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Effect of Wheat Flour Supplemented with Barely and/or Corn Flour on Balady Bread Quality

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This study was focused on substituting a part of wheat flour (WF) with whole meal barley (WBF), gelatinized corn flour (GCF) and both of them in balady bread, as an attempt to solve the shortage in wheat production. Chemical, rheological, color and sensory properties were determined. Stalling of balady bread was evaluated. It is found that the incorporation of WBF and GCF into balady bread improved protein, fat, fiber, ash, β-glucan and minerals (Ca, P, K and Fe). Blending WBF or GCF with WF gave higher rheological parameters of dough; meanwhile lightness of the produced breads was reduced. Also, sensory properties of the separation layers and roundness were not affected significantly, but a significant difference was observed in taste, crust colour and odour at replacement level of 30%. Generally, WF supplemented with WBF:GCF (30:15%) did not affected technological quality of balady bread and improved its nutritive values.

INTRODUCTION

Balady bread is an Egyptian product that represents the main diet component for rich and poor Egyptian consumers. In Egypt, there is a big gap between wheat production and its consumption, where the total production of wheat grains covers only about 55% of the total needs [Yaseen *et al*., 2010]. Therefore, many researchers studied the possibility of supplementing wheat flour with other cheaper flour [Khalil *et al*., 2000; McWatters *et al*., 2004; Edema *et al*., 2005; Olaoye *et al*., 2006]. The influence of the addition of cereal flours such as sorghum, maize and barely flours, as well as the flours obtained from lysine-rich legumes, on the physicochemical or rheological properties of bread dough and final products has been reported in the last three decades [Gayle *et al*., 1986; Dhingra & Jood, 2002; McWatters *et al*., 2004; Eissa *et al.*, 2007].

The primary constituents of the barley kernel are: starch (52–71%), protein (8–13%), lipids (2–3%), non-starch polysaccharides, and portion of β-glucan (3–11%) [MacGregor & Fincher, 1993]. Barley is now gaining renewed interest as a functional food ingredient because it is considered as a rich source of β-glucans [Brennan & Cleary, 2005; Soares *et al*., 2007]. Barley β-glucan is effective in flattening the postprandial blood glucose [Li *et al*., 2003; Ostman *et al*., 2006] and reducing the cardiovascular disease risk factors in comparison with other sources of soluble fibers [Behall *et al*., 2004].

As a result of wheat milling, several important nutrients decrease, while the palatability is increased [Hoseney, 1986]. Therefore, the nutritive value of bread could be increased if wheat bran is incorporated into bread formula [AL-Mussali *et al*., 2007]. Alian *et al*. [1997] found that the content of some nutrients in whole wheat flour balady bread was as follows: moisture (33–34%), protein (11.8–11.9%), fat (2.53––2.55%), crude fiber (3.62–3.93%), ash (2.63–2.98%), carbohydrate (78.91–78.98%), and individual elements expressed in mg/100 g, *i.e.* Mn (3.5–4.1), Mg (167–1751), Zn (2.20––3.04), Cu(0.49–0.561), Ca (30–321), and P (310–3401).

Rheological properties of corn and wheat dough showed that corn dough had lower water absorption, extensibility, resistance to extension and dough energy than wheat flour dough [Yaseen *et al*., 2010]. Also, addition of barley flour up to 20% in the formulation had no effect on rheological properties, but higher amounts exhibited deterioration effect, *i.e.* stability time was increased, while 20% barely flour reduced the resistance of extension but it was still suitable for baking requirements [Ashour & El-Faham, 2003].

This study aimed to improve the nutritional, healthy values and quality of balady bread by replacing WF with GCF and/or WBF, with the possibility of completing shortages of wheat raw material. The chemical, rheological, sensory and stalling properties of the obtained balady bread were evaluated.

MATERIALS AND METHODS

Material

Wheat flour (82% extraction) was purchased from the North Cairo Flour Mills Company, Egypt. Naked barley

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(*Hordeum vulgare* variety Giza 130) was obtained from Barley Research Department, Field Research Institute, Agric. Res. Center, Giza, Egypt. White corn (Pioneer 30 K8) was purchased from the Corn Breeding Section, Field Crops Department, Agric. Res. Center, Giza, Egypt.

Preparation of flour mixtures

Barley grains were cleaned, tempered (15% moisture) and milled (Quadrumat Junior flour mill) to 100% extraction flour. Gelatinized corn flour (GCF) was prepared according to Vidal-Quintanar *et al*. [2001]. Nine blends with WF were prepared and compared with control sample (WF) as follows: three levels of WBF (10%, 20% and 30%), three levels of GCF (5%, 10% and 15%) and three levels of mixed WBF with GCF (10:5%, 20:10% and 30:15%). The samples were stored in air--tight containers and kept in a refrigerator (7°C) till used.

Rheological properties

Rheological properties of dough were evaluated using Farinograph, extensograph and Falling number according to AACC [2000].

Preparation of balady bread

Different blends (Table 1) were mixed at the rate of 100 g blended flour with 0.5 g active dry yeast, 1.5 g sodium chloride, and 75–80 mL tap water for about 6 min till forming consistent dough. The dough was left to ferment (1 h/30°C/85% relative humidity), then divided to pieces (125 g). The pieces were arranged on a wooden board that had been sprinkled with a fine layer of bran and were left to ferment for about 45 min at the same temperature and relative humidity. The pieces of fermented dough were flattened to be about 20 cm in diameter. The flattened loaves were proofed at 30–35°C and 85% relative humidity for 15 min and then were baked at 400–500°C for 1–2 min. The loaves of bread were allowed to cool on racks for about 1 h before evaluation.

