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The Impact of Milling, Steaming and Microwave Heat Treatments on Physicochemical Properties of Wheat Bran and dough Empirical Rheology

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ABSTRACT: Wheat bran (WB) is used in bread formulation to improveitsnutritional values.The objective of this study was to investigate the modification processes such as micronization, microwave and steaming processes of WB on bran and dough characteristics. Size reduction increased lightness of WB (48.23 to 58.67) while b*, ΔE, hue, chroma, whiteness and yellowness values decreased. Control and very fine bran showed the highest and lowest values for water holding capacity from 743.99% and 478.35% respectively. WB additions increased water absorption of dough from 59.8 to 63.1%. Development time reduced (1.7 to 1.3) while dough stability increased (2.6 min to 4.2) by WB size reduction. As coarse WB added, dough extensibility and extension decreased from 67 to 46 cm^2 and 153 to 138 mm respectively. Fine WB decreased dough energy (42 cm^2). Steaming process reduced phytic acid content (0.68mg/g) and increased dough resistance to extension (251 HE).

Keyword: Flour, Wheat bran, Micronization, Microwave treatment, Steaming.

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INTRODUCTION

Wheat bran is now used by baking industry as a major source of dietary fiber (Vetter 1988). There are evidences that confers wheat bran (WB) metabolic benefits, reduces the risk of chronic, development of diabetes type 2, improve glycemic control, reduction of the cholesterol levels and the risk of colon cancer (Anderson, 1991; Liu *et al*. 1999; Chandalia *et al*. 2000; Pereira *et al* 2002; Tavani *et al*., 2003).WB is a by-product of roller milling during the milling process of wheat grain. Wheat milling process especially for low extraction rate flours produces large amounts of bran, which contains about 45-53% dietary fiber (Majzoobi *et al.,* 2012). In this process, outer pericarp of wheat together with adherent aleurone layer is separated from the endosperm. These layers contain insoluble dietary fibers and low soluble fibers including xylans and beta-glucans, non-gluten proteins, enzymes, phenolic compounds, lignans, vitamin E, vitamin B, minerals, phytic acid, lipids, and different plant sterols (Chalamacharla *et al* 2018). Despite the health benefits, the presence of external parts of grain and germ in flour has adverse effects on the dough and bread properties. Incorporating WB into flour decreases loaf volume (Noort *et al*., 2010; Gomez *et al*., 2011), produces less desirable appearance, taste and sensory properties and increases product hardness (Pomeranz *et al*., 1977; Yadav & Rajan, 2012; Sobota *et al*., 2015). Due to these reasons, in spite of knowledge about bran benefits, most consumers prefer bakery products of refined white flour to whole wheat products or supplemented bread with bran; because of perceive on textural properties, appearance and taste of WB enriched bread and bakery products are less attractive (Boz and Karaoglu, 2013). Therefore, it is necessary to use physical, chemical and biological treatments to eliminate the adverse properties of bran and increase the tendency of customers for high fiber products (Peressini and Sensidoni 2009). For this purpose, different processes such as size reduction and milling (Onipe *et al* 2017, Gan *et al* 1992), heat treatment (De. kock *et al* 1999), pre-fermentation (Messia, *et al*. 2016), extrusion (Gomez *et al* 2011), pre-hydration and cultivar selection (Nelles *et al* 1998) for were investigated for improvement of bran properties. Particle size Reduction changes physical, chemical and functional properties of the WB (Zhu *et al*., 2011). WB contains high amount of polysaccharides which bind water through the formation of hydrogen bonds which lead to significant water absorption in high extraction rate wheat flours.

However, the mechanism behind water absorption varies with the particle size distribution of WB. Functionality of bran in bread is usually evaluated by dough or bread characteristics. Bran addition to flour formulation caused detrimental change on dough properties fermentation, gas retention, bread-loaf volume, dough texture and consistency (Zhang & Moore, 1999). Furthermore, the performance of bran in dough is deepened onthe quality and/or strength of flour used and the cultivar origin of the flour and/ or bran used (Hemdane *et al*., 2016). The aim of this study was to determine the effect of bran size reduction and heat treatment processes on phytic acid content, water holding capacity, bulk and tapped density and color attributes as well as farinograph and extensograph parameters of dough and final bread product in order to find the best treatment for WB modification.

