



Production of Balady bread from wheat, barley and oat flour and its effect on blood glucose level of hyperglycemic rats

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Abstract

This research was carried out to evaluate the effect of wheat flour substitution by different levels from whole barley flour (WBF), whole oat flour (WOF) and mixture (WBF+WOF) of them on chemical, rheological and organoleptic characteristics of Balady bread as well as its effect on lowering blood glucose level of hyperglycemic rats. The results showed that blending of WBF or/and WOF to wheat flour increased protein, fat, ash and crude fiber content in produced bread. Also, minerals concentration was increased gradually by increasing replacement levels of WBF and WOF in all tested samples compared with control. Rheological parameters such as water absorption, arrival time, dough development, dough stability and weakening were increased significantly ($P \leq 0.05$). In contrast, elasticity, extensibility, proportion number and energy were decreased in all samples compared with control. Organoleptic properties of roundness and separation of layers for all tested bread samples were not affected significantly, while, a significant ($P \leq 0.05$) difference was observed in taste, odor and crust color when WBF and WOF levels were increased over 20%. Results also revealed that the hyperglycemic rats fed on bread containing 20% WBF, WOF and (WBF+WOF) for 28 days caused a significant ($P \leq 0.05$) decrease in blood glucose level compared with hyperglycemic rat's control. Thus, it can be suggested that combination of WBF or/and WOF in bread up to 20% gave good quality characteristics without adversely affecting the consumer acceptability of the bread and leads to lower blood glucose level in hyperglycemic rats.

Keywords: diabetes, β -glucan, barley flour, oat flour, Balady bread.

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1. Introduction

Diabetes mellitus is one of the most serious challenges for the Egyptian health system. Type (II) diabetes accounts for 90%–95% of all disease cases (Hegazi *et al.*, 2015). The numbers of people with type (II) diabetes mellitus have increasing in developing countries, where about 80% of cases with diabetes mellitus live of low- and middle-income countries (Abdulfatai *et al.*, 2012). The international diabetes federation (IDF) listed Egypt among the world top 10 countries in the number of patients with diabetes (IDF, 2019). The consumption of low glycaemic index foods such as whole grains, legumes and fruits was a helpful alternative in controlling diabetes (Kabir *et al.*, 2002). Important among these foods were those rich in fiber, especially those with a high level of beta-glucans (Jenkins *et al.*, 2002). Beta-glucan has non-starch polysaccharide present in grains like oat, rye and barley (Ahmad *et al.*, 2012). Many Studies were suggested that foods containing beta-glucan has anti-diabetics effect (Kabir *et al.*, 2002), reducing glycemic index (Granfeldt *et al.*, 2008), lowest plasma cholesterol and improve lipid metabolism (Cugnet-Anceau *et al.*, 2010). This fiber may be form a barrier of the small intestine which prevent glucose and other nutrients absorption, reducing consequently the glycaemia, insulinaemia (Liatis *et al.*, 2009), also cholesterol levels (Ho *et al.*, 2016). Whole grain crops like barley (*Hordeum vulgare*), rye (*Secale Cereale*)

and oat (*Avena sativa*) were considered as functional grains because it has contained β -glucan, phytochemicals and antioxidant potential (Sharma and Gujral, 2010). Among the cereals, barley and oat were the excellent sources of beta-glucan, rang from 3–11% and 3–7% on dry basis. This beta-glucan was usually concentrated in the aleurone and endosperm cell wall of barley (Koeksel *et al.*, 1999), oat (Wood, 1993) and wheat (Kontula *et al.*, 1998). The consumption of whole grain foods in particular has been associated with lower risks of Type (II) diabetes; cardiovascular disease and weight gain (Ye *et al.*, 2012). Balady bread is one of the most important constituents of diet for rich and poor Egyptian consumers (El-Soukkary, 2001). Many researchers studied the effects of wheat flour substitute with other cereals such as barley, corn, sorghum, rice and oat flours on quality and rheological properties of bread (Abou-Ray *et al.*, 2014; Eissa *et al.*, 2007; Hussein *et al.*, 2013). Many clinical studied that the whole grains consumption plays an important role in reduced risk of Type (II) diabetes. (Venn and Mann, 2004; Egbunike, 2006 and Modu *et al.*, 2011). The aim objective of this study has been performed to evaluate the effect of partial replacement for wheat flour (82% extraction) with whole barley flour (WBF), Whole oat flour (WOF) and (1:1) mixture both of them at the levels of 10%, 20% and 30% on the chemical, rheological and organoleptic characteristics of balady bread as well as their influence on lowering blood glucose levels in tested hyperglycemic rats.