Sensory evaluation

Balady bread loaves of supplemented WF with WBF, GCF and WBF + GCF were evaluated organoleptically by 15 trained panelists according to El-Farra *et al*. [1982]. Each sample was tested for its general appearance (20), layers separation (20), roundness (15), crumb distribution (15), crust colour (10), taste (10), and odour (10).

Analytical methods

Moisture, crude fiber, ash, protein and fat of raw materials and different balady bread blends were determined according to AOAC [2000]. Total carbohydrates were calculated by difference. β-Glucan was determined according to Hussein *et al*. [2006]. Individual elements (Ca, P, K, Na, Fe, Mn and Cu) in all samples of pan bread were determined according to the method described by Chapman & Pratt [1978]. Hunter color parameters (L, a and b) of raw materials and different balady breads were determined using Tristimulus Color Analyzer (Hunter, Lab Scan XE, Reston, Virginia) with standard white tile.

Freshness of bread

Freshness of balady bread loaves was tested after wrapping in polyethylene bags and storage at room temperature for 1, 3 and 5 days. It was determined using Alkaline Water Retention Capacity test (AWRC) according to the method of Yamazaki [1953], modified by Kitterman & Rubenthaler [1971].

Statistical analysis

The obtained results were evaluated statistically using the analysis of variance as reported by McClave & Benson [1991].

RESULTS AND DISCUSSION

Chemical composition of wheat, barley and corn flours

Table 1 shows that there were no significant differences in moisture content between WF, WBF and GCF. Gelatinized corn flour was lower than WF and WBF in protein. The lowest fat value was found in WF, meanwhile it was 4.0 and 4.39% in WBF and GCF, respectively. Total carbohydrate of the studied flours ranged between 76.71–83.02%. Whole meal barely flour was characterised with its highest crude fiber and β-glucan content (3.35 and 5.12%, respectively). These values agreed with those reported by Izydorczyk *et al*. [2001], Hussein *et al.* [2006], Hussein & Hegazy [2007a] and Yassen *et al.* [2010]. The healthy effect of barely flour could be due to the presence of high amount of β-glucan, but WBF had the lower falling number (250 sec) than GCF (450 sec) and WF (310 sec), which agreed with the results found by Hussein *et al.* [2006]. This result indicated that both flours (WF and GCF) demonstrated a low activity of na-

TABLE 1. Chemical composition (dry weight basis) and Falling number of wheat flour (WF), whole meal barley flour (WBF) and gelatinized corn flour (GCF).

Sample	Chemical composition (%)						β-glucan (%)	Falling No. (sec)
	Moisture	Protein	Fat	Ash	TC	Crude fiber		
WF	$11.65^c \pm 0.18$	$12.05^a \pm 0.11$	$1.81^b \pm 0.08$	$1.47^b \pm 0.0$	$83.02^a \pm 0.78$	$1.65^c \pm 0.01$	$1.75^b \pm 0.04$	$310^b \pm 0.65$
WBF	$12.79^a \pm 0.12$	$12.44^a \pm 0.17$	$4.00^a \pm 0.06$	$3.08^a \pm 0.03$	$76.71^b \pm 0.93$	$3.35^a \pm 0.03$	$5.12^a \pm 0.08$	$250^c \pm 0.55$
GCF	$12.65^b \pm 0.08$	$9.60^b \pm 0.13$	$4.39^a \pm 0.09$	$1.22^c \pm 0.02$	$81.49^a \pm 0.72$	$3.29^b \pm 0.07$	$1.86^b \pm 0.02$	$450^a \pm 0.15$
LSD at 0.05	0.02	1.99	1.95	0.04	1.92	0.04	2.02	14.52

Values are means of three determinations ± standard deviation. [a,b] – mean values in columns with different letters differ significantly.
TC : Total carbohydrate.

tive α-amylase, which may suppress the amylolytic activity of the produced dough.

Mineral content of wheat, barley and corn flours

Mineral content of the studied flours was also evaluated and presented in Table 2. Results indicated that WBF was characterised with its highest phosphorus, potassium, sodium and iron (410, 410, 886 and 6.59 mg/100 g, respectively), while GCF was characterised with its highest value of calcium, copper and magnesium (141, 0.93 and 120 mg/100 g, respectively). The mineral content of WF was low due to the separation of germ and bran during milling, on contrary to GCF and WBF [Shouk, 1996]. It is well known that aleurone cells, together with the germ and testa, contain the essential nutrients required for the growth and development of the embryo [Clydesdale, 1994; Saxalpy & Venn-Brown, 1980]. The obtained results agreed with those reported by Izydorczyk *et al*. [2001], Hussein *et al*. [2006], Hussein & Hegazy [2007b], and Al-Mussali *et al*. [2007].

Rheological properties of dough

Rheological properties of nine blended flours with WF were evaluated using a Farinograph as shown in Table 3. The water absorption, arrival time, dough development time, dough stability and weakening of dough increased with an increasing level of WBF or WBF and GCF added. This increment may be due to high protein and fiber content of WBF compared to WF, where proteins and fibers tend to bind more water. Proteins and fibers in WBF may be interacting with WF ingredients and added water, consequently stability of dough increased. In this respect, Kim *et al*. [1997a] reported that water absorption and stability of dough increased as rice grain dietary fibers increased in the formulation. Urooj *et al*. [1998] and Hussein *et al.* [2006] reported that increasing proportion of barley flour in the blend with white flour caused progressive increase in water absorption, arrival time and dough stability, while water absorption decreased with the addition of GCF to WF. This reduction in water absorption could be attributed to the ability of wheat starch to absorb water 2.47 times more than corn starch (2.40 times) [Whistler *et al*., 1984].