MATERIALS AND METHODS

Wheat bran and flour was kindly obtained from a local mill (Khoshe-Talaei Co., Shiraz, Iran). Wheat vital gluten was obtained from Faradaneh Co. (Shriaz, Iran). Chemical composition ofWheat bran was as follow: moisture content of 10.8%, crude protein content of 17.0%, dietary fiber of 45.5%, and ash content of 6.4%. Wheat flour had the following specifications: moisture content: 11.8 %, protein content: 11.2%, wet gluten: 28.2%, ash content: 0.55%, falling number: 280 s and Zeleny sedimentation value of 26 cc.

A. Wheat bran milling

Wheat bran was milled using a laboratory mill (Toosshekan, Mashhad, Iran) with rotational speed of 20000 rpm. The milling process was stopped every 60 s to prevent possible overheating during milling. In every stop fine particles were separated by sieving. Coarse bran particles or raw bran were then fed again to the mill for further size reduction(used nomenclatures are shown in Table 1). Particle size distribution determined using a vibratory sieve shaker (WS Tyler, Cleveland, US) equipped with different size screens (20, 40, 60, 80, 100, 120 and 230) after 15 min. Particle size distribution of control bran, wheat flour and milled bran is shown in Table 2 and 3.

Table 1: Nomenclature used.

Symbol	Treatment
Wheat flour (WF)	Bread Sample whit out bran
Control bran (C)	Bran without any treatment
Coarse Bran (CB)	Bran milled and separated by sieve No 20 (particle size smaller than 1 mm)
Medium bran (MB)	Bran milled and separated by sieve No 40 (particle size smaller than 0.5 mm)
Fine bran (FB)	Bran milled and separated by sieve No 60 (particle size smaller than 0.25 mm)
Very fine bran(VFB)	Bran milled and separated by sieve No 80 (particle size smaller than 0.125 mm)
SB-5	Bran steamed by autoclave for 5 min
SB-10	Bran steamed by autoclave for 10 min
MW-5	Bran toasted by microwave for 5 min
MW-10	Bran toasted by microwave for 10 min

Table 2: Particle size distribution of milled WB.

Particle size	VFB	FB	MB	CB	C
x>0.850 mm	0±0	0±0	0±0	1.39±5.49	1.38±17.09
850µ>x>425µ	0±0	0±0	1.49±11.85	3.38±42.17	1.42±13.87
425µ>x>250µ	0±0	0.52±9.18	3.42±45.84	1.99±25.00	0.76±17.42
250µ>x>180µ	1.72±40.94	1.64±41.87	2.82±24.21	0.74±015.13	0.77±14.58
180µ>x>150µ	1.15±18.29	1.45±15.06	0.71±5.86	0.31±4.86	0.53±10.74
150µ>x>125µ	2.32±20.51	2.15±13.19	0.48±8.84	0.95±3.69	0.30±14.89
125µ>x>63µ	1.03±20.20	1.73±17.26	0.27±3.35	0.87±3.24	0.54±7.56
63µ>x	0.04±0.07	0.25±3.45	0.03±0.06	0.49±0.42	0.12±3.95
total	100	100	100	100	100

Table 3: Particle size distribution of microwave and steaming treated WB.

Particle size	WF	SB-10	SB-5	MW-10	MW-5
x>0.850 mm	0±0	0±0	0±0	0±0	0±0
850µ>x>425µ	0±0	0±0	0±0	0.25±5.22	0.50±6.43
425µ>x>250µ	0.29±4.76	8.20±5.88	1.14±10.29	0.66±9.92	0.66±12.15
250µ>x>180µ	1.48±19.37	43.2±4.88	1.89±41.51	1.12±31.30	2.11±37.18
180µ>x>150µ	4.03±45.89	1.46±18.93	0.55±17.50	0.51±13.01	0.89±13.50
150µ>x>125µ	2.02±24.74	0.60±9.44	0.68±10.53	0.17±10.83	0.56±5.31
125µ>x>63µ	0.86±3.99	0.95±16.99	0.56±16.79	0.89±27.27	1.97±22.44
63µ>x	0.48±1.24	0.10±3.24	0.77±3.39	0.21±2.46	0.61±2.98
total	100	100	100	100	100

Milled bran samples were packed in airtight polyethylene bags and stored at -20ºC for further characterization.