2. Materials and Methods

2.1 Materials

Wheat flour (*Triticum Sativum L*, var. Sakha 95) (82% extraction) was purchased from Middle and West Delta Mills Company, Tanta, Egypt. Barley (*Hordeum vulgare* var. Giza 2000) grains and oat (*Avena sativa* var. common oat) grains were obtained from Field Crops Institute, Agricultural Research Center, Giza, Egypt. Active dry yeast (*Saccharomyces cerevisia*) and salt (Sodium chloride) were purchased from local market. All chemicals and reagents were of analytical pure grades and purchased from El Gomhouria Company, Cairo, Egypt. Adult male albino rats (weighting 120-130 g) were purchased from Biological Products and Vaccines Holding Company, Helwan Farm, Cairo, Egypt.

2.21 Methods

2.2.1 Formulation of flour blends

Barley and oat grains were cleaned and milled to 100% extraction flour. Nine blends were prepared by mixing barley and oat flour with wheat flour (82% extraction) using an electric blender and compared with control sample (100% wheat flour) in the (%) as shown in Table (1).

2.2.2 Dough rheology characteristics

Rheological measurements of dough

were carried out using farinograph (Barabender OGH Duisburg, Germany) and extensograph (Barabender Duis Bur G type 860001, Germany) testes according to AACC (2002).

2.2.3 Balady bread preparation

Balady bread was processed according to the method described by (Yaseen, 1985). The recipe of the balady bread was 1 kg wheat flour or its blends mixing with other ingredients including 1.5% active dry yeast, 1.5% sodium chloride and 700 ml water. The mixture was well mixed in mixer (250 rpm) for 20 min. The dough was left to ferment (15 min. /30°C/ 85% relative humidity), then divided to pieces (160 g). Each piece of bread was laid on a wooden board previously covered with a fine layer of bran and left to ferment 10-15 min at the same mentioned temperature and relative humidity. The fermented dough pieces were flattened to about 20 cm diameter. The flat loaves were proofed at 380-400°C for 1-2 min in electric oven. Bread loaves were allowed to cool at room temperature before chemical and sensory evaluation.

2.2.4 Analytical methods

2.2.4.1 Determination of chemical composition

Contents of crude protein, fat, crude fiber and ash in flours and balady bread samples were determined according to AOAC (2008). The percentage of

carbohydrates was calculated by different as follows:

$$\text{Carbohydrates (\%)} = 100 - (\% \text{ protein} + \% \text{ fat} + \% \text{ crude fiber} + \% \text{ ash})$$

2.2.4.2 Determination of minerals content

Contents of Ca, P, K, Fe, Mn, Na and Zn were determined in flours and balady bread samples using Atomic Absorption

Spectrophotometer-Atomic (1100B Perkin-Elmer) as described in AOAC (2008).

2.2.5 Sensory evaluation

Sensory evaluation of the Balady bread samples were formed using ten members of staff of Food Science and Technology Department, Faculty of the Agriculture, Al-Azhar University, Cairo, Egypt.

Table (1): Formulation of flour blends.

Treatment	Flour blends (%)
Control	100% WF (82% extraction).
Blend 1	(90% WF: 10% WBF)
Blend 2	(80% WF: 20% WBF)
Blend 3	(70% WF: 30% WBF)
Blend 4	(90% WF: 10% WOF)
Blend 5	(80% WF: 20% WOF)
Blend 6	(70% WF: 30% WOF)
Blend 7	(90% WF: 5% WBF: 5% WOF)
Blend 8	(80% WF: 10% WBF: 10% WOF)
Blend 9	(70% WF: 15% WBF: 15% WOF)

WF: Wheat flour; WBF: Whole Barley flour; WOF: Whole oat flour.

The tested bread samples were presented in a randomized order to the panelists to evaluate the appearance, taste, crumb distribution, roundness, odor, crust color and separation of layers (Mousa *et al.*, 1979).

2.2.6 Biological evaluation

2.2.6.1 Experimental animals

Thirty-six adult male albino rats, weighting 120-130 g were housed in polyethylene plastic cages with wood shavings at 25±2°C and 65±5 % relative

humidity with a 12 hr light/dark cycle and allowed to be acclimated for 15 days prior to experimental use. The animals were fed on basal diet, composed of 70% starch (corn starch), 12% casein, 8% fat (corn oil), 4% salt mixture, 1% vitamins mixture and 5% cellulose as described by AOAC (2008), and water were available ad libitum.

