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EVALUATION OF A NOVEL PAN BREAD FORMULATED BY WHEAT/MILLET FLOUR DIFFERENT BLENDS

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ABSTRACT: ***The effect of substituting wheat flour (WF) with different levels (10, 20, 30 and 40%) of millet flour (MF) on rheological properties and pan bread quality were investigated. Substituting WF with MF significantly ($p \leq 0.05$) increased protein, fat contents and dough stretching while reduced carbohydrate, wet gluten, dry gluten, all solvent retention capacity parameters, lightness (L*), total color difference (ΔE^*) value, dough stability and water absorption. No significant ($P>0.05$) difference was found in physical parameters and overall acceptability of pan bread between control and wheat formulated with up to 10% MF. Generally, the increase in the millet levels caused the increase in the lightness (L*) of crust and crumb color. The crumb L* became lighter ($p \leq 0.05$) with incorporating a higher levels of WF. Also, pan bread formulated with 40% MF had the highest ($p \leq 0.05$) value of b*, c* and total color difference. No significant difference ($p>0.05$) was detected in hardness, springiness, cohesiveness and resilience between control and pan formulated with MF up to 30% (and up to 40% for adhesiveness, gumminess and chewiness). In addition, increasing the storage (at 25°c ± 2) time increased significantly ($p<0.05$) hardness, gumminess and chewiness.***

Key words: ***Millet flour, SRC, Rheological properties; pan bread; Texture profile; physical properties.***

INTRODUCTION

In Egypt, wheat is the most important grain crop. Egypt is the world's biggest wheat importer and the General Authority for Supply Commodities of the Ministry of Supply and Internal Trade of Egypt alone is the world's biggest wheat purchaser. It is thus understandable that wheat is a product of paramount importance to Egypt and wheat policy is a priority for the government. The importance of wheat policy is reinforced by Egypt's specific social realities: with over a quarter of the Egyptian population living under the poverty line, assuring the food security of all citizens is a key challenge for the government (FAO 2017).

In recent years, many researches have studied substitutes wheat flour with other grain such as barley (Izydorczyk and Dexte 2008), buckwheat (Kaur *et al.,* 2015), rice flour (Chung *et al.,* 2014), pearl millet flours (Balasubramanian and Viswanathan 2010; Rai *et al.,* 2014; and Altındag *et al.,* 2015), oat flour (Duta and Culetu, 2015), amaranth (Barca *et al.,* 2010) and corn flour (Altındag *et al.,* 2015). However, local crops like millet flour could be a substitution to wheat flour to fill this gap. Pearl millet show nutritional and texture features, which make them suitable for replacing, at least in part, traditional cereal-based products.

Pearl millet (*Pennisetum glaucum* Synonyms: *Pennisetum americanum*, *Pennisetum typhoides*) a small-seeded crop known as Bajra (Gull *et al.,* 2012) is the sixth most important cereal grain worldwide (Saleh *et al.,* 2013 and Amadou *et al.,* 2013). It can grow under adverse ecological conditions and can tolerate poor soil and a certain degree of drought better than any cereal crop (Shimelis 2009; Jideani and Jideani 2011; Saleh *et al.,* 2013 and Devi *et al.,* 2014). It can also survive in semi-arid and arid lands and is well adapted to drought and sandy acid soil of low fertility (Osman Magdi 2011; FAOSTAT 2011; Yadav and Rai 2013 and Amadou *et al.,* 2013). Most of which are adapted to hot, dry climates (Supriya *et al.,* 2016).

Several studies indicated the possibilities of incorporating pearl millet and other flours in wheat flour at various levels for producing bread, biscuit, breakfast cereals and other snacks (Krishnan and Prabhasankar 2010; Krishnan *et al.,* 2011; Singh *et al.,* 2012 and Angioloni and Collar 2012a), cake (Desai *et al.,* 2010), pasta (Kaur *et al.,* 2012 and Balasubramanian *et al.,* 2014a,b)

Providing the millet similar to rice and wheat would improve its acceptability (Saha *et al.,* 2011). With the increase in substitution percentage of millet flours, the firmness value significantly was decreased ($p \leq 0.05$) by Gull, *et al.,* (2015).

Ballolli *et al.* (2014) reported that the physical characteristics of the bread decreased with increased substitution levels of millet flour, it might be due to the decrease in the proportion of the gluten content. Mamata *et al.* (2015) who reported that no change ($p>0.05$) was detected in loaf weight between wheat flour and substitution with 10% millet flour incorporated bread. Meanwhile, increase substitution of higher levels showed a more irregular structure with most gluten layers without a continuous distribution and surrounded by large starch granules (Monika *et al.,* 2015) and also the crumb firmness was the highest for the bread (Regine *et al.,* 2013).