Mixing tolerance index and dough weakening were decreased by increasing the level of WBF and GCF (85: 10: 5, 70: 20: 10 and 55: 30: 15). Minimized dough stability may be related to partial breakdown of dough proteins and starch as a result of the action of proteolytic and amylolytic enzymes in WBF and GCF.

As shown in Table 4, resistance to extension, and proportional number increased in different levels of blended WBF or mixed WBF and GCF with WF while the extensibility of the dough and dough energy decreased in blended WBF or mixed WBF and GCF. This effect may be due to the presence

TABLE 2. Mineral content of wheat flour (WF), whole meal barley flour (WBF) and gelatinized corn flour (GCF) (mg/100 g on dry weight basis).

Sample	Ca	P	K	Na	Fe	Mg	Cu
WF	23.00^{c} ± 0.01	190.12^{c} ± 0.12	102.0^{c} ± 0.08	630.18^{c} ± 0.65	1.71^{c} ± 0.01	104.61^{c} ± 0.22	0.30^{c} ± 0.01
WBF	65.00^{b} ± 0.02	410.00^{a} ± 0.16	410.0^{a} ± 0.06	886.00^{a} ± 0.42	6.59^{a} ± 0.09	110.00^{b} ± 0.36	0.59^{b} ± 0.03
GCF	141.00^{a} ± 0.09	230.00^{b} ± 0.19	160.0^{b} ± 0.02	742.00^{b} ± 0.82	3.50^{b} ± 0.03	120.00^{a} ± 0.41	0.93^{a} ± 0.05
LSD at 0.05	2.66	19.98	15.62	14.97	0.18	0.16	0.19

Values are means of three determinations ± standard deviation. ^{a,b} – mean values in columns with different letters differ significantly.

TABLE 3. Effect of WF supplementation with WBF and/or GCF on rheological properties of dough (Farinograph parameters).

Samples	Water absorption (%)	Arrival time (min)	Dough development time (min)	Dough stability (min)	Mixing tolerance index (BU)	Weakening (BU)
Control – WF	55.5^{ef} ± 0.15	1.0^{c} ± 0.29	2.5^{c} ± 0.19	4.0^{de} ± 0.15	60^{c} ± 2.90	110^{c} ± 4.30
			WF : WBF			
90 : 10	57.0^{de} ± 0.17	1.0^{c} ± 0.00	3.0^{b} ± 0.29	5.0^{c} ± 0.15	50^{d} ± 2.50	110^{c} ± 7.80
80 : 20	59.0^{c} ± 0.15	1.25^{b} ±0.01	3.5^{a} ± 0.50	7.0^{a} ± 0.13	40^{e} ± 5.20	120^{b} ± 2.90
70 : 30	61.5^{a} ± 0.21	1.50^{a} ± 0.05	3.5^{a} ± 0.19	7.0^{a} ± 0.17	30^{f} ± 3.50	130^{a} ± 9.60
			WF : GCF			
95 : 5	55.0^{fg} ± 0.15	1.50^{a} ± 0.02	2.0^{d} ± 0.45	4.5^{cd} ± 0.50	60^{c} ± 5.80	100^{d} ± 5.20
90 : 10	54.0^{g} ± 0.20	1.25^{b} ± 0.17	2.5^{c} ± 0.50	3.5^{ef} ± 0.25	70^{b} ± 3.20	110^{c} ± 7.80
85 : 15	54.0^{d} ± 0.13	1.0^{c} ± 0.11	2.0^{d} ± 0.25	3.0^{f} ± 0.12	80^{a} ± 2.50	110^{c} ± 6.50
			WF : WBF : GCF			
85 : 10 : 5	57.5^{bc} ± 0.11	1.5^{a} ± 0.05	2.5^{c} ± 0.36	4.0^{de} ± 0.29	60^{c} ± 1.20	100^{d} ± 11.90
70 : 20 : 10	60.0^{ab} ± 0.17	1.0^{c} ± 0.07	2.0^{d} ± 0.15	6.0^{b} ± 0.35	40^{e} ± 1.70	90^{e} ± 2.90
55 : 30 : 15	61.0^{ab} ± 0.14	1.5^{a} ± 0.12	3.0^{b} ± 0.35	7.0^{a} ± 0.50	30^{f} ± 3.20	60^{f} ± 2.50
LSD at 0.05	1.48	1.70	1.69	0.54	1.71	1.65

Values are means of three determinations ± standard deviation. ^{a,b} – mean values in columns with different letters differ significantly.
WF – wheat flour; WBF – whole meal barley flour; GCF – gelatinized corn flour.

TABLE 4. Effect of WF supplementation with WBF and/or GCF on rheological properties of dough (Extensograph parameters).

Samples	Resistance to extension (R) (BU)	Extensibility (E) (mm)	Ratio (R/E)	Energy (cm)
Control – WF	200^{h} ± 3.0	110^{b} ± 2.0	1.82^{de} ± 0.10	90^{a} ± 1.5
WF: WBF				
90 : 10	330de ± 1.5	120^{a} ± 2.1	2.75^{bcde} ± 0.11	80^{ab} ± 1.03
80 : 20	340^{d} ± 6.0	100^{d} ± 2.5	3.4^{abcd} ± 0.16	80^{ab} ± 1.02
70 : 30	410^{a} ± 5.2	95^{e} ± 3.2	4.32^{ab} ± 0.09	70^{bc} ± 0.59
WF : GCF				
95 : 5	300^{f} ± 2.5	120^{a} ± 2.0	2.5^{cde} ± 0.03	90^{a} ± 1.5
90 : 10	200^{h}± 3.5	120^{a}± 2.1	1.67^{e} ± 0.02	80^{ab} ± 1.1
85 : 15	280^{g}± 3.5	105^{c} ± 3.0	2.67^{cde} ± 0.13	70^{bc} ± 0.8
WF : WBF : GCF				
85 : 10 : 5	320^{e} ± 4.5	110^{b} ± 2.5	2.91^{bcde} ± 0.15	65^{bcd} ± 1.5
70 : 20 : 10	360^{c} ± 5.0	95^{e} ± 3.2	3.79^{abc} ± 0.03	60^{cd} ± 0.9
55 : 30 : 15	390^{b} ± 2.1	80^{f} ± 3.1	4.75^{a} ± 0.06	50^{d} ± 1.0
LSD at 0.05	16.16	1.70	1.62	16.16