2.2.6.2 Induction of diabetes mellitus (II)

All rat groups were feeding on standard basal diet for 7 days (for acclimatization). Diabetes mellitus type

(II) was induced by single intraperitoneal injected of alloxan monohydrate (which causes partial destruction of the pancreatic cells secreted by the hormone insulin) in sterile saline solution at a dose of 150 mg/kg body weight according to the method described by (Buko *et al.*, 1996). The rats with fasting plasma glucose concentration (FPGC) > 150 mg/dl for 5 consecutive days were considered hyperglycemic rats and selected for the biological study (from group 2 to group 6).

2.2.6.3 Experimental design

Thirty-six rats were used and randomly divided into 6 groups; each group had six rats. Group (1): Non diabetic (normal) rats (Negative control) fed on the basal diet only; group (2): Hyperglycemic rats (Positive control) fed on the basal diet only; group (3): Hyperglycemic rats fed on bread containing 100% wheat flour; group (4): Hyperglycemic rats fed on bread containing 20% WBF; group (5): Hyperglycemic rats fed on bread containing 20% WOF; group (6): Hyperglycemic rats fed on bread containing 20% mixture of them (WBF+WOF). All groups of rats were fed on the experimental diets for 28 days.

2.2.6.4 Determination of blood glucose level

Blood samples were collected from the retro-orbital sinus plexus from all animals after being fasted for 12 hrs.

Blood samples of rats were collected at the beginning of experiment (initial), after 7, 14, 21 and 28 days for measured of blood glucose levels according to (Trinder, 1969).

2.2.7 Statistical analysis

The results were expressed as mean values and standard deviation of their mean using one-way analysis of variance and test significant differences tests (ANOVA) according to the method described by McClave and Benson (1991). Duncan's multiple range tests were also used to test the significant differences between the mean values by using SPSS (version 20.0).

3. Results and Discussion

3.1 Chemical composition of studied flour used in bread preparation (on dry weight basis)

Wheat flour (82% extraction), barley flour (100% extraction rate) and oat flour (100% extraction rate) were analyzed for their chemical composition (on dry weight basis). Results in Table (2) indicated that, the highest protein content was found in barley flour (12.36%), followed by oat and wheat flour (12.15% and 11.38%); respectively. While, highest amount of fat was found in oat flour which recorded (6.49%) compared with their content in barley flour (2.27%) and wheat flour (1.86%). Also, the

highest content of ash was found in barley and oat flour, while the lowest contents were found in wheat flour. Total carbohydrate of the tested flour blends ranged between (69.71% - 82.90%). The highest amount of crude fiber was found in barley flour which recorded (4.20%)

followed by (3.76%) in oat flour, while the lowest content was found in wheat flour which recorded (1.82%). These results were in harmony with those obtained by Abou-Raya *et al.* (2014), Youssef *et al.* (2016) and Nakov *et al.* (2019).

Table (2): Chemical composition (%) of wheat flour, whole barley flour and whole oat flour (on dry weight basis).

Components (%)	Wheat flour (WF)	Whole Barley flour (WBF)	Whole oat flour (WOF)
Protein	11.38 ± 0.96	12.36 ± 0.15	12.15 ± 0.30
Fat	1.86 ± 0.53	2.27 ± 0.19	6.49 ± 0.07
Ash	1.42 ± 0.18	2.98 ± 0.29	2.12 ± 0.12
Crude fiber	1.82 ± 0.16	4.20 ± 0.09	3.76 ± 0.215
Carbohydrates*	82.90 ± 2.59	69.71 ± 3.40	75.48 ± 1.70

Means of three replicates ± standard deviation, *Total carbohydrates were calculated by difference.

3.2 Minerals content of studied flour used in bread preparation (on dry weight basis)

Minerals content of wheat flour, whole barley flour and whole oat flour were

evaluated and presented in Table (3). Data noticed that the WBF contained a highest value of potassium, phosphor, magnesium, calcium and sodium (612.30, 416.50, 138.42, 65.75 and 63.10 mg /100 g, respectively).

Table (3): Minerals content (mg/100g) of wheat flour, whole barley flour and whole oat flour (on dry weight basis).