B. Microwave and Steaming treatment

For microwave heating treatment wheat bran samples (moisture adjusted to 15%) were heated in batches of 150 g in a microwave oven (wavedom, LG Microwave, South Korea) with an internal volume of 20 L, and power of 850 W. During the heating process, the bran was frequently homogenized at 1 min intervals with a spoon to avoid burning and formation of hot spots. Steaming is applied with a batch of 150 g in a laboratory autoclave (MEGA, Kavosh, Iran) with an internal volume 10 L by use of a autoclave bags at 121 ºC. The wheat brans heated for 5 and 10 min. Then, SWB samples were cooled down in the tray about 30 min to reach room temperature and packed in airtight polyethylene bags and stored at -20ºC for further characterization.

C. pH and moisture content

The pH value of fermented bran was measured from analiquot of 10 g of fermented bran blended with 100 mL of distilled water (CG 824 pH meter, Germany). Moisture content was determined according to ICC method 109/ 1 (ICC, 1995).

D. Bulk and packed densities measurement

Bulk and packed densities of WB were measured according to the method described by Prakongpan *et al*. (2002). For bulk density measurement, an empty measuring cylinder (50 mL) was weighed. First, it was filled with WB sample and after a gentle shaking, the volume of bran was obtained. Then, the weight of the filled cylinder with bran was measured. Bulk density was calculated from the following Equation:

$$\text{Bulk density (g/mL)} = \frac{\text{Bran weight}}{\text{Bran volume}} \quad \ldots(1)$$

For tapped density, an exact amount of *2* g WB was filled in a measuring cylinder (10 mL) followed by manual tapping of WB until no further volume reduction was occurred. The packed volume was read and bran packed density was obtained using the following Equation:

$$\text{Packed density (g/mL)} = \frac{\text{Bran weight}}{\text{Packed volume}} \quad \ldots(2)$$

E. Fiber color determination

Color determination of NC was carried out on bread crust using a Minolta Colorimeter (CM 2600 d, Minolta Co., Osaka, Japan) L* measures lightness from black to white (0-100); a* indicates red (+) to green (–); while b* measures yellow (+) to blue (–). The total color difference (ΔE) was calculated as follows:

$$\Delta E_{L^* a^* b^*} = \sqrt{[(L^* - L^*_0)^2 + (a^* - a^*_0)^2 + (b^* - b^*_0)^2]} \quad \ldots(3)$$

Where, zero indices refer to color parameters of control (flour) bran samples.

The hue angle (expressed in degrees; 0° for red, 90° for yellow, 180° for green and 270° for blue), chroma, whiteness and yellowness indices were calculated from the following formula:

$$\text{Chroma} = \sqrt{(a^*)^2 + (b^*)^2} \quad \ldots(4)$$

$$\text{Whiteness index} = 100 - \sqrt{(100 - L^*) + (a^*)^2 + (b^*)^2} \quad \ldots(5)$$

$$\text{Yellowness index} = \frac{142.86 \times b^*}{L^*} \quad \ldots(6)$$

F. Measurement of water holding capacity (WHC)

Water holding capacity of WB was determined according method described by method of Raghavendra *et al*. (2004) with slight modification as follows. Dry WB (approximately 1 g) was weighted in to a 50 mL graduated test tube to which ca. 30 mL distilled water was added. The tube was closed and kept rotating for 24 hr. at ambient temperature, then centrifuged for 1 h at 14000 g at 20 ºC. The supernatant was filtered off on a paper towel. Hydrated residue was weighed and then dried at 105 °C for 2 h and bran WHC was dtermined using the following Equation:

$$\text{WHC}(\%) = \frac{\text{Residue hydrated weight} - \text{Residue dry weight}}{\text{Residue dry weight}} \times 100 \quad \ldots(7)$$

G. Phytic acid content

Phytic acid content was determined according to method described by Garcia-Estepa *et al*. (1999). To do this, 5.0 g of grounded bran samples was extracted with 40.0 ml of extraction solution (10 g/100 g Na_2SO_4 in 0.4 mol/l HCl) for 3 h at ambient temperature. The suspension was centrifuged at 4000 rpm for 30 min and the supernatant was filtered. An amount of 10.0 ml supernatant with 10.0 ml of 0.4 mol/l HCl, 10 ml of 0.02 mol/l $FeCl_3$ and 10.0 ml of 20 g/100 g sulphosalicylic acid were pipetted into a centrifuge tube and shacked gently. The tube was sealed and placed in a boiling water bath for 15 min fallowed by cooling down to room temperature. The sample was then centrifuged at 4000 rpm for 10 min. Decanted, filtered and the residue was washed with small volumes of distilled water. The supernatant and washed fractions were diluted to 100.0 ml. One aliquot (20.0 ml) adjusted to pH 2.5±0.5 by addition of glycine was diluted to 200 ml. The solution was heated at 70±80 ºC and, whilst still warm, titrated with 50 mmol/l EDTA solution. The 4:6 Fe/P atomic ratio was used to calculate phytic acid content.

