

# Evaluation of Bakery Products Made from Barley-Gelatinized Corn Flour and Wheat-Defatted Rice Bran Flour Composites

Ahmed M. S. Hussein, Sahar Y. Al-Okbi

**Abstract**—In the present research, whole meal barley flour (WBF) was supplemented with gelatinized corn flour (GCF) in 0 and 30%. Whole meal wheat flour (WWF) was mixed with defatted rice bran (DRB) to produce 0, 20, 25, and 30% replacement levels. Rheological properties of dough were studied. Thermal properties and starch crystallinity of flours were evaluated. Flat bread, balady bread and pie were prepared from the different flour blends. The different bakeries were sensory evaluated. Color of raw materials and crust of bakery products were determined. Nutrients contents of raw flours and food products were assessed. Results showed that addition of GCF to WBF increased the viscosity and falling number of the produced dough. Water absorption, dough development time and dough stability increased with increasing the level of DRB in dough while, weakening and mixing tolerance index decreased. Extensibility and energy decreased, while, resistance to extension increased as DRB level increased. Gelatinized temperature of WWF, WBF, GCF, and DRB were 13.26, 35.09, 28.33, and 39.63, respectively. Starch crystallinity was affected when DRB was added to WWF. The highest protein content was present in balady bread made from 70% WWF and 30% DRB. The highest calcium, phosphorus, and potassium levels were present in products made from 100% WBF. Sensory attributes of the products were slightly affected by adding DRB and GCF. Conclusion: Addition of DRB or GCF to WWF or WBF, respectively affect the physical, chemical, rheological and sensory properties of balady bread, flat bread, and pie while improved their nutritive values.

**Keywords**—Bakeries, rheological properties, chemical and sensory attributes, flour thermal properties and starch crystallinity.

## I. INTRODUCTION

CEREALS and cereal products especially the whole grains are important healthy foods. Among these cereals are wheat, corn, rice, and barley. Different healthy effect of barley including potential hypocholesterolemic, anti-inflammatory and antioxidant effect were reported due to presence of phytate,  $\beta$ -glucan, tocopherols and tocotrienols [1]. Also Barley bread was reported to improve kidney dysfunction in experimental animals [2]. Rice bran and its defatted form were shown to contain high percentage of dietary fibers [3], [4] that showed anticancer and hypercholesterolemic effect [5], [6]. Antitumor and antidiabetic effects of rice bran dietary fibers have been reported [7],[8]; cellulose, hemicellulose,  $\alpha$ - and  $\beta$ -glucan are among the dietary fibers present in rice bran.

A. M. S. Hussein is with the Dept. of Food Technology, National Res. Center, Dokki, Giza, Egypt (corresponding author to provide phone: +201224642449; fax: 002-33370931; e-mail: a\_said2220@yahoo.com).

S. Y. Al-Okbi is with the Food Sciences and Nutrition Dept., National Res. Center, Dokki, Giza, Egypt.

Defatted rice bran also showed to be rich in phenolic compounds and flavonoids [4] that reflect its potential health benefits as antioxidant and anti-inflammatory. Rice bran was used previously in different bakery products and showed successful results [9].

Bread and bakery products are the basis of human nutrition worldwide. Beside its main function as starch and energy supplier, bread and bakery products could offer high amounts of vitamins, minerals, trace elements, and dietary fiber if made from whole grain (such as corn and wheat). As nutritionally beneficial constituents are primarily located in the germ and bran, whole-grain cereal products are rich in these compounds. Additionally, a low glycaemic index of whole grain can lower the risk for chronic diseases. Starch in breads baked with fine flour evokes a rapid increase in plasma glucose, while after consumption of wholegrain products the increase in the concentration of postprandial glucose is lowered [10]. This can lead to a decreased risk for type 2 diabetes. However, in many countries the consumption of whole-grain foods is estimated to be limited [11], [12]. Tremendous efforts are made to enhance the consumption of whole-grain food through clarifying its health benefits to consumer as being a functional food [[13]-[15].

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 [16]. Gelatinized corn flour showed good quality of dough than non gelatinized corn. Hussein et al. [17] reported that wheat flour could be replaced with whole barely flour and gelatinized corn flour at the level of 15-30% without drastic effect on the technological quality and sensory properties of bread. Moreover, higher nutritive values of that bread are achieved. Supplementation improved protein, fat, fiber, ash,  $\beta$ -glucan and Ca, P, K and Fe of balady bread.

Inclusion of more than one cereal in a bakery product could have an added health effect. Therefore, the present research aimed at studying the chemical composition and physical properties of whole meal barley flour, gelatinized corn flour, whole meal wheat flour, and defatted rice bran flour. The aim included production of flat bread, balady bread, and pie from mixture of the aforementioned flour along with studying the rheological properties of dough. Chemical composition and sensory evaluation of the different bakery products were among the aim of the present research.

## II. MATERIALS AND METHODS

### A. Materials

Wheat grains (Giza 168) was purchased from Wheat Research Department, Field Research Institute, Agric. Res. Center, Giza, Egypt. Naked barley (*Hordeum vulgare* variety Giza 129) was obtained from Barley Research Department, Field Research Institute, Agric. Res. Center, Giza, Egypt. White corn grains (Single cross10) were purchased from the Corn Breeding Section, Field Crops Department, Agric. Res. Center, Giza, Egypt. Rice bran was obtained directly from Delta Company for rice milling, Tanta, Egypt and stabilized instantaneously by heating at 125°C for 15 minutes as previously reported [9].

### B. Preparation of Defatted Rice Bran (DRB)

Stabilized rice bran was sieved through a 20 –mesh sieve to remove broken pieces of rice and husks, mixed homogeneously and stored within tight poly ethylene bags in a deep freeze until used. Rice bran was defatted by petroleum ether using continuous extraction apparatus (Soxhlet). Residual solvent was removed by heating DRB in hot air oven at 40°C. Then defatted rice bran was reduced to very fine powder.