The aim of the present research was to evaluate the effect of substituted wheat flour with different levels of millet flour on the chemical-physicochemical properties, color, rheological properties as well as, on the physical properties, sensory, crust and crumb color and texture profile of the formulated pan bread.

MATERIALS AND METHODS

MATERIALS:

Grains samples:

Hard red winter wheat grains (*Triticum vulgare*) were obtained from Egyptian Milling Technology Center during 2014/2015 seasons, the pearl millet grain (*Pennisetum glaucum*) hulled form, was obtained from Almizan Natural Trading ETS, Kingdom of Saudi Arabia. Dry yeast, sodium chloride, sugar, shortening, skimmed milk powder were obtained from local market.

METHODS:

1. Technological methods:

1.1. Preparation of grains:

Wheat and millet grains were cleaned and tempered to 16.5% moisture content for 8 and 24 hr, respectively. The grains were milled through a Quadrumat Senior Laboratory Mill (Brabender OHG, Model No 8802, Duisburg, Germany) according to AACC method 26-50 (2010).

1.2. Preparation of pan bread:

The wheat flour (100% WF as control) was substituted with millet flour (MF) by 10% (90% WF+10% MF), 20% (80% WF+20% MF), 30% (70% WF+30% MF) and 40% (60% WF+40% MF).

The straight dough process was performed in pan bread preparation according to AACC method 10-10B (2010). The bread dough formula consisted of the previous flour blends (100 g), dry yeast (3 g), sodium chloride (2 g), sugar (5 g), shortening (3 g), dry skimmed milk (3 g) and water (according to farinograph test).

2. Proximate Chemical method:

2.1. Proximate chemical composition:

Moisture, ash, protein (N×5.7), crude fat and crude fiber of blends were determined according to AACC methods (2010). The total carbohydrate content was calculated by difference as the following equation: Total carbohydrate % = 100 - (ash %+ crude protein % + crude lipid %).

2.2. Starch damage:

Starch damage of blends (WF substituted with different levels of MF) was determined using SD_{matic} instruments (Chopin, Triplette et Renauld, Paris, France) according to AACC methods 76-33 (2010) by using the amperometric method.

2.3. Gluten determination:

Wet, dry gluten and gluten index of blends of WF substitute with different level of MF were determined using (Glutomatic perten instruments AB type 2200, Huddinge, Sweden) according to AACC methods 38-12 (2010).

3. Physicochemical method:

3.1. Falling number:

Falling number of blends was determined using falling number AB instrument (type 1402, No. 539 Stockholm, Sweden) according to AACC methods 56-81 (2010)

3.2. Color analysis:

Color grade of WF and the other wheat/millet flour blends as well as its formulated pan bread (crust and crumb) was measured using SATAKE color grader (NCGA, Japan) with a D65 light source. The color parameters were measured as Lightness (L*), Redness (a*) and Yellowness (b*) as described by Mahmood (2015).

3.3. Glutograph determination:

Glutograph determination of wheat/millet flour blends was carried out according to the manual of the manufacturer (Brabender GmbH and Co. Duisburg, Germany) of the glutograph-E according to Alamri *et al.* (2009a,b): wet gluten from 10 g of flour was used for measuring the stretching and elastic properties of the dough to obtain the following data: 1. Shear time or stretching time (STR) as sec: time to reach the deflection or shear angle (determines the extension of the dough); and 2. Relaxation (RX) as BU: the recovery of the sample after 10 sec (determine the elasticity of the dough).

3.4. Solvent retention capacity profile:

Solvent retention capacity (SRC) of wheat/millet flour blends was determined according to AACC method 56-11 (2010).

3.5. Rheological Properties:

Rheological properties of wheat/millet flour blends were carried out using Brabender® faringraph and extensograph according to AACC method 54-21 and 54-10 (2010).

3.6. Bread texture analysis:

Texture analysis of baked loaves formulated from WF substituted with different levels of MF was carried out using texture analyzer (TA- HDi® Stable Micro Systems, Surrey, England). Texture profile analysis (TPA) with 2 compression cycles was used and samples were compressed using 35 mm cylindrical probe with 5 kg load cell. Just after cooling at room temperature (25 ± 2.0 °C) and kept in transparent double zipper, Ziploc® bags, and stored for 6 days at room temperature (25 ± 2.0 °C), texture measurement of bread was made using 3 central slices of about 25 mm total thickness (Bourne *et al.* 1978).

3.7. Physical properties of pan bread:

Weight (g) and volume (cm^3) by rapeseed displacement of coold bread loaf were recorded after cooling for 1 hr. Loaf specific volume (cm^3/g) was calculated by dividing volume by weight as described by AACC methods 10-05 (2010).