Minerals content (mg/100g)	Wheat flour (WF)	Whole Barley flour (WBF)	Whole oat flour (WOF)
Ca	21.86 ± 0.02	65.75 ± 1.53	61.24 ± 0.16
P	178.25 ± 0.26	416.50 ± 2.78	492.35 ± 1.85
K	123.48 ± 0.08	612.30 ± 1.90	346.75 ± 0.95
Fe	1.53 ± 0.05	8.14 ± 0.67	14.29 ± 0.03
Na	28.76 ± 0.15	63.10 ± 0.24	6.45 ± 0.12
Mg	112.49 ± 0.62	138.42 ± 0.05	132.21 ± 2.56
Zn	0.13 ± 0.09	2.67 ± 0.08	3.67 ± 0.14

Means of three replicates ± standard deviation.

While, had lowest content from zinc and iron (2.67 and 8.14 mg /100 g, respectively). Also, data in the same Table (3) showed that, the WOF contained highest contents of phosphor,

potassium, magnesium and calcium (492.35, 346.75, 132.21 and 61.24 mg/100 g, respectively). The minerals content of WF under this study was low compared with their amount of WBF and

WOF. These results are similar to those obtained by Hussein *et al.* (2013); Hu *et al.* (2014) and Darwish *et al.* (2018).

3.3 Influence of wheat flour substitution with barley and oat flour on rheological properties of bread dough

3.3.1 Farinograph parameters

From the data in Table (4), it could be showed that, by increase replacement of wheat flour with partial levels to 30% of

WBF, WOF and (WBF+WOF) led to increase the water absorption compared with control sample. This increase of water absorption in dough samples containing WBF, WOF may be due to the high β -glucan content in WBF, WOF its high-water binding capacity minimize the amount of free water in dough. Therefore, the higher content of water is requiring reaching a fully develop gluten network in flour contained β -glucan (Rosell *et al.*, 2001).

Table (4): Farinograph parameters of flour blends as affected by replacement levels of wheat flour with WBF, WOF and both of them.

Samples	Water absorption (%)	Arrival time (min)	Dough development time (min)	Stability time (min)	Weakening dough (B.U.)
Control [▲]	56.41±0.53 ^f	1.00±0.04 ^f	2.00±0.40 ^d	4.50±0.10 ^f	90±5.72 ^c
10% WBF	58.50 ±0.25 ^d	2.50±0.00 ^c	2.50±0.26 ^c	5.00±0.20 ^e	100±10.35 ^b
20% WBF	60.20±0.10 ^c	3.00±0.14 ^b	3.00±0.13 ^b	6.00±0.10 ^c	110±6.48 ^a
30% WBF	62.53 ±0.57 ^a	3.55±0.05 ^a	3.50±0.22 ^a	7.00±0.25 ^a	100±9.16 ^b
10% WOF	57.33±0.62 ^e	2.00±0.07 ^d	2.00±0.15 ^d	4.50±0.20 ^f	90±7.24 ^c
20% WOF	59.80±0.40 ^c	2.50±0.10 ^c	2.50±0.10 ^c	5.50±0.30 ^d	100±2.55 ^b
30% WOF	61.06±0.15 ^b	3.00±0.05 ^b	3.00±0.55 ^b	5.50±0.15 ^d	100±8.33 ^b
10% WBF+WOF	57.80 ±0.10 ^e	1.50 ±0.00 ^e	2.50±0.08 ^c	4.50±0.10 ^f	90±10.16 ^c
20% WBF+WOF	60.11 ±0.45 ^c	2.50 ±0.13 ^c	3.00±0.25 ^b	5.50±0.20 ^d	100±7.78 ^b
30% WBF+WOF	62.15±0.48 ^a	3.00 ±0.02 ^b	3.50 ±0.19 ^a	6.50±0.50 ^b	110±6.15 ^a

Means ± SD; Means with different superscript within the same column differ significantly ($P \leq 0.05$), [▲]Control samples prepared from 100% wheat flour (82% extraction), WBF: Whole Barley flour, WOF: Whole oat flour.

Concerning, arrival time, dough development time, dough stability and weakening of dough were increased by increasing the replacement levels with WBF, WOF and both of them (WBF+WOF) from 10% to 30% as compared with control sample. This increase in dough stability was attributed to the high fiber and protein content of WBF and WOF compared to WF which leads the dough to be more stable (Salehifar and Shahedi, 2007). These results were agreement with Goldstein *et al.* (2010), Mins *et al.* (2012), Hassan (2016) and

Darwish *et al.* (2018).

