.00±1.16 de	156.00±3.46 bcd
100%WBG	80	96.00±0.00 bcd	138.00±1.16 c	146.00±0.00 de	156.00±1.16 bcd
L.S.D $_{0.05}$	NS	4.66	4.54	4.02	6.11

[z] G.W.f: Germinated Wheat flour); G.B.f: Germinated Barley flour; and G.W.B.f: Germinated Wheat and Barley flour. Values are mean of three replicates ±SE, number in the same column followed by the same letter are not significantly different at P ≤ 0.05 level.

Table (3B): Dough raising capacity (mm) fermented for flour extract (82%) and substituted with germinated grain flour in scond stage.

Sources of flour (z)	High of dough (mm)/				Total Increase (y)	Increase % (x)
	Fermentated Time (mm)					
	75	90	105	120		
Flour (82%)	172.00±0.00 b	196.00 ±0.57 a	200.00±2.89 b	202.00±1.16 b	122.00 ±1.16 b	152.50±1.44 a
Substituted with (G.W.f)						
25% WG	144.00±2.31 f	150.00±0.00 f	160.00±2.89 gh	166.00±0.58 def	86.00±0.58 e	107.50±0.72 bcd
50%WG	180.00±2.89 a	188.00±6.94 b	204.00±2.31 ab	214.00±2.31 a	134.00 ±5.20 a	168.40±12.60 a
75%WG	180.00±0.00 a	186.00±2.31 b	206.00±2.31 a	212.00±0.00 a	132.00±2.89 ab	165.70±9.62 a
100%WG	135.00±2.89 g	142.00±1.16 g	148.00±1.16 i	152.00±1.16 g	72.00±1.16 fg	90.00±1.45 cd
Substituted with (G.B.f)						
25%BG	158.00±1.16 de	160.00±2.89 de	164.00±2.31 fg	168.00±1.16 de	88.00±1.16 de	110.00±1.45 bcd
50%BG	152.00±1.16 e	156.00±2.31 ef	160.00±0.00 gh	164.00±2.31 ef	84.00±8.09 e	107.60±18.01 bcd
75%BG	162.00±1.16 cd	168.00±3.46 c	172.00±1.16 e	178.00±1.73 c	98.00±1.16 cd	122.90±5.90 b
100%BG	142.00±0.00 fg	150.00±0.00 f	158.00±1.16 h	162.00±1.16 f	82.00±1.73 ef	102.90±5.90 bcd
Substituted with (G.W.B.f)						
25%WBG	186.00±.3.46 a	190.00±1.16 ab	192.00±1.16 c	114.00±2.31 h	34.00±0.58 h	42.66±2.27 e
50%WBG	160.00±0.00 d	164.00±2.31 cd	168.00 ±1.16 ef	170.00 ±0.00 d	90.00±0.00 cde	112.50±0.00 bc
75%WBG	168.00±4.62 bc	170.00±0.00 c	178.00±0.00 d	180.00±2.89 c	100.00±5.77 c	125.80±11.80 b
100%WBG	164.00±5.20 cd	166.00 ±0.58 cd	160.00 ±2.89 gh	150.00±0.00 g	70.00±2.89 g	87.99±6.81 d
L.S.D $_{0.05}$	7.07	7.83	5.08	4.75	10.08	23.65

[y] Total Increase=(Rising dough after (120) min - Rising dough in Zero time). Increase % [x]= (Totale increase ÷ High of dough (mm) of zero time) × 100

[z] G.W.f: Germinated Wheat flour); G.B.f: Germinated Barley flour; and G.W.B.f: Germinated Wheat and Barley flour. Values are mean of three replicates ±SE, number in the same column followed by the same letter are not significantly different at P ≤ 0.05 level.

Gluten characteristics

Table (4a) displayed wet gluten, dry gluten, gluten index, and water binding in gluten of flour 72% extraction rate and substituted germinated Gammeza wheat, barley, and blended whole grain flour.

Wet gluten ranged from 2.45±0.03% to 27.16±0.29 % in sample of wheat flour 72% substituted with germinated barley whole grain flour (75% B.B.G) and germinated wheat whole grain flour (100%B.W.G), respectively. Wet gluten was higher in "100%B.W.G" than other substituted.

Dry gluten was higher in sample of wheat flour substituted with 100% germinated wheat whole grain (100% B.W.G) than other substituted. Wheat flour (72% extraction rate) represents the highest value of gluten index and significantly different than the other substituted, however water binding in wet gluten for 75% B.BG had highest value and significantly different than the other substituted.

While Table (4b) showed also the wet gluten, dry gluten, gluten index, and water binding of flour 82% extraction rate and substituted germinated Gammeza wheat, naked barley, and blended whole grain flour. Wet gluten and dry gluten for flour 82% had the highest value and significantly different than the other substituted, while gluten index for (75% b.B.G) had the highest value and significantly different than the flour 82% extraction and other substituted. Water binding of gluten for flour 82% extraction had the highest value and significantly different than the other substituted .The additionally that wet gluten and dry gluten in wheat flour (82%) extraction rate represents highest value than wheat flour (72%) extraction rate. Results are in agreement with **Nelson *et al.*** [36] showed that decreased gluten has been reported in germinated wheat, and the application of proteases derived from barley, wheat and rye to the degradation of gliadin peptides may be of benefit to people with gluten sensitivities. However, **Koehler *et al.***[10] reported that a substantial degradation of gluten proteins (gliadins and glutenins) could be observed during the 168 h germination. Also, **Hartmann *et al.*** [37] showed that proteases of germinated grains can rapidly hydrolase gliadin peptides into fragments that are not toxic for celiac patients.