### C. Preparation of Flour

Naked barley was cleaned, tempered (15% moisture) and milled (Quadrumat Junior flour mill) to 100% extraction flour. Whole meal barley flour (WBF) 100% extraction was well blended with gelatinized corn flour (GCF) to produce individual mixtures containing 0 and 30% replacement levels. The samples were stored in airtight containers and kept at 5-7°C until required.

Wheat grains were cleaned, tempered (15% moisture) and milled (Quadrumat Junior flour mill) to 100% extraction flour. Whole meal wheat flour (WWF) 100% extraction was well blended with defatted rice bran to produce individual mixtures containing 0, 20, 25 and 30% replacement levels. All samples were stored in airtight containers and kept at 5-7°C until required.

### D. Rheological Properties

Whole meal barley flour, GCF and Blend of 30% GCF with 70 WBF were subjected to dough rheology as determined by an amylograph (Brabender amylograph, Duisburg Nr. 940053, type 680022) according to [18]. Falling number of dough with different levels of DRB was measured as described previously [18]. The effect of DRB on the mixing profile of the dough was studied using a farinograph and extensograph according to the standard AACC methods [18].

### E. Thermal Properties of Flours

Thermal properties of WBF, GCF, WWF and DRB were measured by using Diffraction Scanning Colorimeter (shimadzu DSC-50) according to [19]. The temperatures of the characteristic transitions, onset temperature ( $T_o$ ) and end temperature ( $T_e$ ) were recorded and the temperature range ( $T_e-T_o$ ,  $\Delta T$ ) was calculated.

### F. Starch Crystallinity

The crystallinity of starch was evaluated by X-ray diffraction patterns of samples using monochromatic CuK radiation on a Philips X-ray diffract meter at 35 kv and 15 mA (Central Lab, National Research Centre, Egypt). Lyophilized samples were placed on the 1 cm<sup>2</sup> surface of a glass slide and equilibrated overnight at 91% rh and run at 2-32° (diffraction angle 2 $\theta$ ). The spacing was computed according to Bragg's law [20].

### G. Preparation and Evaluation of Flat Bread

Two blends (100% WBF and 70% WBF+30% GCF) were mixed at the rate of 100g blended flour with 1.5 g active dry yeast, sodium chloride (1.5 g) and sugar (10g). The dough was left to ferment for 1 hr at 30°C and 85% relative humidity. The dough was divided into pieces each weigh 50 g. The pieces were spread to 2 mm thickness and baked at 350 °C for 1min [21]. Organoleptic evaluation was carried out for texture, crust color, odor, taste, appearance and overall acceptability.

### H. Preparation and Evaluation of Pie

Two blends (100% WBF and 70% WBF+30% GCF) were mixed at the rate of 100g blended flour with 15g shortening, 1.5 g active dry yeast, sodium chloride (1.5 g) and sugar (10g). The dough was left to ferment for 1 hr at 30°C and 85% relative humidity. The dough was divided into pieces each weighs 50gm. The pieces were arranged on trays and were left to ferment for a further 30 min at the same temperature and relative humidity. The pieces of fermented dough were left again for 15 min at the same temperature and relative humidity then were baked at 230 °C for 10 min. Pies were allowed to cool on racks for about 1 hr before evaluation. They were evaluated organoleptically by 15 trained panelists. The samples were scored according to taste (20 degree), aroma (20), mouth feel (10), crumb texture (15), crumb color (10), crust color (10), break & shred (10) and symmetry shape (5).

### I. Preparation and Evaluation of Balady Bread

Different blends (100% WWF, 80% WWF+20% DRB, 75% WWF+25% DRB and 70% WWF+30% DRB) 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 into pieces (125 g each). 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. Balady bread loaves were evaluated organoleptically by 15 trained panelists. Each sample was tested for its general appearance (20 degree), layers separation

(20), roundness (15), crumb distribution (15), crust color (10), taste (10), and odor (10).

#### J. Color Determinations

The color parameters (L, a and b) of different raw materials and bakery products were measured by using a Spectrocolorimeter (Tristimulus Color Machine) with CIF lab color scale (Hunter, Lab Scan XE, Germany). The assessed color quality includes, L= lightness (100= white; 0= black), a= redness (+100) to green (-80), b= yellowness (70) to blue (-80) and  $\Delta E = (L^2 + a^2 + b^2)^{1/2}$ . The Hue and Chrome were calculated according to [22].

#### K. Determination of Proximate Composition and Mineral Contents of Raw Flours and Food Products

Moisture, crude fiber, ash, protein, and fat of raw materials and different food products were determined [23]. Total carbohydrates were calculated by difference. Individual elements (Ca, P, K, and Fe) in all samples were assessed [24].

#### L. Statistical Analysis

The obtained results were evaluated statistically using analysis of variance [25]

### III. RESULTS AND DISCUSSION

#### A. Chemical Composition, Minerals and Moisture Content of Different Flours

Data presented in Table I showed the chemical composition, minerals and moisture content of WWF, WBF, GCF and DRB flours. Gelatinized corn flour was characterized with its higher content of fat and its lower content of protein than other flours. WBF contained the highest level of phosphorus and potassium. Defatted rice bran (DRB) was of the highest protein, fiber, ash, calcium and iron and the lowest content of total carbohydrate compared to other flours. Such findings are similar to those obtained previously [4], [17], [26], [27].

#### B. Viscoamylograph Measurements and Falling Number of Dough Containing WBF and GCF

The amylograph measures the change in viscosity of a flour-water suspension as the temperature is raised at a uniform rate. The height of the amylogram peak is related to the gelatinization characteristics of the starch and the  $\alpha$ -amylase activity [28].