H. Farinograph test

The addition of wheat bran affects the dough consistency during mixing. Therefore, the required water absorption for comparable dough consistencies in the bread-baking test was determined. The effects of addition of wheat bran on mixing and dough development were evaluated.

According to method described by AACC method 54-21.02 (American Association of Cereal Chemists, 2000) based on constant flour weight by a A Flourgraph E6 from HAUBELT (Laborgeräte GmbH, Berlin, Germany).

I. Extensograph test

The extensibility properties of dough were measured according to AACC method 15.10.01. American Association of Cereal Chemists (2000) by using Flourgraph E7 from HAUBELT (Laborgeräte GmbH, Berlin, Germany). Proving time for the test were 45, 90 and 135 min.

J. Data analysis

Each experiment was replicated at least three times (three or more independent batches were baked with 12 loaves per batch). Collected data analyzed by analysis of variance (ANOVA) followed by least significant difference test (LSD) and the Duncan test by SPSS software (Version 16.0, SPSS Inc., Chicago, IL, USA). Evaluations were based on the $P<0.05$ significance level.

RESULTS AND DISCUSSION

A. Color properties of wheat bran

Wheat bran colors properties affected significantly by size reduction ($p>0.5$). In comparison with wheat flour (WF), all WB samples had lower L* and higher a* and b* values. L*, a* and b* values for control WB (C) was 49.92, 4.72 and 13.8 and for the fine WB (VFB) was 58.67, 4.66 and 10.83 respectively (Table 4). Colors parameters data indicated that reduction of particle size had increasing effect on lightness, a*, hue angle and whiteness decreasing effect on b* and yellowness values of WB. Variation of particle size can notable change the color characteristics of materials, typically when particle size is smaller; less light is absorbed so results in less color. Increased surface area as particle size decreases, leads to increased light reflection (Duran and Calvo 1997). The same results reported by Onipe *et al* (2017). The results showed that Heat treatment reduced L* and increased b*, chroma and yellowness values rather than FB. The longer heat treatment of WB led to lower L* and whiteness and higher a*, b*, ΔE chroma and yellowness. By increasing the tests treatment time from 5 to 10 min chroma and yellowness increased from 15.59 and 46.45 to 17.72 and 56.51 for microwave and 16.89 and 52.97 to 19.67 and 67.75 for autoclave and whiteness decreased from 82.78 to 80.74 for microwave and 81.54 to 78.87 for autoclave treated WB respectively. According to results, size reduction and shorter heating time had better WB fibers colors parameters. Color change in heat treated samples may be due to development of the Maillard and Caramelization (Abdul- Hamid *et al.* 2007; Garcia *et al*, 2012).

B. Bulk and tapped density

The results in Table 5 show that there is a reverse correlation between WB particle size and both bulk and tapped densities. As WB particle size decreased, both bulk and tapped density values increased significantly ($p<0.05$) from 0.29 and 0.39 gr/ml to 0.38 and 0.53 gr/ml respectively.

Table 4: Effect of micronization, microwave heating and steaming wheat brans color parameters.

Sample	L*	a*	b*	ΔE	hue	Chroma	Whiteness	Yellowness
WF	63.45±0.46	-0.12±0.67	8.5±0.74	0.85±0.34	30.54±99.73	8.51±0.76	89.55±0.61	19.12±1.53
C	49.92±0.82	4.72±0.67	13.8±0.68	15.34±0.72	71.04±3.39	14.6±0.42	83.77±0.4	39.52±2.55
CB	48.23±0.97	2.99±0.54	13.39±0.65	16.3±0.9	77.4±2.38	13.73±0.62	84.5±0.55	39.69±2.36
MB	54.43±0.77	4.25±0.7	12.05±0.59	10.66±0.91	70.55±3.36	12.79±0.53	85.53±0.5	31.65±1.95
FB	55.65±0.96	3.52±0.79	12.98±1.09	9.76±1.05	74.67±4.15	13.47±0.92	84.97±0.85	33.35±3.38
VFB	58.67±0.33	4.66±0.31	10.83±0.21	7.17±0.08	66.71±1.04	11.79±0.31	86.57±0.26	26.36±0.41
MW-5	46.68±1.01	3.6±0.73	15.16±0.96	18.45±1.18	76.68±2.21	15.59±1.05	82.78±0.96	46.45±3.7
MW-10	43.29±1.28	4.58±0.84	17.11±0.93	22.45±1.25	75.08±1.91	17.72±1.11	80.74±1.02	56.51±3.55
SB-5	44.37±0.7	3.81±0.52	16.44±0.85	21.04±0.92	76.93±2.08	16.89±0.78	81.54±0.73	52.97±3.47
SB-10	40.34±0.53	4.58±0.71	19.12±0.73	25.87±0.84	76.56±1.89	19.67±0.79	78.87±0.74	67.75±3.41

