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Evaluation of Small Size and Broken Wheat Grain to Utilize the Balady Bread Production

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ABSTRACT

Balady bread is the main food item consumed in Egypt. In this study, the wheat flour 82 % extraction rate (WF) substituted with byproducts from wheat grain cleaning residues (small size and broken wheat grain flour (SSBWGF)) at level 20, 40, 60, 80, and 100% to utilize in balady bread production. Rheological properties**,** chemical composition and sensory properties of the produced balady bread were evaluated. The results of the farinograph data indicated that, water absorption, dough development time and stability time increase gradually by increasing the level of SSBWGF. However extensograph data showed that, the substitution of wheat flour with SSBWGF at different levels minimized extensibility and dough energy. Regarding the chemical composition of balady bread, it could be noticed that, by increasing the level substations of SSBWGF in balady bread products formulas, the protein, ash, fat, crude fiber and minerals content (*i.e*., iron, zinc and calcium) increase. The sensory evaluation showed that, no significant differences were observed between control sample and samples of balady bread at substitution levels of 20, 40 and 60% with SSBWGF. Alkaline water retention capacity (freshness) revealed that wheat bread blends were better than bread control. Freshness of all balady bread blends decreased at different periods as well as bread control compared with zero time period. In addition from economical point of views, the substitution balady bread with SSBWGF decreased the bread cost. It could be suggested that Egyptian balady bread from wheat flour with SSBWGF up to 60% can be produced with low cost and good score acceptability.

Key words*:* Wheat flour, baladybread, rheological properties, sensory properties, chemical composition

Introduction

Wheat is the most important stable food crop for more than one third of the world population and contributes more calories, proteins, minerals, B-group vitamins and dietary fiber to the world diet than any other cereal crops (Abd-El-Haleem *et al*., 1998, Shewry, 2007 and Shewry, 2009). Of all the cereal grains, wheat is unique because only wheat flour can form dough with the rheological properties required for the production of leavened bread and the broad variety of foods that have been developed owing to these attributes (Gianibelli *et al*., 2001).

Egypt is the one of the highest wheat-imported in the world marked as a result of the large gap between the national production and the increasing wheat demand because of the increase in its consumption. The total yield of wheat grain does not satisfy the needs of the population total production of wheat grains covers only about 55% of the total needs. According to the statistical data from (FAOSTAT, 2013) the wheat production was 9280 (10^3ton); consumption 17025 (10^3ton) and the loss of wheat grain was about 19.03% (3240 10^3ton). The Egyptian Standred No.(2005) which recommended that, the ratio of small and broken wheat grain in wheat grain not exceed on 5%

The Egyptian government has to purchase imported wheat with rising cost of dollars and most of them low in quality. This is contributing to food insecurity. The way to overcome this problem as a strategy to reduce wheat import and insures food security in the country is to search for the native cereal sources which could be used with wheat flour bread making (Yaseen *et al.*, 2007).

In Egypt, wheat is the most widely consumed crop for bread making. Bread is the principal food and a stable for a great majority of the population, constituting 70% of daily caloric intake of the average Egyptian. Balady bread is the most popular type of bread in Egypt, since 90% of the Egyptian families consume the subsidized balady bread in their daily meal (Sarhan *et al*., 2010). The daily production of balady bread in Egypt reaches 240 million loaves with an average of about 3 loaves per capita a day (Lahham *et al*., 2013).

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Thus, the present study was to evaluate the quality of adding byproduct from wheat grain cleaning residues (small size and broken wheat grain flour (SSBWGF)) to utilize the balady bread production.

Materials and Methods

Material:

Wheat flour of extraction rate 82% (WF) was obtained from the South Cairo Mills Company, Egypt. Small size and broken wheat grain (SSBWG) was obtained from the South Cairo Mills -Imbaba mill-House cleaning residues. It was milled using Hummer mill to obtain whole meal flour. Whole meal wheat flour was sieved through 50 mm sieve to obtain required refined flour. Other materials were obtained from local market such as dry yeast and salt.

Methods:

Preparation of balady bread:

Balady bread formulas are shown in Table (1). Balady bread was produced according to the method described by (Yaseen *et al*., 2007).