4. Sensory evaluation of pan bread:

Sensory analysis including symmetry shape, crust color, break and shred, crumb texture, crumb color, aroma, taste, mouth feel and overall acceptability of the fresh pan breads was performed by 15 members of a panel of graduate students of staff, using a hedonic scale of global acceptance (9. Like extremely; 8. Like very much; 7. Like moderately; 6. Like slightly; 5. Neither like nor dislike; 4. Dislike slightly; 3. Dislike moderately; 2. Dislike very much; 1. Dislike extremely) (Ajila *et al.* 2008). Bread was evaluated after 3 hr after baking, when loaves were sliced into 2 cm thick slices by a bread slicing machine. Panelists evaluate slices of different bread system which were offered at the same time in an open area without special lighting. Water was provided for rinsing purpose.

5. Statistical analysis:

Statistical analysis which data was performed using one way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with ($P \leq 0.05$) degree being considered statistically significant. Statistical analyses were performed with the Statistical Analysis System software 9.2 (SAS Institute, Cary, NC, USA). While Factorial experiment was used to analyze the data of extensograph parameters and texture profile analyzer of bread (Montgomery 1984). Least significant difference (LSD) was followed to make the multiple comparisons. The significant difference was determined at 0.05 % level.

RESULTS AND DISCUSSION:

1. Chemical and physicochemical characteristics of WF substituted with different levels of MF:

1.1. Proximate composition:

The proximate compositions of wheat flour substituted with different levels (10%, 20%, 30% and 40%) of millet flour are shown in Table (1). Significant ($p \leq 0.05$) increase was observed in moisture, total ash, total fat, and crude fiber by increasing the MF substitution levels. Meanwhile, the carbohydrate contents decreased ($p \leq 0.05$) by increasing substitution levels of MF. Whereas, no difference ($P > 0.05$) was detected in total protein between WF and that substituted with up to 30% MF. These results are similar to those reported by Hadimani and Malleshi (1993); Coda *et al.* (2010) and Buresova *et al.* (2017). Vidya *et al.* (2013) showed that the proximate composition of the wheat flour was moisture 12.8%, protein 11.8%, fat 1.7% ash 1.5% and carbohydrate (by difference) 72.2%. However, millet flour composition was moisture 12.3 - 12.5%, protein 8.2-13%, fat 1.5–5.1%, ash 2.6–3.0% and carbohydrate (by difference). Gull *et al.* (2015) reported that the moisture and ash content of pearl millet flour was 13.49 and 0.73 g/100 g, respectively.

On the other side, significant ($p \leq 0.05$) decrease was detected in gluten parameter by increasing MF substitution levels (except for the 10% substitution levels which had no significant ($p > 0.05$) changes in wet gluten and gluten index). These observations are in agreement with the results obtained by Taylor *et al.* (2014); Gulati *et al.* (2016) and McSweeney *et al.* (2017). They reported that the millet although it being gluten free, it contains protein content similar to wheat and higher than commonly consumed gluten free crops. The significant highest ($p \leq 0.05$) wet gluten (32.14 and 31.49 %), dry gluten (12.59 and 11.06%) and gluten index (95.94 and 94.11%) were given by WF and 90% WF +MF10%, respectively. Also, significant ($p \leq 0.05$) decrease in starch damage was observed by substitution WF with increasing levels of MF.

Table (1): Proximate composition (on dry weight basis) and gluten parameters of wheat /millet flour blends:

	MF	WF	Substitution levels (%)				LSD
			10	20	30	40	
Proximate composition							
Moisture	11.85	13.70[b]	13.86[a]	13.77[a]	13.73[a]	13.83[a]	0.13
Total ash	1.23	0.56[e]	0.63[d]	0.68[c]	0.76[b]	0.83[a]	0.03
Total protein	14.54	14.03[b]	14.08[b]	14.13[b]	14.18[ab]	14.32[a]	0.18
Total fat	4.80	1.06[e]	1.43[d]	1.81[c]	2.18[b]	2.56[a]	0.02
Total Crude fiber	4.32	1.05[e]	1.38[d]	1.70[c]	2.03[b]	2.36[a]	0.01
Starch damage (%)	3.17	5.74[a]	5.48[b]	5.19[c]	4.85[d]	4.60[e]	0.02
Total Carbohydrates	64.41	64.91[a]	64.52[b]	64.42[c]	64.30[d]	63.86[e]	0.17
Gluten parameters							
Wet gluten	ND	32.14[a]	31.49[ab]	31.22[b]	28.33[c]	27.96[c]	0.78
Dry gluten	ND	12.59[a]	11.06[b]	11.05[b]	10.20[b]	9.88[c]	1.08
Gluten index	ND	95.94[a]	94.11[ab]	91.92[b]	90.97[bc]	88.34[c]	3.15

Data are mean of three replicates.
Values followed by different letters in the same row are significantly different ($P \leq 0.05$).
Total carbohydrates by difference.
ND: not determined.