Folic acid content

Folic acid content in wheat flour; fresh and dried germinated wheat and barley are in Table (5). Folic acid content ranged from 0.23±0.01 to 1.52±0.01 mg kg-1 in wheat flour (82% extraction rate) and fresh Germinated Wheat (moisture 13.18% and 49.38%), respectively. Folic acid content was higher in "Fresh Germinated Wheat" (Gammeza wheat) than other treatment and wheat flour. Folic acid contents were decreased after dried. Results are in agreement with **Hefni and Witthoft**[38] who found that the dominant folate form was increased in germinated wheat and the folate content in different wheat cultivars. Also, Oven drying of germinated wheat grains at 50C° (48 and 72h) did not affect the folate stability, Also, **Hefni and Witthoft** [39] found that germination of wheat grains resulted in a three to four folds higher folate content, depending on the germination temperature. Also, they found that the folate content in grains dried at 50C° at was higher than the initial content in un-dried, germinated grains

Conclusions

From the result, it can concluded that the chemical, functional and rheological properties were significantly influenced by the germination process. A significant decrease crude protein, ether extract, ash, carbohydrate and gluten content in Gammeza wheat and naked barley. Moreover, the minerals content, i.e Mg and Zn, increase by the germination process. In addition, rheological properties (Dough raising capacity) increased of substituted germinated grain flour and folic acid content increased of Gammeza wheat and naked barley germinated.

Table (4a): Percentage of wet and dry gluten; gluten index; and water binding in gluten of flour 72% extraction rate and substituted germinated grain flour.

Samples	Wet gluten (%)	Dry gluten (%)	Gluten Index	Water binding in wet gluten
Flour (72%)	26.03±0.32 [b]	8.61±0.08 [b]	96.10±0.85 [a]	66.92±0.13 [d]
75% B.W.G.	19.90±0.18 [c]	6.19±0.06 [c]	49.70±0.00 [d]	68.89±0.01 [c]
75% B.B.G.	2.45±0.03 [e]	0.45±0.01 [e]	86.94±1.02 [b]	81.63±0.02 [a]
75% B.W.B.G.	18.90±0.26 [d]	5.77 ±0.08[d]	66.40±0.91 [c]	69.47±0.01 [b]
100% B.W.G.	27.16±0.29 [a]	8.99±0.10 [a]	65.10±0.71 [c]	66.90±0.0 [d]
100% B.W.B.G.	n.d	n.d	n.d	n.d
L.S.D $_{0.05}$	0.82	0.25	2.25	0.2

B.W.G.: flour (72%) substituted with germinated wheat; B.B.G.: flour (72%) substituted with germinated barley; and B.W.B.G.: flour (72%) substituted with germinated wheat and barley.
Values are mean of three replicates ±SE, number in the same column followed by the same letter are not significantly different at P ≤ 0.05 level.

Table (4b): Percentage of Wet; Dry gluten; Gluten index; and Water binding in gluten of flour (82%) extraction rate and substituted germinated grain flour

Samples	Wet gluten (%)	Dry gluten (%)	Gluten Index	Water binding in gluten
Flour (82%)	30.71±0.03 [a]	10.21±0.01 [a]	77.20±0.08 [c]	66.75 ±0.01[a]
75%b.W.G.	16.62±0.01 [c]	5.77±0.01 [c]	12.39±0.01 [d]	65.28±0.05 [b]
75%b.B.G.	17.52±0.03 [b]	6.18±0.01 [b]	96.92±0.19 [a]	64.73±0.01 [c]
75%b.W.B.G.	10.50±0.02 [d]	3.81±0.01 [d]	89.67±0.07 [b]	63.71±0.02 [d]
L.S.D $_{0.05}$	0.04	0.002	0.32	0.09

B.W.G.: flour (72%) substituted with germinated wheat; B.B.G.: flour (72%) substituted with germinated barley; and B.W.B.G.: flour (72%) substituted with germinated wheat and barley.
Values are mean of three replicates ±SE, number in the same column followed by the same letter are not significantly different at P ≤ 0.05 level.

Table (5): Folic acid contents in wheat flour (82%extraction rate), wheat flour (72%extraction rate) and fresh and dried germinated wheat and barley

Sample	Moisture (%)	Folic acid (mg/kg)
Wheat flour (82% extraction rate)	13.18±0.06 [b]	0.23±0.01 [d]
Wheat flour (72% extraction rate)	11.89±0.26 [c]	0.16 ±0.01[e]
Fresh Germinated wheat (Gamaza wheat)	49.38±0.20 [a]	1.52±0.01 [a]
Fresh Germinated Barley	49.12±0.03 [a]	0.52±0.01 [b]
Dried Germinated Wheat flour	8.97±0.17 [d]	0.30±0.00 [c]
Dried Germinated Barley flour	6.26±0.05 [e]	0.24±0.43 [d]
L.S.D $_{0.05}$	0.55	0.032

Values are mean of three replicates ±SE, number in the same column followed by the same letter are not significantly different at P ≤ 0.05 level.

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