Whole barley flour (WBF), GCF and mixture of 70% WBF plus 30% GCF were rheologically evaluated by viscoamylograph for heat of transition, maximum viscosity, temperature of maximum viscosity, break down viscosity and set-back viscosity as presented in Table II. Results showed that WBF and GCF had 60.5°C and 72.5°C, 80 °C and 86°C, 310BU and 515BU, 180 BU and 280 BU and 350 BU and 920 BU for heat of transition, temperature of maximum viscosity, maximum viscosity, break down viscosity and set-back viscosity, respectively. Addition of GCF to WBF at a rate of 30% to 70% gradually increased all measured parameters compared to WBF from 60.5 to 65°C, from 80 to 82°C, from 310 to 380 BU, from 180 to 230 BU and from 350 to 500 BU for heat of transition, temperature of maximum viscosity, maximum viscosity, break down viscosity and set-back viscosity, respectively.

The above mentioned results indicated that addition of GCF to WBF increased the viscosity of the produced dough. This might be attributed to the higher content of starch in the blends and starch molecular weight of corn and its solubility compared to that of WBF. The gelatinization temperature of WBF (60.5°C) is lower than that of GCF (72.5°C) which agreed with [29]. So corn starch granules is more rigid than barley starch granules, it requires more heat energy to achieve complete swelling.

The effect of replacing WBF with GCF on the falling number test is presented in Table II. The falling number of WBF was 180 sec. while that of GCF was 430 sec. Addition of GCF to WBF increased the falling number (from 180 to 250sec.).

TABLE I  
PROXIMATE COMPOSITION (%) AND MINERAL CONTENT (MG/100G) OF RAW MATERIALS (ON DRY BASIS) AND THE MOISTURE OF FRESH SAMPLES

Parameters	Raw materials				Lsd at 0.05
	Wwf	Gcf	Wbf	Drb	
Moisture	10.50 <sup>d</sup> ± 0.01	12.05 <sup>a</sup> ± 0.09	11.65 <sup>b</sup> ± 0.07	11.04 <sup>c</sup> ± 0.02	0.42
Protein	11.9 <sup>b</sup> ± 0.27	9.33 <sup>c</sup> ± 0.05	12.15 <sup>b</sup> ± 0.03	15.77 <sup>a</sup> ± 0.52	0.56
Fat	2.59 <sup>c</sup> ± 0.09	4.50 <sup>a</sup> ± 0.09	3.92 <sup>b</sup> ± 0.09	1.56 <sup>d</sup> ± 0.03	1.07
Ash	2.12 <sup>c</sup> ± 0.17	1.35 <sup>d</sup> ± 0.03	3.02 <sup>b</sup> ± 0.01	4.68 <sup>a</sup> ± 0.01	0.45
Crude fiber	3.15 <sup>b</sup> ± 0.12	3.15 <sup>b</sup> ± 0.09	3.22 <sup>b</sup> ± 0.02	9.25 <sup>a</sup> ± 0.06	0.96
Carbohydrate	80.24 <sup>a</sup> ± 1.16	81.67 <sup>b</sup> ± 0.72	77.69 <sup>c</sup> ± 0.53	68.74 <sup>d</sup> ± 1.09	1.11
Ca	23 <sup>d</sup> ± 0.01	43.0 <sup>c</sup> ± 0.16	62.0 <sup>b</sup> ± 0.01	80 <sup>a</sup> ± 1.11	1.62
P	190.1 <sup>c</sup> ± 0.09	235.0 <sup>b</sup> ± 0.11	420.0 <sup>a</sup> ± 0.03	2.1 <sup>d</sup> ± 0.11	0.65
K	102.0 <sup>c</sup> ± 0.05	165.0 <sup>b</sup> ± 0.09	405.0 <sup>a</sup> ± 0.01	1.9 <sup>d</sup> ± 0.09	1.19
Fe	1.71 <sup>d</sup> ± 0.0	4.060 <sup>c</sup> ± 0.03	6.35 <sup>b</sup> ± 0.02	11.0 <sup>a</sup> ± 0.22	2.16

Wwf= wholemeal wheat flour; wbf= wholemeal barley flour; gcf= gelatinized corn flour; drb= defatted rice bran.  
Means followed by different superscripts within row are significantly different at the 5% level.

TABLE II  
VISCOAMYLOGRAPH PARAMETERS AND FALLING NUMBER OF DOUGH

Samples	Temperature of (°C)		Viscosity (bu)			Falling no. (sec)
	Transition	Maximum viscosity	Maximum	Break down	Set-back	
Wbf	60.5	80	310	180	350	180
Gcf	72.5	86	515	280	920	430
70% w bf + 30% gcf	65	82	380	230	500	250

bu= brabender unit

The results obtained by falling number test confirmed that obtained by viscoamylograph. This means that the addition of corn starch decreased the amylolytic activity of the dough and consequently increased the maximum viscosity. This effect might be due to decrease the efficiency and the level of  $\alpha$ -amylase activity as a result of increasing corn starch concentration and decreasing WBF. Similar findings were observed previously [30], where it was reported that lower levels of  $\alpha$ -amylase enzymes means higher falling number value.

TABLE III  
FARINOGRAPH PARAMETERS OF DOUGH CONTAINING DRB

Samples	Wa (%)	At (min)	Ddt (min)	St (min)	Dw (bu)	Mti (bu)
100%wwf	60.0	1.5	2.5	10.0	100	60
80%wwf + 20% drb	64	2.5	3.5	12.0	80	40
75%wwf + 25%drb	70	3.5	5	13.0	75	35
70%wwf + 30% drb	73	4.0	5.5	13.5	70	35

bu = brabender unit, wa = water absorption, at = arrival time, ddt = dough development time, ds = dough stability time, dw = dough weakening, mti = mixing tolerance index.