Table 1: Formulae of balady breads

Ingredients	Bread samples					
	Control	B_1	B_2	B_3	B_4	B_5
Wheat flour 82% ext.(WF)	100	80	60	40	20	-
Small size and broken wheat grain flour (SSBWGF)	-	20	40	60	80	100

Balady bread was prepared by mixing 100 g of wheat flour 82% extraction (WF) with small size and broken wheat grain flour (SSBWGF) at levels of 20, 40, 60, 80 and 100% separately, 0.5 g of active dry yeast, 1.5 g of sodium chloride, and 75–80 ml of water were added and mixed by hand for about 6 min to form the needed dough. The dough was left to ferment for 1 h at 30ºC and 85% relative humidity and was then divided into 125 g pieces. 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 30–35ºC and 85% relative humidity for 15 min and then were baked at 400–500ºC for 1–2 min. The loaves of bread were allowed to cool on racks for about 1 h before evaluation.

Chemical composition:

Moisture, protein, fat, crude fiber and ash content were determined according to the methods described in A.O.A.C. (2010). Total carbohydrates content was calculated by difference on dry weight basis.

Minerals content, i.e., Fe, Zn and Ca were estimated by atomic absorption spectrophotometer (model 3300, Perkin-Elimer, Beaconsfield, UK) and digestion according to the procedure outlined by A.O.A.C. (2010).

Rheological properties:

Rheological properties of dough were evaluated using farinograph, and extensograph according to A.A.C.C. (2002).

Wet and dry gluten:

Wet and dry gluten percentages were measured according to A.A.C.C. (2002).

Sensory evaluation:

All samples were evaluated by ten panelists from the Bread and Pastry Res. Dept. staff in Food Tech. Res., Institute Agric. Res. Center. The balady bread loaves were sensory evaluated for crumb texture, crust color, taste, diameter, separation, crust texture, crumb color, flavor and overall scores as mentioned by Mohamed *et al.* (1996).

Freshness of bread:

After baking the balady bread and cooling at room temperature, bread freshness was determined at zero time, 24, 48 and 72 hours of storage by Alkaline water retention capacity (AWRC) according to the method of Kitterman and Rubentholar (1971).

Statistical analysis:

The data were statistically analyzed using the analysis of variance as out lined by Snedecor and Cocheran (1980).

Results and Discussion

Chemical analysis of raw materials:

Data presented in Table (2), showed the chemical analysis of raw materials used in the preparation of balady bread. It could be demonstrated that small size and broken wheat grain flour (SSBWGF) contained the highest values in protein, ash, fat and crude fiber (11.53, 1.51, 1.93 and 3.52%, respectively.) whereas it was the lowest values in total carbohydrates (81.51%) compared with wheat flour (WF) 82 % extraction rate. From the same table, it could be seen that, the SSBWGF had the highest value of iron (Fe), zinc (Zn) and calcium (Ca) (2.03, 1.57and 39.40 mg/100g, respectively), whereas wheat flour (82% extraction rate) showed lesser contents of the aforementioned mineral. These results are agreement with those reported by Sharoba *et al*. (2009) they reported the content of WF 82% extraction rate was as follows: protein 12.80%, fat 1.91%, ash 1.06%, crude fiber 1.93% and carbohydrate 82.30%. Hussein *et al*. (2013) found that WF 82% extraction rate had protein 12.05%, fat 1.81%, ash 1.47%, crude fiber 1.65%, total carbohydrate 82.30%, Fe 1.71mg/100g, and Ca 23 mg/100g.

Table 2: Chemical composition of raw materials (% on dry weight basis).

Components (%)	Wheat flour 82% (WF)	Small size and broken wheat grain flour (SSBWGF)
Protein	11.18	11.53
Ash	1. 23	1.51
fat	1.70	1.93
Crude fiber	1.68	3.52
Total carbohydrate *	84.21	81.51
Minerals (mg/100g)		
Fe	1.68	2.03
Zn	1.06	1.57
Ca	30.54	39.40

**Calculated by difference.*

Rheological properties of dough:

Water absorption, the amount of water required for a dough to reach a defined consistency and a general profile of the mixing behavior, mixing time, mixing stability of the dough (D'Appolanine, 1984). Data presented in Table (3) showed that the effect of substitution WF (82% extraction) with SSBWGF at different ratios on farinograph parameters. It could be noticed that, the water absorption, dough development time and stability time increase gradually by increasing the substitution ratios than that found in the control sample. The increasing water absorption might be due to addition of SSBWGF which containing more fiber content, which retained more water. Similar effects on water absorption were observed by Sudha *et al*. (2007) when wheat bran or rice bran was added. These results were confirmed by those obtained by Hemery *et al*. (2001) who pointed out that the increase in water absorption probably due to their higher fiber content. Meanwhile, the substitution WF with SSBWGF caused gradual reduction in degree of weakening. This clear decrease might due to dilution of gluten protein from WF with the increase fiber content from SSBWGF. Rosell *et al*. (2001) reported that the differences in water absorption is mainly due caused by the greater number of hydroxyl group which exist in the fiber structure and allow more water interaction through hydrogen bonding.