3.3.2 Extensograph parameters

As shown in Table (5), the dough elasticity decreased by increasing replacement levels of wheat flour with WBF, WOF and both of them (WBF+WOF) to 30% as compared with control sample. On the other hand, the dough Extensibility parameter (mm) it was recorded increased by increase added WBF to 30%, however, recorded decreased by increase added WOF and

(WBF+ WOF) flour to 30% as compared with control sample. Also, proportion number (R/E) decreased by increase added WBF and WOF. While, recorded increase by increase added (WBF+ WOF) to 30%.

Table (5): Extensograph parameters of prepared bread dough samples by different substitution levels of wheat, barley and oat flour.

Blends	Elasticity (Brabender Unit) (R)	Extensibility (mm) (E)	Proportion Number (R/E)	Energy (Cm ²)
Control [▲]	436 ± 9.16 ^a	90 ± 2.00 ^{cd}	4.84 ± 0.04 ^d	80.00±2.00 ^a
10% WBF	382 ± 2.50 ^{cd}	94 ± 4.15 ^{bc}	4.06 ± 0.08 ^f	75.50±1.50 ^b
20% WBF	326 ± 4.18 ^e	98 ± 1.50 ^{ab}	3.32 ± 0.01 ^h	70.00±1.07 ^c
30% WBF	271 ± 3.80 ^f	103 ± 4.58 ^a	2.63 ± 0.06 ⁱ	60.00±0.90 ^d
10% WOF	388 ± 2.90 ^c	88 ± 6.00 ^{cde}	4.41 ± 0.09 ^e	80.00±1.00 ^a
20% WOF	337 ± 5.25 ^e	85 ± 2.50 ^{cd}	3.96 ± 0.02 ^f	75.20±1.90 ^b
30% WOF	287 ± 2.60 ^f	82 ± 0.57 ^e	3.50 ± 0.03 ^g	70.00±0.08 ^c
10% (WBF+WOF)	413 ± 8.20 ^b	83 ± 2.00 ^c	4.97 ± 0.03 ^c	80.00±1.20 ^a
20% (WBF+WOF)	385 ± 4.30 ^c	75 ± 5.00 ^f	5.13 ± 0.16 ^b	75.50±1.16 ^b
30% (WBF+WOF)	360 ± 5.10 ^d	66 ± 2.00 ^g	5.45 ± 0.05 ^a	60.00±0.95 ^d

Means ± SD; Means with different superscript within the same column differ significantly (P ≤ 0.05), [▲]Control samples prepared from 100% wheat flour (82% extraction), WBF: Whole Barley flour; WOF: Whole oat flour.

From the same Table (5), it could be observed that the Energy (Cm²) decreased by increase replacement levels of WBF, WOF and both of them compared with control sample. These results were approximately similar with Abou-Ray *et al.* (2014); Hassan (2016) and Darwish *et al.* (2018).

3.4 Chemical composition of balady bread produced from different levels of wheat, barley and oat flour

Results presented in Table (6) show the chemical composition of the tested balady bread samples. Results showed the contents of protein, fat, ash and crude fiber were gradually increased (P ≤ 0.05) by increasing the substitution level of WBF and WOF and both of them in all tasted bread samples compared with control sample. On the other side, a slight

decrease in carbohydrates content was noticed in the same samples. This alteration could be attributed to the addition of WBF and WOF as partial substituting of wheat flour in making the Balady bread, which is rich in fiber content and the other components. These Results were agreement with Hussein *et al.* (2013) and Nakov *et al.* (2019) they noticed the concentration of protein, fat, ash, crude fiber and β-glucan in WBF and WOF were higher than those content of WF.

3.5 Minerals content of balady bread produced from different levels of wheat, barley and oat flours

The minerals content of the different bread samples was determined and recorded in table (7). The results indicated that the control Balady bread

sample contained Ca, P, K and Mg at levels of 21.84, 178.10, 123.40 and 112.46 mg /100 g, on dry weight basis. The minerals content for tested Balady bread was increased with increasing the incorporation levels of WBF, WOF and both of them from 10% to 30% in all the tested bread samples compared with control. In this concern, Balady bread produced from WBF, WOF and (1:1) mixer of them at replacement level 30%

exhibited highest contents ($P \leq 0.05$) of Ca (35.06, 33.67 and 34.96 mg /100 g), P (251.56, 270.26 and 266.45 mg /100 g), K (268.50, 191.58 and 244.14 mg/ 100 g) and Mg (122.50, 120.75 and 119.37 mg /100 g), respectively. This increase attributing to the high content of these mineral salts in barley and oat bran (Winiarska-Mieczan and Kwiecien, 2011; Chauhan *et al.*, 2018), when compared with wheat flour.