### C. Farinograph Parameters

The effect of DRB supplementation on rheological characteristics of WWF is summarized in Table III. It can be noticed that water absorption (WA) increased with increasing level of DRB from 60.0% (in WWF) to 73% (WWF with 30% substitution of DRB). This increase may be referred to high protein and fiber contents of DRB compared to WWF where protein and dietary fibers tend to bind more water. Protein and dietary fibers in DRB may interact with wheat flour ingredients and water, consequently stability of doughs increased. In this respect, it was reported that water absorption and stability of dough increased as rice bran dietary fibers increased [31]. This finding is confirmed by previous results [32], [33]. WA is associated with a number of factors including the protein and non-starch polysaccharides contents in the dough and higher water absorption is attributed to higher protein and fiber contents especially higher molecular weight proteins and non-starch polysaccharides [[34]. The explanation of this phenomenon is based partly on the fact that the fiber structure contains a large number of hydroxyl groups, which interact with the hydrogen bonds of water [35], [36].

Dough development time (DDT) increased from 2.5 to 5.5 min with 30% incorporation of DRB. During this phase of mixing, water hydrates the flour components and the dough are developed [37], [38]. Similar trends in DDT were observed previously [33], [39]. Increasing of DDT could be attributed to

the fiber-gluten interaction, which prevents protein hydration [36]. Dough stability (DS) is known to be related to the quality of the protein matrix, which is easily damaged by the incorporation of other ingredients [40]. Addition of DRB induced increasing of DS from 10.0 to 13.5 min. This observation is similar with that obtained by [41]-[43] for orange by-products, commercial potato fiber and rice bran supplemented wheat dough. This effect could be explained by a higher interaction between fibers, water and flour proteins [39]. From the measurements, it was also concluded that increasing level of DRB resulted in decrease of dough weakening (DW) and mixing tolerance index (MTI). These results were in agreement with previous studies [37], [41] that substituted wheat flour by citrus by-products. Reduction of MTI could be due to interactions between fiber and gluten [35], [44]. Arrival time (AT) increased with increasing the level of DRB.

TABLE IV  
EXTENSOGRAPH PARAMETERS OF DOUGH PREPARED FROM DIFFERENT FORMULAS

Samples	E (mm)	R (bu)	(r/e)	Energy (cm <sup>2</sup> )
100%wwf	165	180	1.09	70
80%wwf + 20% drb	140	195	1.39	50
75%wwf + 25% drb	130	200	1.54	45
70%wwf + 30%drb	125	210	1.68	40

bu= brabender unit; e= extensibility; r= resistance to extension; R/e= proportional number.

### D. Extensograph Parameters

Data in Table IV show the effect of blending DRB (in ratios of 20, 25, and 30%) with WWF dough on the extensograph parameters [extensibility (E), resistance to extension (R) and the ratio between them and also the energy]. Extensibility and energy decreased while resistance to extension increased as DRB level increased. This effect may be related to the presence of high content of fibers in DRB which dilute gluten content of dough. Viscoelastic properties of wheat dough depend on gluten quality and quantity. So, as gluten content increased, viscoelastic properties improved. These results are confirmed by previous studies [32], [33].

### E. Thermal Properties of WBF, GCF, WWF and DRB

Figs. 1 (a)-(d) illustrate gelatinization properties of WWF, WBF, GCF, and DRB determined using the differential scanning calorimeter (DSC). DSC parameters recorded were  $T_0$ ,  $T_e$  and the temperature range ( $T_e-T_0$ ). Gelatinization temperatures and enthalpies associated with gelatinization endosperms varied between starches.  $T_0$  was 51.62, 40.43, 39.22 and 37.09°C,  $T_e$  was 64.88, 75.52, 77.55, and 76.72 °C for WWF, WBF, GCF, and DRB samples, respectively. The

gelatinized temperature range  $\Delta T$  of starch was 13.26, 35.09, 28.33 and 39.63 for WWF, WBF, GCF, and DRB, respectively. The obtained results were in agreement with those reported previously [27], [45].

The starch gelatinization is affected by the degree of milling and the percentage of non-starch lipids presented in rice sample [46]. Gelatinization temperature is considered a parameter of crystallite perfection because amylopectin plays a major role in starch granule crystallinity, the presence of amylose lower the melting temperature of crystalline regions and the energy for starting gelatinization [47]. More energy is needed to intimate melting in the absence of amylose-rich amorphous regions. This correlation indicated that starch with higher amylose content has more amorphous region, less crystalline, lower gelatinization temperature and endothermic enthalpy. Native and mixed starches with the same amylose contents showed clearly different gelatinization onset and peak temperature. The difference in gelatinization properties between native and mixed starches are due to varied homogeneity [48]. Fredriksson et al. [49] reported that a wide temperature range implies a large amount of crystals with varied stability. Also DSC parameters are influenced by the molecular structure of the crystalline region which corresponds to the distribution of amylopectin short chain and not to the propagation of the crystalline region which corresponds to the amylose [50].

#### F. Starch Crystallinity of WBF, GCF, WWF, DRB and Blends from WWF and DRB

Changes of organized crystalline raw starch granules of WWF, WBF, GCF, DRB and mixtures by adding different levels of DRB to WWF could be demonstrated by X-ray-technique. Starch granules are known to vary in their proportion of amylose and amylopectin, crystallite type [48] and extent of amylopectin branching [51]. Therefore, X-ray diffraction patterns of such granules are subsequently varied. According to X-ray diffraction data, the structure of starch can be grouped into four types; A, B, C and V [51]. Figs. 2 (a)-(f) show the diffractograms of analyzed samples and their respective crystallinity value. This pattern closely matches reported values of A-type cereal starches [52]. However, additional peak was observed at  $2\theta$  value of  $17.5^\circ$  (5.8 Å d-spacing value). The diffractogram of WWF (Fig. 2 (a)) shows similar peaks with some shifting where these peaks appeared at  $2\theta$  value of 30, 50%, 100% and 78.88 indicating a d-spacing value of 10.3, 4.7 and  $4.3^\circ$  Å, respectively. The diffractogram of WBF (Fig. 2 (b)) shows similar peaks with some shifting where these peaks appeared at  $2\theta$  value of 70, 33%, 100%, and 90.92 indicating a d-spacing value of 5.9, 5.04 and  $3.9^\circ$  Å, respectively. In addition, GCF (Fig. 2 (c)) peak was observed at  $2\theta$  value of about 22.75, 100 and 77.23% indicating a d-spacing value of 5.9, 5.01 and  $3.9^\circ$  Å, respectively.