Values are means of three determinations ± standard deviation. ^{a,b} – mean values in columns with different letters differ significantly.
WF – wheat flour; WBF – whole meal barley flour; GCF – gelatinized corn flour.

of WBF fibers and barley protein fractions that dilute the wheat gluten complex of dough. It is well known that viscoelastic property of wheat dough depends on gluten quality and quantity. Therefore, as gluten content increased the viscoelastic property was improved. This decrement may be due to the presence of prolamine fractions in WBF or GCF, without the possibility of forming a gluten complex. The proportional number increased as the percentage of WBF flour increased. These findings agreed with results reported by Naeem *et al.* [2002].

Colour attributes of raw materials and balady bread as affected by adding WBF and/or GCF to WF

The colour parameters of raw materials and balady bread samples were evaluated as shown in Table 5. Balady breads

TABLE 5. Effect of WF supplementation with WBF and/or GCF on balady breads colour (Hunter colour parameters).

Samples	L*	a*	b*	a/b	Saturation	Hue	ΔE*
Flours							
WF	90.45^{a}±2.52	0.48^{i}±0.02	8.34^{m}±0.17	0.056^{i}±0.0	10.07^{l}±0.16	86.71^{a}±1.56	-
WBF	85.28^{ab}±1.50	0.68^{i}±0.01	11.79^{j}±0.25	0.57^{c}±0.01	11.81^{k}±0.12	86.69^{a}±1.22	-
GCF	83.96^{b}±2.16	1.53^{h}±0.09	9.76^{l}±0.18	0.16^{h}±0.0	9.88^{m}±0.08	81.09^{b}±1.65	-
Balady Breads							
Control	62.97^{e}±1.01	2.86^{g}±0.06	16.50^{f}±0.32	0.17^{h}±0.001	16.75^{g}±0.19	80.17^{c}±1.18	-
WF: WBF							
90 : 10	49.11^{fg}±1.05	6.65^{c}±0.16	16.57^{e}±0.14	0.40^{e}±0.02	17.85^{f}±0.13	68.12^{g}±1.16	42.6^{e}±0.27
80 : 20	37.92^{f}±0.56	8.97^{a}±0.22	13.70^{i}±0.07	0.65^{b}±0.02	15.38^{i}±0.15	56.83^{j}±0.56	53.48^{b}±0.45
70 : 30	31.18^{i}±0.85	9.20^{a}±0.42	11.73^{a}±0.18	0.78^{a}±0.01	14.91^{j}±0.07	52.00^{k}±0.72	60.00^{a}±0.62
WF : GCF							
95 : 5	65.72^{de}±0.75	3.22^{g}±0.26	18.16^{c}±0.11	0.199^{gh}±0.001	18.44^{d}±0.22	79.95^{c}±0.90	26.74^{g}±0.62
90 : 10	68.22^{cd}±1.80	4.56^{e}±0.15	20.17^{b}±0.16	0.23^{fg}±0.001	20.68^{b}±0.18	77.25^{d}±0.75	25.51^{h}±0.40
85 : 15	73.65^{c}±1.13	5.32^{d}±0.35	22.18^{a}±0.16	0.24^{fg}±0.002	22.18^{a}±0.26	76.51^{e}±1.15	22.29^{i}±0.36
WF : WBF : GCF							
85:10:5	53.25^{f}±1.45	3.99^{f}±0.13	15.70^{g}±0.22	0.25^{f}±0.003	16.19^{h}±0.16	75.74^{f}±2.56	38.08^{f}±0.22
70:20:10	46.82^{g}±1.20	8.44^{b}±0.15	17.37^{d}±0.26	0.49^{d}±0.002	19.31^{c}±1.15	64.08^{h}±1.25	45.26^{d}±0.52
55:30:15	44.82^{g}±0.65	8.60^{b}±0.09	16.20^{g}±0.12	0.53^{c}±0.002	18.34^{e}±0.08	62.04^{i}±2.06	47.00^{c}±0.35
LSD at 0.05	5.89	0.37	5.04	4.91	0.02	0.54	0.36

Values are means of three determinations ± standard deviation. ^{a,b} – mean values in columns with different letters differ significantly.
WF – wheat flour; WBF – whole meal barley flour; GCF – gelatinized corn flour.

made from mixtures of WBF and GCF with WF were darker than control balady bread or those containing GCF, where lightness (L*) and redness (b*) decreased as the level of WBF increased. The same trend was observed in case of yellowness (a*) and total color difference (ΔE) of balady bread samples, where their values were getting higher as WBF level was increased. The obtained result could be attributed to the darkness of WBF sample (lower L*). Such a finding is in agreement with results described by Kim *et al*. [1997b], Kordonowy &Young [1985] and Ramy *et al*. [2002].