Table (6): Proximate chemical composition (%) of Balady bread produced by different substituted levels of wheat, barley and oat flour (on dry weigh basis).

Bread samples	Protein	Fat	Ash	Crude fiber	Carbohydrates*
Control [▲]	11.36±0.03 ^e	1.62±0.10 ^b	1.56±0.02 ^d	1.95±0.07 ^g	83.51 ±1.01 ^a
10% WBF	11.60±0.04 ^d	1.78±0.06 ^g	1.67±0.13 ^c	2.31±0.09 ^{ef}	82.64±2.12 ^b
20% WBF	11.95±0.06 ^c	2.04±0.26 ^{ef}	1.88±0.12 ^b	2.68±0.10 ^c	81.45±1.19 ^c
30% WBF	12.24 ±0.13 ^a	2.33±0.03 ^d	2.24±0.02 ^a	3.34±0.12 ^a	79.84±2.83 ^e
10% WOF	11.57±0.03 ^d	2.15±0.15 ^c	1.59±0.05 ^{cd}	2.24±0.03 ^f	82.45±0.02 ^b
20% WOF	11.88±0.10 ^c	2.62±0.05 ^c	1.65±0.04 ^{cd}	2.37±0.10 ^{de}	81.48±2.05 ^c
30% WOF	12.07±0.02 ^b	2.94±0.14 ^a	1.80±0.11 ^b	2.69±0.12 ^c	80.50±0.02 ^d
10% WBF+WOF	11.58±0.12 ^d	1.94±0.02 ^f	1.64±0.08 ^{cd}	2.28±0.04 ^f	82.56±2.00 ^b
20% WBF+WOF	11.90±0.05 ^c	2.51±0.08 ^c	1.81±0.12 ^b	2.44±0.05 ^d	81.34±2.46 ^c
30% WBF+WOF	12.18±0.07 ^a	2.80±0.09 ^b	1.86±0.03 ^b	2.93±0.13 ^b	80.23±0.21 ^{de}

Means ± SD; Means with different superscript within the same column differ significantly ($P \leq 0.05$), [▲]Control samples prepared from 100% wheat flour (82% extraction), WBF: Whole Barley flour, WOF: Whole oat flour, *Carbohydrates were calculated by difference.

Table (7): Minerals content (mg/100g) of Balady bread produced by different substituted levels of wheat, barley and oat flour (on dry weigh basis).

Blends samples	Ca	P	K	Mg
Control [▲]	21.84±0.10 ^d	178.10 ±1.14 ^g	123.40±1.20 ⁱ	112.46±1.29 ^g
10% WBF	26.43 ± 0.08 ^c	201.94±2.16 ^f	171.21±0.98 ^f	114.78±1.06 ^{ef}
20% WBF	30.63 ± 0.16 ^b	227.86±1.86 ^d	220.35±1.65 ^c	117.94±2.15 ^{cd}
30% WBF	35.06 ± 0.05 ^a	251.56±1.72 ^b	268.50±2.07 ^a	122.50±1.33 ^a
10% WOF	25.92 ± 0.17 ^c	210.50±2.25 ^e	144.58±0.56 ^b	113.25±1.65 ^{fg}
20% WOF	29.76 ± 0.24 ^b	242.38±2.09 ^c	172.15±1.80 ^f	116.90±0.80 ^{def}
30% WOF	33.67 ± 0.03 ^a	270.26±1.65 ^a	191.58±1.42 ^e	120.75±0.97 ^{ab}
10% (WBF+WOF)	25.48 ± 0.19 ^c	208.75±3.24 ^e	158.75±1.16 ^g	115.98±1.46 ^{def}
20% (WBF+WOF)	29.90 ± 0.03 ^b	231.12±2.10 ^d	211.66±2.25 ^d	117.06±1.90 ^{def}
30% (WBF+WOF)	34.96 ± 0.12 ^a	266.45±1.96 ^a	244.14±1.31 ^b	119.37±2.20 ^{bc}

Means ± SD; Means with different superscript within the same column differ significantly ($P \leq 0.05$), [▲]Control samples prepared from 100% wheat flour (82% extraction), WBF: Whole Barley flour, WOF: Whole oat flour.