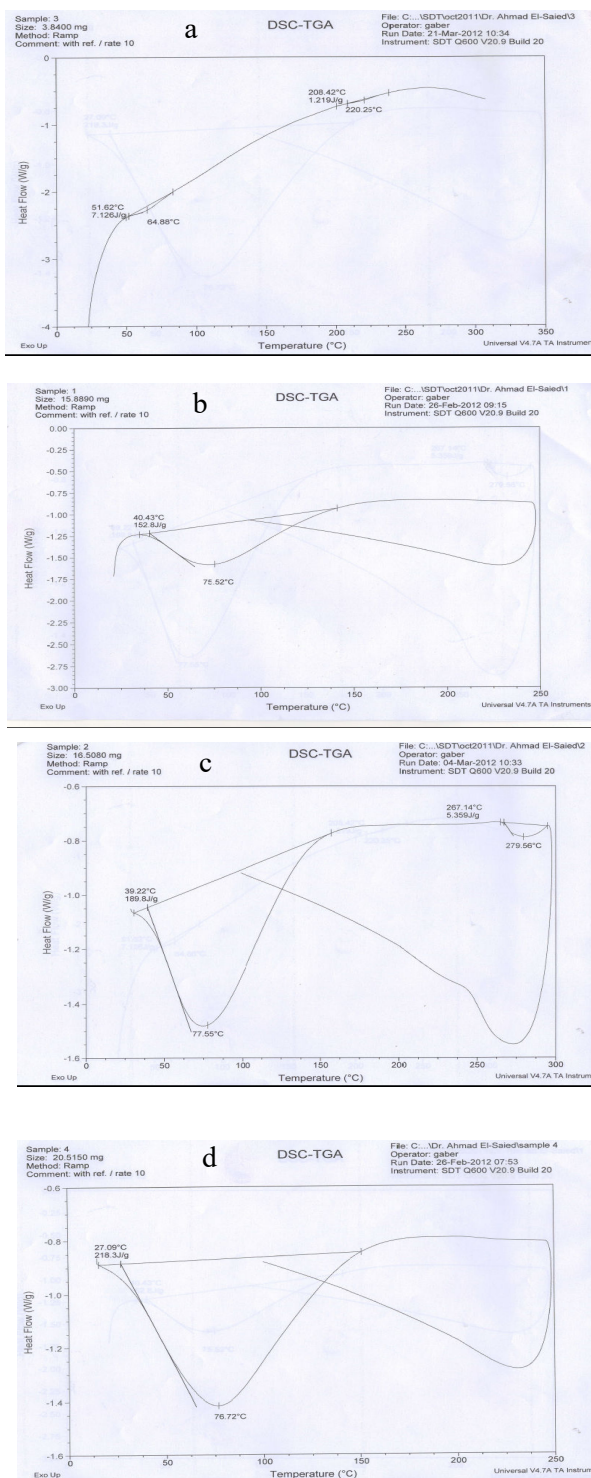


Fig. 1 (a) DSC of WWF; (b) DSC of WBF; (c) DSC of GCF; (d) DSC of DRB



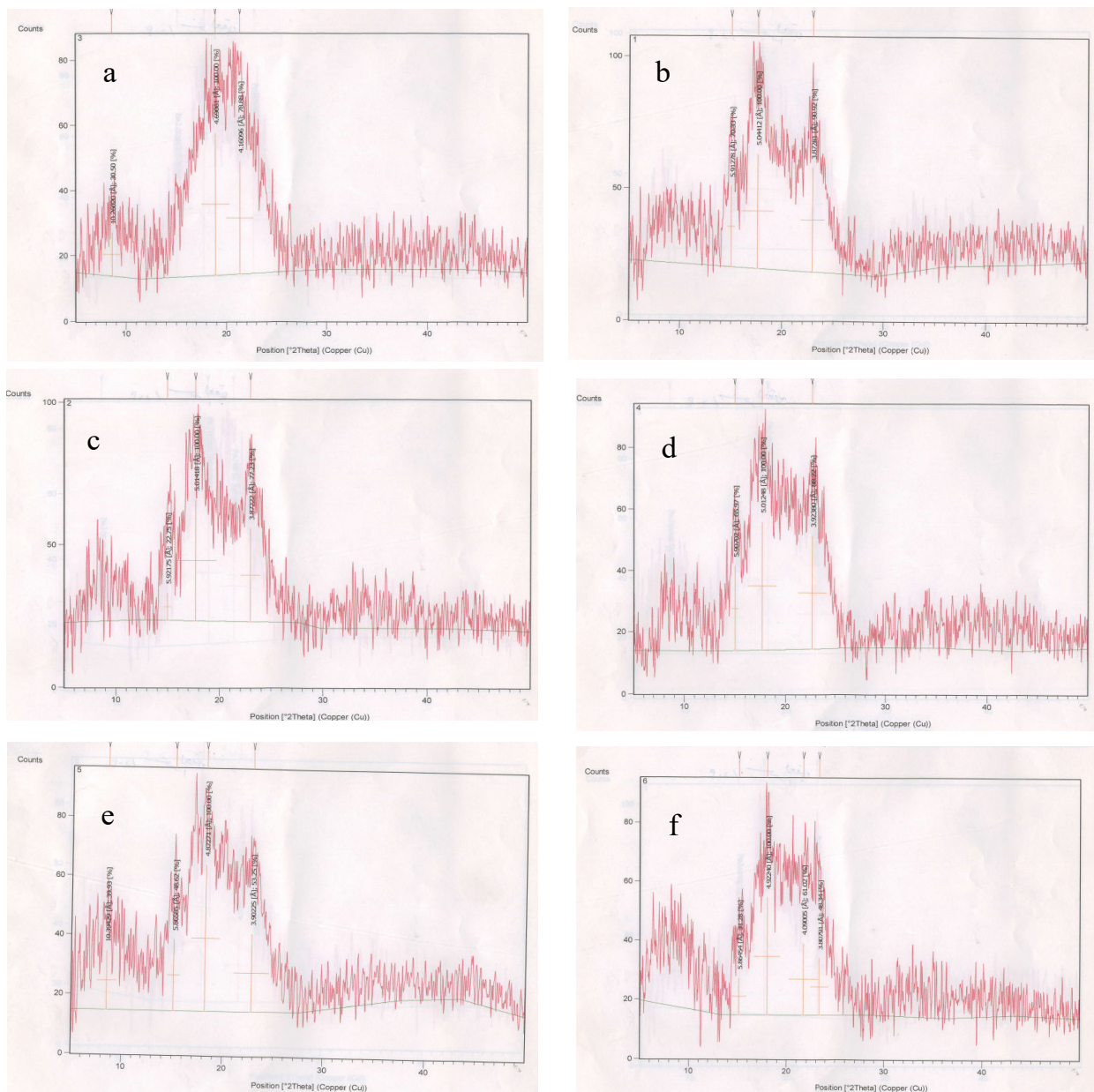


Fig. 2 (a) X ray diffractograms of WWF; (b) X – ray diffractograms of WBF; (c) X – ray diffractograms of GCF; (d) X – ray diffractograms of DRB; (e) X – ray diffractograms of blend (80%WWF: 20%DRB); (f) X – ray diffractograms of blend ( 70%WWF: 30%DRB)

The diffractogram of DRB (Fig. 2 (d)) shows similar peaks with some shifting where these peaks appeared at  $2\theta$  value of 65, 97%, 100%, and 88.22 indicating a d-spacing value of 5.9, 5.01 and  $3.9^\circ$  Å, respectively. Concerning the blend 1 that contains 80%WWF with 20% DRB, (Fig. 2 (e)), the main peaks of A-type starches were observed with some shifts as well as additional peaks were recorded appeared at  $2\theta$  value of 39, 93%, 48.62%, 100% and 53.25 indicating a d-spacing value of 10.4, 5.9, 4.9 and 3.9 Å. Blend 2 that contains 70% WWF with 30% DRB (Fig. 2 (f)), the main peaks of A-type starches were observed with some shifts as well as additional peaks were recorded appeared at  $2\theta$  value of 31.28%, 100%,

61.02 and 48.34 indicating a d-spacing value of 5.9, 4.9, 4.09 and 3.8 Å. This peak is the distinguishing feature of v-type starch [53]. Blends1 to blends2 displayed another amorphous X-ray pattern as reported previously [54] with a peak around  $10.4^\circ$  Å to  $3.9^\circ$  Å. Accordingly, the material is no longer a rigid but rather exhibits the properties of a liquid [55]. Sorghum tortilla chips was previously reported to display another amorphous X-ray pattern [54] with a peak around  $4.5^\circ$  Å. The location of this peak was slightly displaced from the strong  $4.4^\circ$  Å peak characteristic of the v-type amylose-lipid complex pattern [20].

### G. Chemical Composition of Bakery Products

Data presented in Table V showed the proximate composition, minerals content and moisture of different prepared bakery products. Flat bread made from 100% WBF and balady bread produced from 100% WWF were characterized by their higher contents of total carbohydrates (80.9 and 80.24%, respectively) than other bakeries. Crude fiber and fat content in flat and balady bread made from WBF with GCF were higher than that produced from