Table 3: Farinograph parameters of WF (82% extraction) with different levels of SSBWGF.

Treatments	Water absorption (%)	Dough development (min)	Dough stability (min)	Degree of weakening (B.U.)
Control	58.9	1.5	8.0	70.00
B_1	59.5	1.5	8.5	67.25
B_2	61.5	2.00	9.0	64.00
B_3	61.8	1.5	9.0	60.00
B_4	63.8	2.00	9.0	57.20
B_5	66.1	2.50	9.5	50.00

Control: WF (82%extr.) *B_1: 20 % (SSBWGF) + 80%WF* *B_2: 40 % (SSBWGF) + 60%WF*
B_3: 60 % (SSBWGF) + 40%WF *B_4: 80 % (SSBWGF) + 20%WF* *B_5: 100% SSBWGF*

The extensograph reading in the Table (4) showed that, the value of resistance to extension and proportional number showed ascending order with enhancing of the value of SSBWGF. Meanwhile, the value of extensibility and energy was gradually reduction by increasing the substitution ratios of WF with SSBWGF than that found in the control sample. These results were confirmed by those obtained by Gomez *et al*. (2003) and Bojňanská *et al*. (2014).

Table 4: Extensograph parameters of WF (82% extraction) with different levels of SSBWGF.

Treatments	Resistance to extension (B.U.)	Extensibility (min.)	Proportional number (R/E)	Energy (cm^2)
Control	150	130	1.15	45
B_1	160	125	1.28	39
B_2	180	110	1.64	35
B_3	180	115	1.57	35
B_4	210	100	2.10	33
B_5	200	105	1.90	32

Control: WF (82%extr.) *B_1: 20 % (SSBWGF) + 80%WF* *B_2: 40 % (SSBWGF) + 60%WF*
B_3: 60 % (SSBWGF) + 40%WF *B_4: 80 % (SSBWGF) + 20%WF* *B_5: 100% SSBWGF*

Gluten content:

From the data in Table (5) it could be observed that, WF (control) used in this study showed high wet and dry gluten content value of 23.28% and 8.3% respectively. The addition of SSBWGF to WF caused decrease in the amount of wet and dry gluten.

Table 5: Gluten content of WF (82% extraction) with different levels of SSBWGF

Treatments	Wet gluten %	Dry gluten %	Gluten index %
Control	23.28	8.3	94.65
B_1	19.42	8.2	92.42
B_2	17.82	7.10	90.76
B_3	17.11	7.00	89.34
B_4	16.74	6.38	85.34
B_5	16.08	6.12	81.87

Control: WF (82%extr.) *B_1: 20 % (SSBWGF) + 80%WF* *B_2: 40 % (SSBWGF) + 60%WF*
B_3: 60 % (SSBWGF) + 40%WF *B_4: 80 % (SSBWGF) + 20%WF* *B_5: 100% SSBWGF*

This result agrees with that reported by Gan *et al.* (1992) who reported that the addition of bran to wheat flour dilutes the concentration of gluten-forming proteins of the dough, and the bran particles disrupt the gluten network. Perten (1990) and Ohm and Chung (1999) reported that the quantity and quality of proteins may be determined by the content and quality of gluten.

With respect to gluten index, it is depends on the amount of wet gluten that passes through a sieve under centrifugal force, and a higher proportion of gluten that remains on the sieve after centrifugation indicated stronger gluten (Dowell *et al*., 2008). The greater of gluten index value, the greater the force of gluten, although this fact is not always associated with a big bread volume (Ranhotra *et al*., 1992). Gluten index decreased from 94.65% to 81.87% with the increase of (SSBWGF) incorporated into the WF. This result may be due to the levels of substitution of SSBWGF which rich in fiber absorb more water. This finding agree with Enriquez *et al*. (2003) they reported that, the optimum gluten index value for baked purposes should between 60 and 90%. Also, they established that, there is not any correlation between wet gluten and gluten index. Skendi *et al*. (2010) and Wang *et al*. (2002) suggested that addition of high levels of fibers lead to gluten dilution and reduction of gas extension capacity in the dough and a possible deterioration in the gluten network structure during proofing.