Effect of blending WBF and/or GCF with WF on sensory properties of balady bread

The influence of blending WBF and GCF on the organoleptic properties of balady bread was evaluated (Table 6 and Figure 1). The obtained results indicated that increasing the level of WBF decreased sensory scores of balady bread for general appearance, separation of layers, roundness, and distribution of crumb, crust colour, taste and odour. Separation of layers and roundness of balady bread samples were not affected significantly ($p<0.05$) in case of using WBF or GCF when compared with control bread sample. A significant difference ($p<0.05$) was detected when WBF level was increased over 10%. The WBF level (30%) was proportional to lower scores in taste, crust colour and odour. These effects may be due to higher fiber content of WBF which affected colour and taste of bread. As the level of WBF in blends was increased, crust colour of breads changed from white creamy to dull brown. A significant difference in crust colour was observed in all blended breads. The data suggested that the darkest colour was observed in bread prepared from WBF and WBF with GCF blended flours. The darker crust colour may be due to the presence of Millard reaction products [Raidi & Klein, 1983].

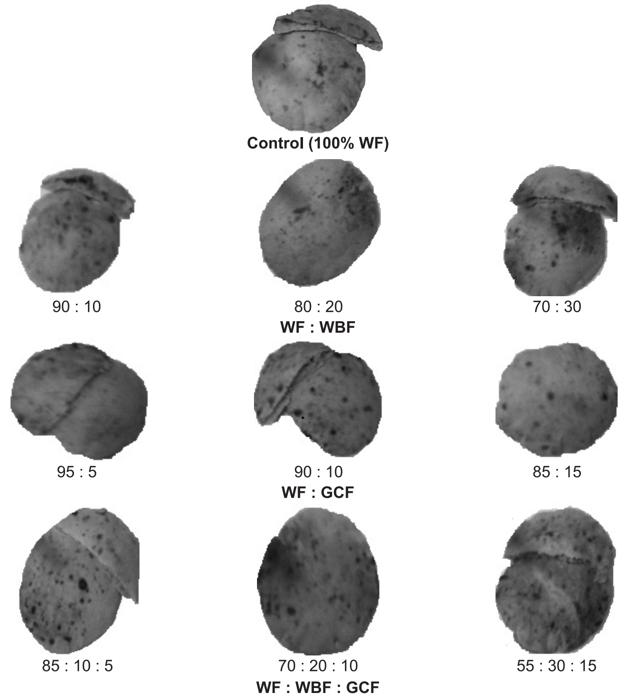

FIGURE 1. Balady breads supplemented with WBF and/or GCF.

In this respect, Zumbado *et al.* [1997] reported that sensory scores of bakery products decreased with an increasing level of rice bran. The deterioration in the crumb texture and crumb colour of wheat bread due to the similar supplementations was observed by several researchers [Rathna & Neelakantan, 1995; Sharma *et al*., 1999; Carson *et al*., 2000]**.** Furthermore, Pena & Amaya [1993], Doxastakis *et al*. [2002] and Naeem *et al*. [2002] stated that acceptable pan bread can be produced by using 1:1 wheat and triticale flour blend.

TABLE 6. Effect of WF supplementation with WBF and/or GCF on sensory properties of balady breads.

Balady bread	General appearance (20)	Separation of layers (20)	Roundness (15)	Distribution of crumb (15)	Crust colour (10)	Taste (10)	Odour (10)
Control	17.5^{a} ± 0.88	18.5^{a} ± 0.87	14.7^{a} ± 0.48	14.4^{a}± 0.70	9.1^{a} ± 0.88	9.15^{a} ± 0.67	8.85^{a}± 0.79
WF: WBF							
90 : 10	17.3^{a} ± 0.82	18.4^{a} ± 0.76	14.5^{a} ± 0.53	13.7^{ab}± 0.67	8.1^{bc} ± 0.87	8.45^{bc} ± 0.45	8.75^{ab}± 0.33
80 : 20	16.5^{b} ± 0.74	18.3^{a} ± 0.82	14.5^{a} ± 0.53	13.0^{bc}± 0.82	7.3^{cd} ± 0.82	8.35^{c} ± 0.65	8.3^{bc} ± 0.48
70 : 30	16.0^{bc} ± 0.95	18.6^{a} ± 0.65	14.4^{a} ± 0.52	12.7^{c}± 1.17	7.3^{cd} ± 0.95	7.55^{f} ± 0.49	8.1^{c} ± 0.66
WF : GCF							
95 : 5	17.7^{a} ± 0.92	18.2^{a} ± 0.57	14.2^{a} ±0.42	13.3^{bc}± 0.95	9.1^{a} ± 0.74	8.9^{ab} ± 0.52	8.15^{c} ± 0.41
90 : 10	17.5^{a} ± 0.64	18.1^{a} ± 0.66	14.3^{a} ± 0.48	13.3^{bc} ± 1.34	9.0^{a} ± 0.97	8.2^{cd} ± 0.62	8.25^{c} ± 0.47
85 : 15	17.0^{ab} ± 1.08	18.3^{a} ± 0.77	14.1^{a} ± 0.88	13.2^{bc} ± 1.03	8.1^{bc} ± 0.74	8.05^{cd} ± 0.74	8.5^{b}±1.15
WF: WBF : GCF							
85:10:5	17.0^{ab} ± 0.83	18.4^{a} ± 0.62	14.1^{a} ± 0.74	13.1^{bc} ± 1.2	8.3^{ab}± 0.95	8.2^{cd}± 0.26	8.4^{bc} ± 0.46
70:20:10	16.7^{b} ± 0.87	18.5^{a} ± 0.86	14.4^{a} ± 0.52	12.8^{bc}± 1.23	7.4^{cd} ± 0.97	8.1^{cd} ± 0.65	8.4^{bc} ± 0.32
55:30:15	16.5^{b} ± 0.56	18.3^{a} ± 0.77	14.2^{a} ± 0.63	13.0^{bc}± 0.82	7.1^{d} ± 0.36	7.8^{de} ± 0.46	8.6^{ab} ± 0.74
LSD at 0.05	1.32	NS	NS	0.93	0.83	0.46	0.44

Values are represents the average of 15 scores ± standard deviation. ^{a,b} – mean values in columns with different letters differ significantly.