WBF. Moisture, ash, crude fiber, calcium, and iron increased as the level of DRB increased in balady bread. This might be due to high ash, crude fiber, calcium and iron level in DRB. Pie produced from 70%WBF plus 30% GCF contained lower percentage of moisture, protein, fat, calcium, phosphorus, potassium and iron than pie produced from 100%WBF.

It has been reported previously that rice bran is the main source of rice protein [56]. In a previous work rice bran defatted by hexane was shown to contain moisture as  $2.76 \pm 0.72$ , protein as  $15.89 \pm 0.11$ , fat as  $0.94 \pm 0.03$ , ash as  $6.75 \pm 0.13$ , crude fibers as  $3.37 \pm 0.29$ , and carbohydrates as  $70.29 \pm 0.55$  g/100g [4]. DRB contained more protein than WWF but from the technological point of view, it is well known that wheat protein plays a major role in bread making and other bakery products industry as it has the gluten protein which has a unique ability to make a viscoelastic dough. In addition, it is well stated that, as the extraction rate of wheat flour increased the quantity of the protein increased but the quality of the protein decreased as a result of decreased gluten protein which concentrates in the endosperm. With lower extraction rates, the wheat flour protein content is lower. However, the extraction rate seems to have no major effect on the nutritional quality of the flour proteins [57].

### H. Color of Raw Materials and Bakery Products Made from GCF and WBF

Color is one of the most important sensory attribute that affect directly the consumer preference of any product; so special attention should be given to the color of bakery products. Crust color of the bakery products made from WWF, WBF, GCF and DRB were evaluated using a Hunter laboratory colorimeter. Hunter color parameters of flours and bakery products produced from them (L, a, b, chroma, hue and  $\Delta E$  values) are summarized in Table VI. The "L" scale ranges from 0 (black) to 100 (white); the "a" scale extends from a negative value (green hue) to a positive value (red hue) and the "b" scale ranges from negative blue to positive yellow. The color of GCF was lighter than WWF, WBF and DRB, while its "a" value was lower than WWF, WBF and DRB. Such findings agreed with previous studies [31], [58], [59].