1.2. Falling number (FN), glutograph and color degree parameters:

Falling number (FN) test was carried out to measure amylolytic activity in flour (which indicates the alpha amylase enzyme activity). The FN values of WF was 594.26 sec which agreed with the results obtained by Pasha, (2006) who reported that the falling number of pakistani wheats ranged from 243 to 648 sec in fifty different wheat varieties. Significant decrease ($p \leq 0.05$) was noticed by substitution WF with MF (Table 2). This might be indicating that there was higher alpha amylase activity in MF.

Flour color is important, not only as an alternative way of monitoring flour refinement but also as a predictor of color in products. Generally, increasing the substitution levels of MF resulted in a significant ($p \leq 0.05$) decrease in lightness (L*); redness to greenness (a*); hue angle (h*) and total color difference (△E*) value. Meanwhile, increased ($p \leq 0.05$) the yellowness to blueness (b*) and chroma (c*). The decrease in L* value may be attributed to the presence of dark colored flours of millet.

Significant ($P \leq 0.05$) increase in stretching values was noticed between control and the blends substituted with different level of MF. Also, no significant ($p > 0.05$) change was detected in relaxation values between control and up to 30% MF. The significant ($p \leq 0.05$) highest (the maximum value that by glutograph registered) stretching value (304.33 sec.) and relaxation values (87.00 BU) were recorded for the blends of 60% WF+MF40%, while the significant lowest ($p \leq 0.05$) values (184.33 sec. and 55.67 BU, respectively) was detected in control samples.

Table (2): Physicochemical characteristic of wheat/millet flour blends:

Blends	Falling number (sec.)	Color degree						Glutograph		Solvent retention capacity (SRC)			
		L*	a*	b*	c*	h*	ΔE*	Stretching (Sec.)	Relaxation (BU)	H_2O (100%)	Sodium carbonate (5%)	Sucrose (5%)	Lactic acid (5%)
WF (100%)	594.26^{a}	98.03^{a}	-0.24^{a}	-0.02^{e}	0.24^{e}	0.09^{a}	98.03^{a}	184.33^{c}	55.67^{b}	71.20^{a}	82.71^{a}	99.56^{a}	116.09^{a}
90%WF+MF10%	586.10^{ab}	97.96^{b}	-0.31^{b}	0.96^{d}	1.01^{d}	-0.99^{b}	97.97^{b}	242.67^{b}	58.67^{ab}	69.29^{b}	76.41^{b}	99.11^{a}	106.48^{b}
80%WF+MF20%	572.78^{bc}	97.60^{c}	-0.35^{c}	1.61^{c}	1.65^{c}	-1.00^{b}	97.61^{c}	282.00^{ab}	65.67^{ab}	66.80^{c}	74.25^{c}	98.80^{a}	99.57^{c}
70%WF+MF30%	562.92^{c}	97.55^{d}	-0.43^{d}	2.26^{b}	2.30^{b}	-1.00^{b}	97.58^{d}	297.33^{a}	69.00^{ab}	65.39^{cd}	72.70^{cd}	98.30^{a}	95.21^{d}
60%WF+MF40%	545.61^{d}	97.37^{e}	-0.45^{d}	2.63^{a}	2.67^{a}	-1.00^{b}	97.41^{e}	304.33^{a}	87.00^{a}	64.51^{d}	71.46^{d}	97.32^{a}	90.51^{e}
LSD	14.15	0.02	0.03	0.03	0.03	0.07	0.016	39.33	28.91	1.61	1.93	2.34	1.06

Data are mean of three replicates.

Values followed by the same letters in the same column are not significantly different ($p>0.05$).

Where: L*: lightness, a*: redness to Greenness, b*: yellowness to blueness, c*: Chroma, h*: hue angle and ΔE*: total color difference.

The stretching parameter of glutograph (dough strength parameter) strongly corresponds to the following dough strength parameters of the other instruments: Stability (Table 3); resistance to extension, area under the curve, maximum resistance (Table 4). In contrast, the relaxation parameter of the glutograph corresponds more to extensibility and length of curve than to stability, resistance to extension due to their negative correlations. Thus, glutograph dough strength parameters could possibly be used to replace other dough strength parameters obtained from other standard rheological dough.

1.3. Solvent retention capacity profile (SRC):

Water absorption is essential for determining the effect of any additive to wheat flour that might change the dynamics of water in the dough system. Data in Table (2) proposed that a significant ($p \leq 0.05$) decrease was observed in all solvent retention capacity profile (SRC) parameters by increasing the substitution levels of MF. The decrease in sodium carbonate retention might be due to its reaction with the damaged starch in flour which decreased with increasing the substitution levels. The increase in Na_2Co_3 value (compared to H_2O SRC) could be explained by high pH of sodium carbonate which increased the water absorption due to the ionization of the hydroxyl groups of the blends including starch that allows for hydrogen bonding (Gains 2000).