TABLE 7. Chemical composition and mineral content of balady breads supplemented with WBF and/or GCF (dry weight basis).

Components (%)	Control – WF	WF : WBF			WF : GCF			WF : WBF : GCF			LSD at 0.05
		90 : 10	80 : 20	70 : 30	95 : 5	90 : 10	85 : 15	85 : 10 : 5	70 : 20 : 10	55 : 30 : 15	
Moisture	34.52^{cd}± 1.70	35.11^{bcd}± 1.22	36.00^{ab}± 1.03	37.16^{a}± 0.85	34.35^{cd}± 1.00	34.65^{cd}± 0.96	35.01^{bcd}± 0.76	35.20^{bcd}± 0.68	36.07^{ab}± 0.54	37.35^{a}± 1.02	1.41
Protein	11.65± 0.22	11.80± 0.16	12.05± 0.12	12.20± 0.02	11.50± 0.23	11.45± 0.16	11.40±0.09	11.75± 0.16	11.92± 0.05	12.10± 0.03	NS
Fat	1.65^{e}± 0.01	1.80^{d}± 0.03	2.10^{c}± 0.05	2.50^{b}± 0.0	1.75^{d}± 0.001	1.90^{d}± 0.02	2.15^{c}± 0.02	2.0^{c}± 0.01	2.40^{b}± 0.02	3.05^{a}± 0.01	0.15
Ash	1.45^{e}± 0.01	1.65^{cd}± 0.02	1.72^{bc}± 0.03	1.85^{a}± 0.01	1.40^{ef}± 0.03	1.35^{f}± 0.05	1.30^{f}± 0.001	1.60^{d}± 0.00	1.68^{cd}± 0.01	1.75^{b}± 0.02	0.08
Carbohydrate	83.25^{a}± 2.35	82.50^{b}± 2.65	81.68^{c}± 3.12	80.75^{d}± 2.70	83.45^{a}± 2.65	83.40^{a}± 3.12	83.43^{a}± 2.14	82.45^{b}± 2.12	81.65^{c}± 3.10	80.60^{d}± 3.15	0.37
Crude fiber	2.00^{b}± 0.03	2.25^{b}± 0.06	2.45^{b}± 0.07	2.70^{a}± 0.03	1.90^{c}± 0.06	1.80^{c}±0.01	1.72^{c}± 0.006	2.20^{b}± 0.001	2.35^{b}± 0.06	2.50^{ab}± 0.03	0.30
β-glucan	1.70^{c}± 0.02	1.93^{c}± 0.001	2.45^{b}± 0.006	2.85^{a}± 0.12	1.73^{c}± 0.09	1.75^{c}± 0.03	1.78^{c}± 0.004	2.16^{c}± 0.003	2.52^{b}± 0.01	2.90^{a}± 0.06	0.30
Minerals (mg/100 g)											
Ca	23.00^{e}± 0.13	30.0^{d}± 0.22	37.5^{c}± 0.26	43.32^{b}± 0.35	30.10^{d}± 0.45	38.12^{c}± 0.45	45.07^{b}± 0.55	37.09^{b}± 1.10	45.5^{b}± 1.03	55.16^{a}± 1.55	2.35
P	190.0^{h}± 1.16	225.0^{f}±2.03	265.0^{d}±2.13	300^{b}± 3.10	195^{h}± 2.55	210.0^{g}±2.32	221^{f}± 1.81	230^{ef}± 2.35	272^{c}± 3.22	315^{a}± 2.19	9.72
K	96.00^{i}± 0.75	132.0^{f}±1.36	172.0^{d}±1.69	210^{b}± 2.25	105^{h}± 1.16	120.0^{g}±1.56	132^{f}± 1.15	138^{f}± 2.12	180^{c}± 1.42	220^{a}± 2.25	6.81
Fe	1.82^{i}± 0.09	2.35^{ef}± 0.009	2.85^{d}± 0.01	3.32^{b}± 0.06	1.95^{h}± 0.002	2.14^{g}± 0.13	2.27^{f}± 0.08	2.40^{e}± 0.02	2.93^{d}± 0.03	3.60^{a}± 0.01	0.07

Values are represents the average of three representative samples ± standard deviation. ^{a,b} – mean values in columns with different letters differ significantly.

Chemical composition of bread

Data presented in Table 7 show the chemical composition and mineral content of blended barley-corn-wheat bread compared with wheat bread. Corn-wheat bread was characterised with lower protein, fiber and ash content, and higher carbohydrate content than wheat bread. WBF-wheat bread was higher in protein, fiber, ash and β-glucan and lower in carbohydrate content than wheat bread. The addition of WBF and GCF to wheat bread caused changes in chemical (moisture, protein, fat, ash, crude fiber and β-glucan) and mineral content (Ca, P, K and Fe) of bread samples except carbohydrate content which was not affected. The obtained results indicated that higher nutritional values (chemical and minerals) for balady bread were obtained by blending WBF (30%) and GCF (15%) with WF without affecting the technological and sensorial properties.

Freshness of balady bread

The effect of storage period (1–5 day) at room temperature on freshness of balady bread was evaluated. Table 8 showed that the control bread sample had the highest values of alkaline water retention capacity which were declined during 1, 3 and 5 days of storage to 350, 290 and 240%, respectively. However, blended WBF or GCF with WF caused a noticeable decrease in alkaline water retention capacity values at the same storage period. Such an effect might be related to the difference in quantitative distribution of protein fractions and physicochemical properties of wheat, corn and barley starch. Such limited information is not sufficient to explain stalling. Further research is needed to elucidate why triticale bread stales much faster than wheat bread [Yaseen *et al.*, 2007].