Chemical analysis of the produced balady bread:

Data in Table (6), showed that, balady bread which containing SSBWGF at level of 100% had the highest value of protein, ash, fat and fiber and lowest value of total carbohydrate compared with the control 100% WF(12.28, 2.44, 1.90, 3.57, and 79.81% respectively). All samples of balady bread (except control 100% WF) had protein content ranged from 11.80-12.28%, ash 2.15-2.44%, fat 1.73-1.90%, crude fiber 1.93-3.57%, and total carbohydrate 82.39-79.81%. Also the results presented in Table (6), showed that all samples of balady bread which containing SSBWGF at level 100% had the highest values in minerals content i.e., Iron (Fe), zinc (Zn) and calcium (Ca) compared with the control. The addition of SSBWGF to formulation contributed to the increase in their mineral content, especially iron, zinc and calcium due to their higher amounts of these compounded. These results are confirmed by those of Mohamed *et al.* (2013).

Table 6: Chemical analysis of produced balady bread with different levels (% on dry weight basis).

Components %	Control	B_1	B_2	B_3	B_4	B_5
Protein	11.74	11.80	11.89	12.03	12.10	12.28
Ash	2.02	2.15	2.21	2.30	2.39	2.44
Fat	1.68	1.73	1.77	1.80	1.86	1.90
Crude fiber	1.82	1.93	2.23	2.70	3.12	3.57
Total carbohydrate*	82.74	82.39	81.81	81.17	80.53	79.81
Minerals (mg/100g)						
Fe	2.28	2.39	2.45	2.58	2.68	2.72
Zn	0.93	1.03	1.12	1.21	1.30	1.39
Ca	35.80	37.79	39.94	42.39	44.98	47.13

**Calculated by difference. Control: WF (82%extr.) B_1: 20 % (SSBWGF) + 80%WF*
B_2: 40 % (SSBWGF + 60%WF B_3: 60 % (SSBWGF) + 40%WF B_4: 80 % (SSBWGF) + 20%WF
B_5: 100% SSBWGF

Sensory evaluation of produced balady bread:

Data in Table (7) shows the sensory evaluation of balady bread produced from WF (82% extraction) substitution with SSBWGF at different levels ratio 20, 40, 60, 80 and 100%. The sensory evaluation included the crumb texture, crust color, taste, diameter, separation, crust texture, crumb color, flavor and overall scores.

The results showed that, no significant differences were observed for balady bread fortified with SSBWGF at 20, 40 and 60% levels in their crumb texture, crust color, taste, diameter, separation, crust texture, crumb color, flavor and overall scores compared with WF control bread. On the other hand sensory properties of balady bread were decreased with increasing the levels of SSBWGF (80 and 100% levels) and significant quality reduction. This result agrees with that reported by (Gómez *et al*., 2003) concluded that, there was no clear relationship between the sensory score and the quantity of fiber added, but depended on the kind of fiber tested. Small additions of dietary fiber to wheat flour (at the 2% level) produced, in general, very similar bread to the white wheat bread without any noticeable damage to acceptability. The increase of wheat fiber addition to 5%, with the inherent enhanced positive nutritional effect, did not deteriorate the bread sensory evaluation compared with control. Noort *et al*. (2010) they reported that most consumers prefer product of fine wheat flour more than whole grain products, because they perceive the textural properties of whole grain products to be less attractive.

Table 7: Sensory evaluation of produced balady bread

Items	Control	B_1	B_2	B_3	B_4	B_5
Crumb texture (5)	4.9 ±0.11^a	4.8±0.07^a	4.8±0.15^a	4.7±0.08^a	4.3±0.09^b	4.1±0.08^b
Crust color (5)	4.9±0.07^a	4.9±0.05^a	4.8±0.10^a	4.8 ±0.05^a	4.3±0.03^b	4.2±0.10^b
Taste (5)	4.9 ±0.07^a	4.9 ±0.05^{ab}	4.8±0.10^a	4.7±0.13^a	4.1±0.10^b	4.0±0.20^b
Diameter (5)	4.7±0.05^a	4.7±0.10^a	4.7±0.05^a	4.6±0.90^{ab}	4.5±0.10^{bc}	4.4±0.15^c
Separation (5)	4.8 ±0.05^a	4.8 ±0.10^a	4.7±0.20^{ab}	4.7±0.00^{ab}	4.6±0.30^{ab}	4.4±0.05^c
Crust textures (5)	4.8 ±0.00^a	4.8±0.20^a	4.7±0.10^a	4.7±0.30^a	4.2±0.20^b	4.0±0.00^b
Crumb color (5)	4.8±0.10^a	4.8±0.20^a	4.7±0.00^a	4.7±0.20^a	4.3±0.30^b	4.0±0.10^b
Flavor (5)	4.8±0.08^a	4.8±0.07^a	4.8±0.09^a	4.7±0.08^a	4.4±0.10^b	4.2±0.10^c
Overall Score (40)	38.50±0.30^a	38.30±0.34^a	38.28±0.15^a	38.25±0.74^a	34.50±0.26^b	32.6±0.14^c