No significant (P>0.05) change in sucrose SRC between WF and WF/MF blend up to 40% substitution. This may be due to its lower levels of pentosans content. Sucrose SRC indicated primarily the pentosan effects and some contribution of the gliadin proteins (Kiszonas *et al.* 2013).

Lactic acid SRC value of control was 116.09% which is gradually decreased by increasing the substituting levels in the blend of MF to reach the significant lowest value of 90.51 in 60% WF+40%MF. These observations are in agreement with the results obtained by Duyvejonck *et al.* (2011) who mentioned that the lactic acid SRC values fluctuated 106.4% to 147.1% for wheat samples with protein content range 10.7% to 14.6%. Lactic acid SRC, didn't affect by total protein (Kiszonas *et al.* 2013) meanwhile, it positively correlated with glutenin content (Colombo *et al.* 2008).

The significant ($p \leq 0.05$) highest distilled water, sodium carbonate, sucrose and lactic acid SRC's values 71.20, 82.71, 99.56 and 116.09%, respectively were recorded by control, while the significant ($p \leq 0.05$) lowest values 64.51, 71.46, 97.32 and 90.51% , respectively were given at 60%WF+40% MF blend.

2. Effect of substituting wheat flour with different levels of millet flour on rheological parameters:

The amount of absorbed water is significant ($p \leq 0.05$) increased as the substitution levels of MF in the WF/MF blend increased. Where by increasing the amount of MF from 30% to 40% substitution, water absorption decreased from 59.5% to 57.8% (Table 3). This observation in full agreement with those reported by Saha *et al.* (2011) and Crassina *et al.* (2012) who reported that water absorption by millet flour is generally lower than that of wheat flour.

The total absorbed water by starch in dough is 45.5%, proteins 31.2% and 23.4% by pentosans. Thus, water absorbation may not be directly related to gluten strength and may be influenced more by other factors such as starch damage and pentosans contents. Differences in water absorption might also be related to differences in chemical and protein composition (Markowski *et al*. 2006).

Table (3): Farinograph parameters of blends of wheat/millet flour blends:

Property	MF levels (%)					
	0	10	20	30	40	LSD
Water absorption (%)	59.90^{a}	57.13^{b}	56.63^{c}	56.23^{d}	55.30^{e}	0.23
Dough development time (min)	9.63^{a}	8.90^{a}	9.37^{a}	1.87^{b}	1.43^{b}	0.74
Dough stability (min)	16.57^{a}	15.83^{a}	14.97^{b}	12.83^{c}	12.07^{c}	0.82
Mixing Tolerance index (BU)	11.00^{b}	17.33^{ab}	26.33^{a}	10.67^{b}	16.67^{ab}	9.71
Time to breakdown (BU)	19.50^{a}	16.90^{b}	15.03^{c}	12.20^{d}	11.63^{d}	1.61
Flour quality number	195.00^{a}	169.00^{b}	150.33^{c}	122.00^{d}	116.33^{d}	16.10

Data are mean of three replicates. Values followed by different letters in the same row are significantly different ($p \leq 0.05$).

Table (4): Extensograph parameters of blends of wheat/millet flour blends:

Property	MF levels (%)						Time (min.)			
	0	10	20	30	40	LSD	45	90	135	LSD
E_x (mm)	177.78^{a}	159.00^{b}	154.00^{b}	148.22^{bc}	141.00^{c}	8.96	152.87^{a}	160.80^{a}	154.33^{a}	11.35
R_{50} (B.U.)	465.00^{a}	487.33^{a}	466.89^{a}	419.56^{b}	415.67^{b}	27.90	432.20^{b}	478.93^{a}	441.53^{b}	25.93
R_m (B.U.)	683.22^{a}	699.67^{a}	687.56^{a}	584.89^{b}	512.00^{c}	56.72	564.20^{b}	678.20^{a}	658.00^{a}	59.39
Energy (cm^3)	163.11^{a}	147.11^{b}	138.11^{b}	115.22^{c}	100.78^{d}	12.91	120.47^{b}	145.53^{ab}	132.60^{a}	17.98
R/E_x Ratio	2.61^{b}	3.09^{a}	3.03^{a}	2.81^{ab}	2.98^{a}	0.24	2.84^{a}	3.00^{a}	2.87^{a}	0.22

Data are mean of three replicates. Values followed by different letters in the same row are significantly different ($p \leq 0.05$).
Where: E_x: extensibility, R_{50}: Resistance to Extension, R_m: maximum resistance.

No significant (*p*>0.05) change in dough development time was observed between WF and that substituted with MF up to 20%, while, significant (*p*≤0.05) decrease was observed by increasing the substitution up to 40%. This may be due to competition for water and consequent delayed development of the gluten network (Jacobs *et al.* 2008 and Rieder *et al.* 2012).