3.6 Organoleptic characteristics of Balady bread produced from different levels of wheat, barley and oat flours

Mean scores for organoleptic properties of tested Balady bread samples given in Table (8). The obtained results revealed significant difference ($P \leq 0.05$) between treatments. Bread samples containing 10% WBF, WOF and both of them (WBF+WOF) had the highest score ($P \leq 0.05$) for most quality attributes

(appearance, crumb distribution, roundness and separation of layers) as compared to bread samples containing WBF or/and WOF at levels 20 and 30%. Roundness and separation of layers for all tested bread samples were not affected significantly ($p \leq 0.05$) by adding WBF or/and WOF at all levels when compared with control samples. A significant difference ($P \leq 0.05$) was observed in taste, odor and crust color when WBF and WOF levels were increased over 10%.

Table (8): Organoleptic characteristics of Balady bread produced by different substituted of wheat, barley and oat flour (Means \pm SD).

Bread samples	Appearance (20)	Taste (20)	Crumb distribution (15)	Roundness (15)	Odor (10)	Crust Color (10)	Separation of layers (10)	Overall acceptability
Control	18.00 ^a \pm 0.92	19.10 ^a \pm 0.12	14.55 ^a \pm 0.22	14.30 ^a \pm 0.26	9.00 ^a \pm 0.36	8.60 ^a \pm 0.93	9.50 ^a \pm 0.35	9.20 ^a \pm 0.34
10% WBF	18.00 ^a \pm 0.65	18.12 ^a \pm 0.23	14.20 ^{bc} \pm 0.34	14.20 ^a \pm 0.48	8.00 ^a \pm 0.68	7.50 ^a \pm 0.65	9.50 ^a \pm 0.29	8.95 ^{ab} \pm 0.31
20% WBF	17.50 ^{ba} \pm 1.12	18.00 ^a \pm 0.62	14.00 ^{cd} \pm 0.90	14.30 ^a \pm 0.12	7.10 ^a \pm 0.55	7.20 ^{cd} \pm 0.72	9.40 ^a \pm 0.61	8.78 ^{ab} \pm 0.29
30% WBF	17.00 ^{bc} \pm 0.80	17.50 ^a \pm 0.28	13.50 ^{de} \pm 0.45	14.20 ^a \pm 0.56	7.00 ^a \pm 0.55	7.00 ^a \pm 0.25	9.50 ^a \pm 0.87	8.57 ^b \pm 0.26
10% WOF**	18.00 ^a \pm 0.98	18.50 ^b \pm 0.28	14.30 ^b \pm 0.20	14.20 ^a \pm 0.27	8.50 ^a \pm 0.38	8.00 ^a \pm 0.59	9.40 ^a \pm 0.24	9.09 ^{ab} \pm 0.32
20% WOF	17.80 ^a \pm 1.23	18.00 ^a \pm 0.25	14.10 ^{bc} \pm 0.19	14.20 ^a \pm 0.19	8.50 ^a \pm 0.27	7.50 ^a \pm 0.34	9.50 ^a \pm 0.77	8.96 ^{ab} \pm 0.29
30% WOF	17.50 ^{ba} \pm 0.37	17.80 ^{cd} \pm 0.17	13.70 ^{ef} \pm 0.10	14.15 ^a \pm 0.42	8.00 ^a \pm 0.91	7.10 ^a \pm 0.90	9.30 ^a \pm 0.54	8.73 ^b \pm 0.27
10% WBF+WOF	17.50 ^{ba} \pm 0.39	18.00 ^a \pm 0.50	14.20 ^{bc} \pm 0.15	14.20 ^a \pm 0.60	8.00 ^a \pm 0.78	7.20 ^{cd} \pm 0.50	9.50 ^a \pm 0.89	8.89 ^{ab} \pm 0.30
20% WBF+WOF	17.50 ^{ba} \pm 1.35	17.50 ^a \pm 0.32	13.80 ^{de} \pm 0.50	14.15 ^a \pm 0.15	7.30 ^a \pm 0.64	7.30 ^{cd} \pm 0.16	9.30 ^a \pm 0.26	8.77 ^{ab} \pm 0.29
30% WBF+WOF	17.00 ^{bc} \pm 0.18	17.50 ^a \pm 0.82	13.40 ^{ef} \pm 0.08	14.15 ^a \pm 0.55	7.00 ^a \pm 0.85	7.00 ^a \pm 0.24	9.40 ^a \pm 0.14	8.55 ^b \pm 0.28

Means \pm SD; Means with different superscript within the same column differ significantly ($P \leq 0.05$), Control samples prepared from 100% wheat flour (82% extraction), WBF*: Whole Barley flour, WOF**: Whole oat flour.