Control: WF (82%extr.) B_1: 20 % (SSBWGF) + 80%WF B_2: 40 % (SSBWGF) + 60%WF
B_3: 60 % (SSBWGF) + 40%WF B_4: 80 % (SSBWGF) + 20%WF B_5: 100% SSBWGF
** Values are means of ten replicates ± SD, number in the same raw followed by the same latter are not significant at 0.05 level.*

Freshness of produced balady bread:

Alkalin water retention capacity (AWRC) of the balady bread was taken as indication on staling degree and freshness. It was determined at different periods; zero time and after storage periods (24, 48 and 72 h) as shown in Table (8). From results, it could be noticed that the substitution WF with SSBWGF in the various balady bread formulations contributed to the increase in alkaline water retention capacity (AWRC) compared with the control, due to SSBWGF which containing more fiber content. Freshness of all balady bread blends was decreased at different periods as well as bread control compared with zero time period. Also, the rate of decrease of all blends in balady bread was decreased during storage at 24, 48 and 72h. of storage at room temperature. The crumb firmness evolution during a storage period of 3 days showed the important effect of fiber addition on bread lifetime. This effect is related to the well-known water binding capacity of fiber that avoids water loss during storage and with the possible interaction between fiber and starch that would delay the starch retrogradation. (Gómez *et al*., 2003).

Table 8: Freshness properties of balady bread stored at room temperature as determined by alkaline water retention capacity (AWRC).

Treatments	AWRC at Zero time (%)	Rate of AWRC after 24 hour (%)	Rate of AWRC after 48 hour(%)	Rate of AWRC after 72 hour(%)
Control	345.12	15.83	28.68	39.59
B_1	356.82	13.65	26.20	37.67
B_2	362.52	12.76	25.35	34.23
B_3	370.73	10.21	24.65	32.23
B_4	379.96	9.01	23.01	29.17
B_5	380.56	8.24	21.43	27.65

Control: WF (82% extr.) B_1: 20 % (SSBWGF) +80%WF B_2: 40 % (SSBWGF) +60%WF
B_3: 60 % (SSBWGF) +40%WF B_4: 80 % (SSBWGF) +20%WF B_5: 100% SSBWGF

Economic evaluation:

Cost production of the produced balady bread were calculated and tabulated in Table (9), it could be noticed that the production cost decreased in all produced balady bread compared with the control (WF 100%) by increasing the level substitution of by-product of SSBWGF. It could be noticed that the lowest cost was obtain in balady bread which containing SSBWGF at level of 100%, followed by balady bread with 80% SSBWGF and balady bread with 60% SSBWGF. Therefore, utilization of by-product of SSBWGF substances is preferable due to decrease the bread cost.

Table 9: Production cost of different types of produced balady bread.

Raw materials	Amount (g)	Cost P.T	Produced Balady bread					
			Control	B_1	B_2	B_3	B_4	B_5
WF (82% extraction)	1000	400	400	320	240	160	80	-
SSBWGF after cleaning ,milling and sieves	1000	175	-	35	70	105	140	175
*(A+B)			189	189	189	189	189	189
Net of cost			589	544	499	454	409	364
**Net cost of one unit of balady bread			45.3	42	38.4	35	31.5	28

Control: WF (82% extr.) *B_1: 20 % (SSBWGF) +80%WF* *B_2: 40 % (SSBWGF) +60%WF*
B_3: 60 % (SSBWGF) +40%WF *B_4: 80 % (SSBWGF) +20%WF* *B_5: 100% SSBWGF*
Other ingredients – Yeast (5 g) + salt (15 g) *Cost of other ingredients (A) = 21 + 18 = 39 P.T*
Cost of production (B) = 150 P.T **(A+B) = 39+ 150 = 189 P.T*
The amount of ingredient gave number 13 bread (weight 115 g).
***Net cost (P.T) for one unit of balady bread weight 115 g.*

Conclusion:

The study suggested that, SSBWGF can be used to improve balady bread up to 60% in balady bread loaves without adversely affecting the consumer acceptability of the bread. Also, it was reduce in cost production of bread.

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