Dough stability time (DST) did not significant (*p*>0.05) change by replacing WF with MF up to 10%. Meanwhile, a significant (*p*≤0.05) decrease in DST was detected up to 20 and 30% MF substitution. The highest dough stability values were 16.57 and 15.83 min detected in WF and that substituted with MF up to 10%. The decrease in stability with the increasing replacement levels of MF in the blends may be attributed to the dilution or weakening of the gluten matrix (Crassina *et al.* 2012). The higher value of stability time was confirmed by the increase of wet gluten (Table 1). These observations are in agreement with the results obtained by Marco and Rosell (2008) who found that the high stability values are usually related to the strength of flour.

Generally, no significant (*p*>0.05) change in MTI was observed between control and that substituted with up to 10% MF. Data also showed that significant (*p*≤0.05) reduction difference in Time to breakdown and farinograph quality number (FQN) was observed between control and substitution with MF at different level. Higher FQN, in general, indicates strong flour with better stability, as it is supported by the stability data (Bojňanská *et al.* 2013).

Extensograph properties of all dough samples were found to be dependent on level of substitution and proving time (Table 4). For regarding substitution levels, Significant (*p*≤0.05) decrease was detected in extensibility (Ex) and energy (E) between WF and that substituted with MF; Meanwhile, significant increase (*p*≤0.05) in R/E_x Ratio, may be attributed to the polymeric protein structure. Extensibility decreased from 177.78 to 141.00 mm when wheat flour was replaced with 40% of MF, this is in agreement with the report of Saha *et al.* (2011).

Generally, no significant (*p*>0.05) differences in resistance to extension (R_{50}) and maximum resistance (R_m) were detected between WF and substitution up to 20% MF. Weipert (2006) stated that the dough with R/E ratio of 1.5 to 3.0 is thought to be of good quality, and could provide higher final baked volume.

Regarding rest time in Table 4, increasing the experimental time (from 45-135 min) had no significant (*p*>0.05) change in E_x. While, significant (*p*≤0.05) increase was detected in R_{50} between 45 to 90 min.

The dough R_m was significantly (*P*≤0.05) increased with increasing resting time. At the same time, increasing the experimental time (from 45-90 min) showed no significant (*p*>0.05) changes in energy and R/E_x Ratio. The statistical analysis revealed that the best rest time was 90 min, while worst at 45min.

3. Baking properties of pan bread formulated with WF and different levels of MF:

3.1. Physical properties:

The physical characteristics (weight, loaf volume and specific volume) are an elementary prediction of quality of pan bread, the dough and pan bread formulated with the different levels of MF (Table 5).

Generally, no significant (*p*>0.05) change in loaf weight, loaf volume and specific volume were found between WF and bread substituted with MF at 10%. Meanwhile, pan bread formulated with more than 10% MF had a higher (*p*≤0.05) weight compared with control, which

Table (5): Physical characteristic and color attributes of pan bread formulated with different levels of Millet flour (MF):

Blends	Physical parameters			color of pan bread											
				Crust						Crumb					
	loaf weight (g)	loaf volume (cm^3)	specific volume (cm^3/g)	L*	a*	b*	c*	h*	ΔE*	L*	a*	b*	c*	h*	ΔE*
Control	132.40^{c}	1025.00^{a}	7.74^{a}	57.74^{e}	17.82^{a}	30.99^{a}	35.75^{a}	0.94^{a}	67.91^{d}	83.06^{b}	-1.61^{c}	9.24^{d}	9.39^{d}	-1.00^{a}	83.59^{c}
90%WF+MF10%	136.73^{bc}	1042.50^{a}	7.64^{a}	60.49^{d}	16.32^{d}	29.20^{b}	33.45^{d}	0.95^{a}	69.12^{c}	83.63^{a}	-1.51^{c}	10.41^{c}	10.51^{c}	-1.00^{a}	84.29^{b}
80%WF+MF20%	138.80^{ab}	975.00^{b}	7.02^{b}	61.77^{c}	16.95^{b}	29.16^{b}	33.73^{b}	0.94^{a}	70.38^{b}	83.74^{a}	-1.48^{c}	11.01^{c}	11.11^{c}	-1.00^{a}	84.47^{b}
70%WF+MF30%	139.68^{ab}	968.75^{b}	6.93^{b}	62.42^{b}	16.93^{b}	29.08^{b}	33.65^{c}	0.94^{a}	70.46^{b}	83.78^{a}	-1.23^{b}	12.32^{b}	12.38^{b}	-1.00^{a}	84.69^{ab}
60%WF+MF40%	142.80^{a}	925.00^{c}	6.48^{c}	63.28^{a}	16.63^{c}	28.57^{c}	33.13^{e}	0.94^{a}	71.43^{a}	84.01^{a}	-1.06^{a}	13.34^{a}	13.38^{a}	-1.00^{a}	85.07^{a}
LSD	4.99	26.52	0.38	0.16	0.04	0.14	0.03	0.01	0.15	0.48	0.13	0.63	0.62	0.00	0.41