All formulas showed a noticeable lighter color for the crust of bread and pie (L values were increased) by adding GCF but the value of redness (a values) of crust were decreased as a result of GCF addition while the "b" values were slightly higher compared with the control (produced from WBF). This is due to that "L" and "b" for GCF were higher than that of WBF while "a" of GCF was lower than that of WBF. The "L" value for tanour bread (flat bread) ranged from 53 to 73.7 as

reported previously [60]. The authors classified values around 50 as dark, 60 as optimum, and 70 as light in color. Applying this finding on the present results reflected the optimum level of L for flat bread made from WBF and GCF ( $L = 59.23$ )

The lightness "L" values of the balady bread decreased in formulas containing DRB compared with the control (WWF bread), this effect was proportional with the percentage of DRB in balady bread. The values of "a" indicated that balady bread prepared using DRB at different levels were more red than those of control. The high "a" values may be attributed to the presence of the red to brown pigments naturally present in the fiber. Value of "b" of balady bread containing DRB was decreased from 36.44 in control to 25.40 in balady bread containing 30% DRB. Overall color quality ( $\Delta E$ ) decreased in the presence of DRB in balady bread. Overall color quality showed lower levels in all formulas supplemented by DRB compared with the control. The same trend was observed previously concerning yellowness (b) and the total color difference ( $\Delta E$ ) of tortilla bread samples containing triticale flour, where their values were getting higher as triticale flour level was increased. The authors ascribed the result to the darkness of triticale flour (lower L) [27].

### I. Organoleptic Properties of Bakery Products

Table VII represents the mean values and statistical significance, for texture, crust color, odor, taste, appearance, and overall acceptability of flat bread. No significant differences at  $<0.05$  were noted when flat bread produced from WBF plus GCF was compared with the control sample (produced from WBF) for all sensory characteristics.

Table VIII showed the sensory attributes of balady bread made from WWF and DRB and that produced from WBF and GCF. It can be noticed that no significant change was present in general appearance, separation of layers, roundness, and distribution of crumb among all products made from WWF and DRB. Crust colour and taste showed significant lower levels in products containing DRB compared to 100% WWF product. The darker crust color may be due to greater amounts of millard reactions between reducing sugars and proteins [61]. In addition, it could be assumed that as DRB level increased adverse effect may increase regarding all tested characteristics due to increased fibers content along with decreased gluten level. In this respect, it was reported that sensory scores decreased with increasing level of rice bran [62]. The deterioration in the crumb texture and crumb color of wheat bread due to similar supplements was observed by other workers [17], [63]-[65].

Results of the sensory evaluation of pie are shown in Table IX. The obtained results showed that, there were no significant differences in taste, aroma, mouth feel, crumb color and break & shred scores when comparing control pie with pie containing 30% GCF. Crust color was improved while symmetry shape and crumb texture were reduced on adding GCF.

TABLE V  
PROXIMATE COMPOSITION (%) AND MINERAL CONTENT (MG/100G) OF BAKERY PRODUCTS (ON DRY BASIS) AND MOISTURE % IN FRESH SAMPLES

Parameters	Flat bread from		Balady bread from		Balady bread from			Pie from		
	100%wbf	70% w bf + 30%gcf	100%wbf	70% w bf + 30% gcf	100%wwf	80%wwf + 20% drb	75%wwf + 25% drb	70%wwf + 30% drb	100%wbf	70% w bf + 30% gcf
Moisture	14.01±0.12	12.5.12±0.16	35.32±0.14	32.25±0.14	38.5±0.32	40.35±0.62	41.12±0.45	42.0±0.62	40.52±0.12	38.16±0.05
Protein	12.10±0.01	10.74±0.08	11.55±0.07	10.70±0.12	11.90±0.44	13.52±0.25	13.95±0.32	14.16±0.18	11.75±0.01	10.80±0.07
Fat	2.50±0.03	4.21±0.05	3.60±0.06	4.35±0.07	2.59±0.16	2.25±0.07	2.19±0.06	2.15±0.12	10.31±0.06	9.18±0.02
Ash	2.64±0.07	2.19±0.01	2.10±0.03	2.15±0.05	2.12±0.22	2.15±0.13	2.40±0.02	2.56±0.16	2.25±0.09	2.30±0.03
Crude fiber	1.86±0.05	3.15±0.03	3.12±0.01	3.20±0.03	3.15±0.05	5.12±0.19	5.32±0.12	5.75±0.05	3.20±0.06	3.25±0.0
Carbohydrate	80.90±0.11	79.71±0.45	79.63±0.78	79.60±0.32	80.24 ±0.96	76.96±0.88	76.14±0.79	75.38±1.12	72.49±0.85	74.47±0.72
Ca	60.32± 0.27	52.07± 0.11	58±0.15	55±0.01	23±0.01	28±0.09	32±0.07	35±0.05	60.0±0.15	52.00± 0.13
P	400± 0.13	327.5± 0.45	410±0.22	332±0.15	190 ±0.09	170 ±0.09	165 ±0.09	150 ±0.09	400±0.42	335.0± 1.16
K	380± 0.22	275± 0.19	370±0.36	260±0.13	102.0±0.05	90.0±0.05	85.0±0.05	80.0±0.05	382±0.36	280.00± 1.05
Fe	6.32± 0.15	5.30± 0.12	6.25±0.01	5.40±0.11	1.71 ±0.0	5.61 ±0.01	6.22 ±0.04	7.0 ±0.07	7.12±0.11	6.05± 0.16

wwf: wholemeal wheat flour (100% extraction); wbf: wholemeal barley flour; gcf: gelatinized corn flour; drb: defatted rice bran