CONCLUSION

From the obtained results it could be concluded that wheat flour could be replaced with whole barely flour

TABLE 8. Effect of storage period at room temperature on the freshness of balady breads supplemented with WBF and/or GCF

Balady bread	Storage period		
	1 day	3 days	5 days
Control – WF	350± 4.70	290± 2.50	240± 3.20
WF : WBF			
90 : 10	340± 5.20	285± 3.70	230± 2.50
80 : 20	330± 6.00	270± 4.20	210± 5.30
70 : 30	280± 2.50	240± 2.20	190± 1.90
WF : GCF			
95 : 5	345± 3.70	285± 4.50	235± 3.50
90 : 10	340± 2.50	280± 4.20	230± 5.50
85 : 15	330± 2.50	270± 3.60	223± 3.20
WF : WBF : GCF			
85 : 10 : 5	335± 1.50	280± 3.00	225± 2.20
70 : 20 : 10	325± 4.10	260± 4.00	200± 6.50
55 : 30 : 15	265± 2.50	225± 3.00	170± 3.50

Values are means of three determinations ± standard deviation.
WF – wheat flour; WBF – whole meal barley flour; GCF – gelatinized corn flour.

and gelatinized corn flour at the level of 30:15% without drastic effect on the technological quality and sensory properties of bread. Moreover, higher nutritive values of this bread are achieved. Supplementation improved protein, fat, fiber, ash, β-glucan and minerals (Ca, P, K and Fe) of balady bread.

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REFERENCES

1. AACC, Approved Methods of the AACC. 8th ed., American Association of Cereal Chemists, INC. St., Paul, 2000, Minnesota, USA.
2. Alian A.M., Abdel-Latif A.R., Yaseen A.A., Production of balady and pan bread from whole wheat flour. Egypt. J. Food Sci., 1997, 25, 213–230.
3. AL-Mussali M.S., Basunbel F., Khamees H., Bread from composite flour of wheat and millet. Yemen J. Agric. Res. Stud., 2007, 16, 5–18.
4. Ashour H.K., El-Faham S.Y.A., Supplementation of durum wheat flour with naked barley flour to produce balady bread and pasta. Minufiya J. Agric. Res., 2003, 28, 1957–1970.
5. AOAC, Official Methods of Analysis of A.O.A.C. International. Published by A.O.A.C, 2000. Virginia, USA.
6. Behall K., Scholfield D., Hallfrisch J., Diets containing barley significantly reduce lipids in mildly hyper cholesterolemic men and women. Amer. J. Clin. Nutr., 2004, 80, 1185–1193.
7. Brennan C.S., Cleary L.J., The potential use of cereal (1→3, 1→4)-β-D-glucans as functional food ingredients. J. Cereal Sci., 2005, 42, 1–13.
8. Carson L., Sitser C., Sun X.S., Sensory characteristics of sorghum composite bread. Int. J. Food Sci. Nutr., 2000, 35, 465––471.
9. Chapman H.D., Pratt P.F., Methods of Analysis for Soil, Plants and Water. 1978, Univ. of California, Div. Agric. Sci., Priced Publication 4034, p. 50.
10. Clydesdale F.M., Optimizing the diet with whole grains. Crit. Rev. Food Sci. Nutr., 1994, 34, 453–471.
11. Dhingra S., Jood S., Organoleptic and nutritional evaluation of wheat breads supplemented with soybean and barley flour. Food Chem., 2002, 77, 479–488.
12. Doxastakis G., Zafiriadis I., Irakli M., Marlani H., Tananaki C., Lupin, soya and triticale addition to wheat flour doughs and their effect on rheological properties. Food Chem., 2002, 77, 219–227.
13. Edema M.O., Sanni L.O., Sanni A.I., Evaluation of maize-soybean flour blends for sour maize bread production in Nigeria. Afr. J. Biotech., 2005, 4, 911–918.
14. Eissa H.A., Hussein A.S., Mostafa B.E., Rheological properties and quality evaluation of Egyptian balady bread and biscuits supplemented with flours of ungerminated and germinated legume seeds or mushroom. Pol. J. Food Nutr. Sci., 2007, 57, 487–496.
15. El-Farra A.A., Khorshid A.M., Mansour S.M., Elias A.N., Studies on the possibility of supplementation of balady bread with various commercial soy-products. 1982, *in*: Materials of 1st Egypt. Conf. on Bread Res., Cairo, 1982, pp. 9–23.
16. Gayle P.E., Knight E.M., Adkins J.S., Harland B.F., Nutritional and organoleptic evaluation of wheat breads supplemented with pigeon pea (*Cajanus cajan*) flour. Cereal Chem., 1986, 63,136–138.
17. Hoseney C.R., Principles of Cereal Science and Technology. 1986, American Association of Cereal Chemists, Inc U.S.A.
18. Hussein A.M.S., Helmy, I.M.F., Mustafa, B.E., Effect of barley flour and some of their functional ingredients on quality of pan bread. Minufiya J. Agric. Res., 2006, 31, 877–897.
19. Hussein A.M.S, Hegazy Nefisa A., Physicochemical characteristics and sensory evaluation of corn and sorghum dry masa flours in relation to packaging materials and storage conditions. J. Agric Sci., Mansoura Univ., 2007a, 32, 7417–7435.
20. Hussein A.M.S, Hegazy Nefisa A., Effect of adding aleurone flour at different levels on pan bread quality. Minufiya J. Agric Res., 2007b, 32, 1349–1363.
21. Izydorczyk M.S., Hussain A., MacGregor A.W., Effect of barley and barley components on rheological properties of wheat dough. J. Cereal Sci., 2001, 34, 251–260.
22. Khalil A.H., Mansour E.H., Dawood F.M., Influence of malt on rheological and baking properties of wheat-cassava composite flours. LWT-Food Sci. Technol., 2000, 33, 159–164.
23. Kim Y.S., Ha T.Y., Lee S.H., Lee H.Y., Effect of rice bran dietary fiber on flour rheology and quality of wet noodles. Korean J. Food Sci. Technol., 1997a, 20, 90–95.
24. Kim Y.S., Ha T.Y., Lee S.H., Lee H.Y., Properties of dietary fiber extract from rice bran and application in breadmaking. Korean J. Food Sci. Technol., 1997b, 29, 502–508.
25. Kitterman J.S., Rubenthaler, G.L., Assessing the quality of early generation wheat selection with the micro AWRC test. Cereal Sci. Today, 1971, 16, 313–316, 328.
26. Kordonowy R.K., Youngs V.L., Utilization of durum bran and its effect of spaghetti. Cereal Chem., 1985, 62, 301–308.
27. Li J., Kaneko T., Qin L., Wang J., Wang Y., Effect of barley intake on glucose tolerance, lipid metabolism and bowel functional in women. Nutrition, 2003, 19, 926–929.
28. MacGregor A.W., Fincher G.B., Carbohydrates of the barley grain. 1993, *in*: Barley: Chemistry and Technology (eds. W. MacGregor, R.S. Bhatty). AACC, St. Paul, USA pp. 73–130.
29. McClave J.T., Benson P.G., Statistical for Business and Economics. 1991, Max Well Macmillan International editions, Dellen Publishing Co.: USA, pp. 272–295..
30. McWatters K.H., Phillips R.D., Walker S.L., McCullough S.E., Mensa-Wilmot Y., Saalia F.K., Hung Y.C., Patterson S.P., Baking performance and consumer acceptability of raw and extruded cowpea flour breads. J. Food Qual., 2004, 27, 337–351.
31. Naeem H.A., Darvey N.L., Gras P.W., MacRitchie F., Mixing properties, baking potential, and functionality changes in storage protein during dough development of triticale-wheat flour blends. Cereal Chem., 2002, 79, 332–339.
32. Olaoye O.A., Onilude A.A., Idowu O.A., Quality characteristics of bread produced from composite flours of wheat, plantain and soybeans. Afr. J. Biotech., 2006, 5, 1102–1106.
33. Ostman E., Rossi E., Larsson H., Brighenti F., Bjorck I., Glucose and insulin response in healthy men to barley bread with different levels of (1→3, 1→4)-β-glucans; predictions using fluidity measurements of *in vitro* enzyme digests. J. Cereal Sci., 2006, 43, 230- 235.