Data are mean of four replicates for physical parameter and of six replicates for bread color.
Values followed by different letters in the same column are significantly different ($p \leq 0.05$).
Where: L*: lightness, a*: redness to Greenness, b*: yellowness to blueness, c*: Chroma, h*: hue angle and ΔE*: total color difference.

caused a reduction in bread quality gradually as well as, the dough was too dry and firm, and a more irregular structure with most gluten layers without a continuous distribution and surrounded by large starch granules, which might be probably due to a gluten dilution effect and/or the increase of alkaline-insoluble protein, which is strongly linked with dough mixing poor quality (Swec and Hruskova 2010; Regine *et al.,* 2013; Monika *et al.,* 2015 and Mamata 2015).

3.2. Crust and crumb color of pan bread:

Significant ($P \leq 0.05$) increase was detected in L* and ∆E* by increasing MF; which means an increase in crust lighteness when the millet concentration was raised (Table 5). Results indicated that the crumb lightness (L*) of breads became lighter ($p \leq 0.05$) when higher levels of MF were incorporated into breads, the highest L* value (84.01) was detected at up to 40% MF. This may be due to creamish white color of pearl millet flour and/or decreased starch damage and/or higher alpha amylase activity. Similar findings were reported by Sharma and Gujral (2014) and Basman and Koksel (2001) who demonstrated that the incorporation of barley flour to wheat flour increased the lightness (L*) and yellowness (b*) during Turkish flat bread preparation. Also, significant ($p \leq 0.05$) increase in b*, c*, and ∆E*. At the same time, no significant ($p > 0.05$) affect in a* between WF and up to 20% MF and up to 40% for h*.

3.3. Texture Profile Analysis parameter:

Texture profile analysis (TPA) is a very useful technique for investigating food products. No significant ($p > 0.05$) difference was detected in hardness, adhesiveness, gumminess and chewiness between WF and the substituted with different levels of MF, While springiness, cohesiveness and resilience up to 30% MF (Table 6).

On the other hand, the hardness, gumminess and chewiness values significantly ($p \leq 0.05$) increased by increasing the storage time (six day). Meanwhile, cohesiveness and resilience decreased ($p \leq 0.05$). Data also showed that no difference ($p > 0.05$) in adhesiveness and springiness between freshly prepared bread and after four to six days storage, respectively. This may be attributed to the low moisture levels and / or caused harder and denser crumb structure breads with increasing storage time by change the quality of protein in the WF+MF bread system. Such data are in line with those obtained by Crassina *et al.* (2012); Ballolli *et al.* (2014) and Bhol and Sowriappan (2014).

The values of the maximum cohesiveness are higher in case of WF (0.54s). Such data are in line with those obtained by Saha *et al.* (2011) who mentioned that the increased gluten content in wheat flour increased the cohesive property of the dough and due to the plasticity of gluten.

3.4. Sensory characteristics:

No significant ($p > 0.05$) changes in symmetry shape, crumb color and mouth feel were noticed between WF and up to 30% MF (and up to 40% of crust color); While, break and shred, crumb texture and taste had no changes ($p > 0.05$) up to 20% (Table 7 and Figure 1). Meanwhile, significant ($p \leq 0.05$) decrease was detected in aroma by increasing MF. The arbitrator's acceptance to control was like very much, while substitution up to 20% was like moderately and at 30 and 40% was like slightly.

Wheat flour substituted with different millet flour levels was identified in a previous work (Angioloni and Collar 2012a) and corresponds to the maximum tolerated levels of non-wheat cereals to produce sensorial accepted breads.

Table (6): Texture profile of pan bread formulated with different levels of Millet flour (MF) blends of wheat flour (WF):