TABLE VI  
HUNTER COLOUR PARAMETERS OF FLOURS AND BAKERY PRODUCTS PRODUCED FROM THEM

Samples	L	A	B	A/b	Chroma	Hue	Δe
Flours							
Wwf	78.16	7.13	18.15	0.39	19.50	68.55	80.56
Wbf	85.00	1.57	10.20	0.15	10.32	81.24	85.62
Gcf	87.60	0.60	11.62	0.05	11.63	87.04	87.97
Drb	59.29	9.66	31.64	0.31	33.08	73.02	67.89
Flat bread made from							
100%wbf	55.65	7.01	19.28	0.36	20.51	70.01	59.31
70% w bf + 30% gcf	59.23	7.00	19.93	0.40	21.43	68.43	62.99
Balady bread made from							
100%wbf	50.95	9.95	19.71	0.50	22.07	63.21	55.53
70% w bf + 30% gcf	53.49	9.08	20.39	0.44	22.32	65.99	57.96
Balady made from							
100%wwf	56.57	12.96	36.44	0.35	38.67	70.42	68.53
80%wwf + 20% drb	44.56	15.41	29.77	0.51	33.52	62.63	55.76
75%wwf + 25% drb	40.98	17.36	27.18	0.63	32.25	57.43	52.15
70%wwf + 30% drb	38.60	19.86	25.40	0.78	32.24	51.97	50.29
Pie made from							
100%wbf	40.38	15.90	18.38	0.82	24.30	49.14	47.13
70% w bf + 30% gcf	42.03	12.92	18.51	0.69	22.57	55.08	47.71

hue =  $\tan^{-1}(b/a)$ , chroma = square root of  $(a^2 + b^2)$ ,  $\delta e = (l^2 + a^2 + b^2)^{1/2}$

TABLE VII  
ORGANOLEPTIC PROPERTIES OF FLAT BREAD

Samples	Texture (10)	Color (10)	Odor (10)	Taste (10)	Appearance (10)	Overall acceptability (10)
100%wbf	7.40 ± 0.84	7.1 ± 1.73	6.9 ± 1.73	7.0 ± 1.56	6.8 ± 1.62	6.2 ± 1.69
70% w bf + 30% gcf	7.62 ± 0.77	7.7 ± 1.16	7.4 ± 1.43	7.0 ± 1.49	7.0 ± 1.15	6.6 ± 1.42
Lsd at 0.05	Ns	Ns	Ns	Ns	Ns	Ns

TABLE VIII  
SENSORY EVALUATION OF BALADY BREAD MADE FROM DIFFERENT FLOUR

Samples	General appearance (20)	Separation of layers (20)	Roundness (15)	Distribution of crumb (15)	Crust colour (10)	Taste (10)	Odour (10)
100%wbf	16.70 ± 1.16	15.12 ± 0.62	12.50 ± 0.26	11.50 ± 0.82	7.20 <sup>b</sup> ± 0.96	6.30 <sup>c</sup> ± 0.34	7.30 <sup>c</sup> ± 0.49
70% w bf + 30% gcf	16.30 ± 1.49	16.50 ± 0.56	12.20 ± 0.96	11.40 ± 0.52	7.60 <sup>b</sup> ± 1.48	6.20 <sup>c</sup> ± 0.32	7.10 <sup>c</sup> ± 0.52
100%wwf	16.93 ± 2.87	20.00 ± 0.96	12.93 ± 1.69	11.57 ± 2.82	8.86 <sup>a</sup> ± 0.77	8.29 <sup>a</sup> ± 1.27	8.86 <sup>a</sup> ± 0.77
80%wwf + 20% rb	17.07 ± 1.14	18.50 ± 1.03	13.0 ± 1.24	11.64 ± 2.62	7.86 <sup>b</sup> ± 0.66	7.75 <sup>b</sup> ± 0.77	8.64 <sup>ab</sup> ± 1.0
75%wwf + 25% rb	16.64 ± 1.34	19.00 ± 1.16	12.14 ± 1.29	11.78 ± 1.53	7.64 <sup>b</sup> ± 0.74	7.68 <sup>b</sup> ± 1.02	8.07 <sup>b</sup> ± 0.73
70%wwf + 30% rb	15.79 ± 1.85	20.00 ± 0.85	12.85 ± 1.23	11.64 ± 2.02	8.07 <sup>b</sup> ± 0.47	7.65 <sup>b</sup> ± 0.46	8.07 <sup>b</sup> ± 0.79
Lsd at 0.05	Ns	Ns	Ns	Ns	0.52	0.62	0.65

Different superscripts in the same column mean significant differences.



TABLE IX  
SENSORY CHARACTERISTICS OF PIE

Samples	Taste (20)	Aroma (20)	Mouth feel (10)	Crumb texture (15)	Crumb Color (10)	Break & shred (10)	Crust color (10)	Symmetry shape (5)
100%wbf	16.5 ± 1.9	17.5 ± 1.08	8.4 ± 1.17	12.0 <sup>a</sup> ± 0.22	8.6 ± 0.84	8.4 ± 1.34	5.8 <sup>b</sup> ± 1.62	4.4 <sup>a</sup> ± 0.52
70% w bf + 30% gcf	16.1 ± 1.63	17.2 ± 2.15	7.9 ± 0.99	11.03 <sup>b</sup> ± 0.83	8.2 ± 0.63	8.6 ± 0.69	6.4 <sup>a</sup> ± 2.17	3.8 <sup>b</sup> ± 0.63
Lsd at 0.05	Ns	Ns	Ns	1.19	Ns	Ns	0.44	0.52

Different superscripts in the same column mean significant differences.

#### IV. CONCLUSION

Addition of DRB or GCF to WWF or WBF, respectively affect the physical, chemical, rheological and sensory properties of balady bread, flat bread, and pie while improved their nutritive values. All food products were accepted by organoleptic evaluation.

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