The decline in taste could be ascribed to the higher fiber content of whole barley and oat flour compared to wheat flour. The obtained results were similar to the results reported by Ereifej *et al.* (2006); Hussein *et al.* (2013) and Majzoobi *et al.* (2016).

3.7 Influence of feeding on Balady bread produced from different flour blends on blood glucose levels of hyperglycemic rats

Based on the results of organoleptic properties for all tested bread samples, chosen bread samples containing 20%

WBF, 20% WOF and 20% (WBF+WOF) for study impact of feeding by them on blood glucose levels of hyperglycemic rats. Blood glucose level was recorded weekly during the experimental period (28 days) and listed in Table (9). The results present in Table (9) revealed that initial blood glucose level after induction with alloxan was significant ($P \leq 0.05$) increased in all diabetic rat groups (+ve) as compared to the normal control rats group (-ve). During the experimental period, higher significant difference in blood glucose level were found in the (+ve) group compared with normal group (-ve). Also, from the same table, it could be noticed that there non-significant ($P \leq$

0.05) differences in glucose level between bread containing 100% wheat flour hyperglycemic rats group (+ve) and beginning 7th day of experiment until the hyperglycemic rat group fed on Balady end.

Table (9): Blood glucose levels (mg/dl) in serum of normal and hyperglycemic rats fed on different blends of Balady bread during experimental period.

Groups	Blood glucose level (mg/dl) during experimental period*				
	Initial	After			
		One week	Two weeks	Three weeks	Four weeks
1 Negative control (-ve)	95.21±1.42 ^b	93.92±1.99 ^c	96.77±5.96 ^f	95.62±7.05 ^f	94.82±2.29 ^e
2 Positive control (+ve)	290.23±7.55 ^a	289.26±2.05 ^a	291.75±2.54 ^a	287.93±2.01 ^a	294.51±2.97 ^a
3 100% WF**	279.25±4.21 ^a	286.41±2.24 ^a	289.71±3.64 ^a	283.85±3.29 ^b	289.27±7.57 ^a
4 80% WF + 20% WBF	278.97±1.76 ^a	259.13±1.86 ^d	229.11±2.04 ^c	196.75±5.16 ^c	141.88±2.68 ^f
5 80% WF + 20% WOF	277.16±3.23 ^a	265.17±2.13 ^c	241.67±3.91 ^d	223.73±3.19 ^d	165.24±4.45 ^e
6 80% WF+20%(WBF+WOF)	281.70±4.37 ^a	264.90±3.29 ^c	239.98±2.88 ^d	223.15±2.68 ^d	189.65±3.90 ^e

*Means ± SD; means in the same column with different superscript letters are significant at ($P \leq 0.05$), (-ve) Normal rats; (+ve) Diabetic rats, **Wheat flour (82% extraction), WBF: Whole Barley flour, WOF: Whole oat flour.

While, these levels gradually decreased ($P \leq 0.05$) in the other tested hyperglycemic rat groups which fed on breads containing 20% WBF or/and WOF with increasing of feeding period up to the end of experiment (28 days). The highest reduction in blood glucose level was observed with hyperglycemic rats group fed on bread containing WBF (141.88 mg/dl) followed by WOF (165.24 mg/dl) and WBF+WOF (189.65 mg/dl) at level 20% compared with hyperglycemic rats group fed on bread containing 100% WF (289.27 mg/dl). The decrease of serum glucose level in hyperglycemic rats under study could be due to the presence of high amount of β -glucans in barley and oat flours, and the effective role of beta glucans in improvement of impaired glucose tolerance, decrease glycaemia and partially restores insulin secretion (Cugnet-Anceau *et al.*, 2010; Francelino *et al.*, 2015). These results are in agreement with Kabir *et al.* (2002), Pereira *et al.* (2002) and Granfeldt *et al.*

(2008) who reported that consumption of whole grains that rich in β -glucans like barley, oat and rye have anti-diabetic effects and reducing glycemic index.

4. Conclusion

Substitution of wheat flour with WBF or/and WOF greatly improved of the chemical characteristics and minerals content for produced bread. Rheological properties recorded increase in water absorption, arrival time, dough development, dough stability and weakening values of dough, also increased of extensibility while decrease of elasticity, proportion number and energy by added WBF, WOF and both of them compared with control. Organoleptic properties of tested balady bread were a good desirable up to 20% replacement of WBF, WOF and (1:1) mixture both of them. Consequently, incorporation of whole grains of barley and oat flour in balady bread up to 20%

gave good quality characteristics and leads to lowering blood glucose level in tested hyperglycemic rats.

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