Property	MF levels						Storage time (Day)*				
	0%	10%	20%	30%	40%	LSD	0	2	4	6	LSD
Hardness (N)	6.01[a]	4.77[a]	7.14[a]	5.61[a]	8.64[a]	2.77	1.77[d]	4.41[c]	8.41[b]	11.15[a]	1.17
Adhesiveness (N.s)	-0.24[a]	-0.09[a]	-0.29[a]	-0.11[a]	-0.66[a]	0.61	-0.11[a]	-0.19[a]	-0.68[a]	-0.15[a]	0.54
Springiness (mm)	0.88[a]	0.88[a]	0.86[ab]	0.85[ab]	0.82[b]	0.03	0.88[a]	0.88[a]	0.85[a]	0.82[b]	0.03
Cohesiveness (s)	0.46[a]	0.46[a]	0.43[ab]	0.41[ab]	0.38[b]	0.05	0.54[a]	0.41[b]	0.39[b]	0.37[b]	0.04
Gumminess (N)	2.66[a]	2.06[a]	2.82[a]	2.15[a]	2.92[a]	1.00	0.95[d]	1.77[c]	3.16[b]	4.21[a]	0.43
Chewiness (Nm)	2.34[a]	1.79[a]	2.38[a]	1.80[a]	2.37[a]	0.83	0.84[d]	1.56[c]	2.68[b]	3.47[a]	0.38
resilience	0.27[a]	0.27[a]	0.23[ab]	0.22[ab]	0.19[b]	0.06	0.36[a]	0.20[b]	0.20[b]	0.19[b]	0.03

Storage conditions: Zero time, after cooling at room temperature (25 ± 2.0 °C) and kept in transparent double zipper, Ziploc® bags, and stored for 6 days at room temperature (25 ± 2.0 °C),
Data are mean of four replicates.
Values followed by different letters in the same row are significantly different ($p \leq 0.05$).

Table (7): Sensory characteristic of pan bread formulated with different levels of Millet flour (MF) blends of wheat flour (WF):

Blends	Symmetry shape	Crust color	Break and shred	Crumb texture	Crumb color	Aroma	Taste	Mouth feel	Acceptability
WF (100%)	8.00^{a}	8.00^{a}	8.09^{a}	8.00^{a}	8.36^{a}	8.27^{a}	8.18^{a}	7.91^{a}	8.10^{a}
90%WF+MF10%	8.00^{a}	7.73^{a}	7.82^{a}	7.45^{ab}	8.00^{a}	7.64^{b}	7.73^{ab}	7.82^{a}	7.77^{ab}
80%WF+MF20%	7.82^{a}	7.64^{a}	7.73^{ab}	7.45^{ab}	7.91^{a}	7.55^{b}	7.64^{ab}	7.73^{a}	7.68^{b}
70%WF+MF30%	7.45^{ab}	7.54^{a}	7.09^{bc}	7.18^{b}	7.73^{a}	7.00^{c}	7.36^{bc}	7.36^{ab}	6.34^{d}
60%WF+MF40%	7.09^{b}	7.18^{a}	6.73^{c}	6.27^{c}	6.73^{b}	6.64^{c}	6.91^{c}	6.91^{b}	6.81^{c}
LSD	0.61	0.80	0.64	0.74	0.64	0.51	0.70	0.75	0.36

Data are mean of four replicates.

Values followed by different letters in the same column are significantly different ($P \leq 0.05$).

Fig. (1): Pan bread prepared by replacing wheat flour with different levels of millet flour.

CONCLUSION

Substitution of wheat flour with MF up to 10% did not affect significantly (*p*>0.05) on chemical and rheological attributes of dough wet gluten, dough development time, stability time, while sensory characteristics of formulated pan breads were acceptable even at 30% substitution level. In this context, the unique technological characteristic of millet deserves special attention for substitution, at least in the traditional cereal-based products.

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"تقييم خبز القوالب المعد بإستبدال دقيق القمح بدقيق الدخن"

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الملخص العربى

هدفت الدراسة الي معرفة تأثير استبدال دقيق القمح بنسب مختلفة من دقيق الدخن على الخصائص الكيميائية والفيزيوكيميائية والريولوجية وجودة خبز القوالب الناتج. أدى الاستبدال من 10 الى 40% إلى زيادة معنوية في محتوى البروتين (14,08 الى 14,32%) والدهن (1,43 الى 2,56%) والألياف (1,38 الى 2,36%) وقيم stretching بينما إنخفض محتوى الكربوهيدرات الكلى والجلوتين الرطب والجلوتين الجاف وقيم قدرة الدقيق على الإحتفاظ بالمذيبات وقيم L*، ∆E* للون الدقيق وفترة ثبات العجين ونسبة امتصاص الماء . أشارت النتائج إلى أن الإستبدال بنسبة 10% لم يؤثر معنويا على الخصائص الفيزيائية والقبول العام لخبز القوالب. وبصفة عامة أدي زيادة نسبة الاستبدال الي زيادة معنوية ايجابية فى قيم L* لقشرة ولبابة الخبز. في حين أدي الاستبدال بنسبة 40% الي زيادة قيم b*, c*, ∆E* بينما لم يؤثر معنويا على قيم الالتصاق والتصمغ و المضغ. في حين أن الاستبدال بنسبة 30% لم يؤثر معنويا على قيم الصلابة والزنبركية والتماسك والرجوعية. كما أدت زيادة فترة التخزين (عند 25°م ± 2) لمدة 6 أيام الى تدهور فى قيم الصلابة والتصمغ والمضغ.

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