34. Pena R.J., Amaya A., Milling and bread making properties of wheat--triticale grain blends. J. Sci. Food Agric., 1992, 60, 483–487.
35. Raidl M.A., Klein B.P., Effect of soy or field pea flour substitution on the physical and sensory characteristics of chemically leavened quick breads. Cereal Chem., 1983, 60, 367–370.
36. Ramy A., Salama Manal F., Shouk A.A., Pollards a potential source of dietary fiber for pasta manufacture. Egypt. J. Food Sci., 2002, 30, 313–330.
37. Rathna K., Neelakantan S.. Effect of incorporation of puffed Bengalgram flour on the quality of bread. J. Food Sci. Technol., 1995, 32, 169–171.
38. Saxalpy C., Venn-Brown U., The structure and composition of wheat grain. 1980, *in*: The Role of Australian Flour and Bread in Health and Nutrition (eds. C. Saxelby, U. Venna-Brown). Glenburn Pty. Ltd., Chat-Swood, Australia, pp. 37–41.
39. Sharma S., Bajwa U., Nagi H.P.S., Rheological and baking properties of cowpea and wheat flour blends. J. Sci. Food Agric., 1999, 79, 657–662.
40. Shouk A.A., Production and evaluation of whole meal wheat bread. Ph.D. thesis, Faculty of Agriculture, Food Science and Technology Department, Cairo University, 1996.
41. Soares R.M.D., DeFrancisco A., Rayas-Duarte P., Soldi V., Brazilian hull–less and malting barley genotypes: I. Chemical composition and partial characterization. J. Food Qual., 2007, 30, 357–371.
42. Urooj A., Vinutha S.R., Puttaraj S., Leelavathy K., Rao P.H., Effect of barley incorporation in bread on its quality and glycemic responses in diabetics. Int. J. Food Sci. Nutr., 1998, 49, 265–270.
43. Vidal-Quintanar R.L., Love J., Johnson L.A., Role of oil on physical properties of corn masa flours and sensory characteristics of corn tortillas. J. Food Process. Preserv., 2001, 25, 1–14.
44. Whistler R.L., Bemiller J.N., Paschall E., Starch: Chemistry and Technology. 1984, Academic Press, Inco. Orlando, San Deigo, New York, London, Toronto, Montreal, Sydney, Tokyo.
45. Yamazaki W.T., An alkaline water retention capacity test for the evaluation of cookie baking potentialities of soft winter wheat flours. Cereal Chem., 1953, 30, 242–246.
46. Yaseen A.A., Shouk A.A., Ramadan M.T., Corn-wheat pan bread quality as affected by hydrocolloids. J. Amer. Sci., 2010, 6, (10) 684–690.
47. Yaseen A.A., Shouk A.A., Selim M.M., Egyptian balady bread and biscuit quality of wheat and triticale flour blends. Pol. J. Food Nutr. Sci., 2007, 57, 25–30.
48. Zumbado H., Ledesma L., Fuertes F., Ventura J., Manufacture of a bakery product with incorporation of high levels of precooked rice bran. Alimentaria, 1997, 280, 21–23.

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