Table 5: Physicochemical properties of flour and micronized, microwaves and steamed wheat brans.

Sample	Moisture content (%)	pH	Balk density(g/ml)	Tab density(g/ml)
Wheat flour	11.87±0.82	6.95±0.30	0.51±0.02	0.64±0.02
C	8.84±0.39	5.67±0.37	0.29±0.02	0.39±0.02
CB	7.62±0.79	5.71±0.22	0.29±0.03	0.41±0.03
MB	9.26±0.29	5.94±0.49	0.36±0.03	0.45±0.01
FB	8.47±0.44	5.81±0.46	0.42±0.02	0.52±0.02
VFB	7.78±0.25	5.73±0.35	0.38±0.01	0.53±0.03
MW-5	9.14±0.46	6.33±0.46	0.44±0.01	0.55±0.01
MW-10	8.90±0.32	6.67±0.27	0.35±0.01	0.47±0.03
SB-5	7.91±0.78	6.20±0.26	0.35±0.01	0.47±0.02
SB-10	8.64±0.52	6.80±0.17	0.51±0.02	0.64±0.02

Packed density is bulk density attained after mechanical tapping. Due to the relative particle motion, the particles rearrange themselves and fill up the voids in the powder bed, resulting in higher particle packing. The bulk density of powder is dependent on particle size distribution. It has been experimentally demonstrated that both bulk and tapped density are highly relatedto surface-volume mean particle diameter and the content of fines (Abdullah and Geldart 1999; Santomaso *et al.*, 2003). Heat treatment by microwaving and steaming differently affected WB density. Short term heat treatments (for 5 min) did not significantly affected ($p<0.05$) the bulk and packed density values. However, longermicrowave treatment time(for 10 min) decreased both bulk and tab density values form 0.44 and 0.55 to 0.35 and 0.47. Also, bulk and tapped density values and increased from 0.35 and 0.47 to 0.51 and 0.64 respectively after 5 and 10 min steaming treatment.

C. Water holding capacity

Hydration is one of important physical properties of fibers and wheat bran. The results showed that all WB samples had higher water holding capacity than wheat flour (Fig. 1). WHC Significantly decreased as WB size reduced ($p<0/05$). WHC for C was 743.9% that decreased to 478.7% in VFB samples. Steam treatment of wheat bran had no effect on WHC while microwave samples had higher WHC than FB (632.8 and 628.3% for MW-5 and MW-10% respectively).

Macro scale, micro-nanoscale and molecular level are three mechanisms of water retention of wheat bran particles. On macroscale water retention is ascribed to filling of void spaces in between bran particles, which arise from random stacking of bran particles. The pericarp cells provide sites for water retention on microscale and capillary mechanisms are involved on nanoscale. These three mechanisms contribute to water uptake of wheat bran in water holding capacity test. Because of higher space between bran with larger particle sizes, it can retain more water content rather than smaller particle size. Also, the result of bulk and tapped density can confirm higher porosity in bran particle with bigger size. When bran is exposed to an external stress like mixing force, only the water strongly bound in nano-pores or through hydrogen bonds will govern water retention. This mechanism explains the lower difference between water absorption in bigger size ofparticle bran in farinograph test. During mixing and kneading, WB is exposed to hygroscopic forces by different flour components which allow WB to pick up water molecules, and this is strongly bound to WB through formation of hydrogen bond. Therefore, stacking phenomena and micropores do not contribute to hydration, since water bound through these mechanisms is bound weakly, and therefore released in the presence of the external forces. (Chapin 2003, Jacob *et al* 2015, Onipe *et al*., 2017).

D. Phytic acid content

The phytic acid content of the samples are presented in Fig. 2. Wheat flour and control bran had 0.466 and 0.907 mg/100g phytic acid respectively. Micronization treatments had no significant effect on phytic acid content while heat treatment reduced phytic acid content.

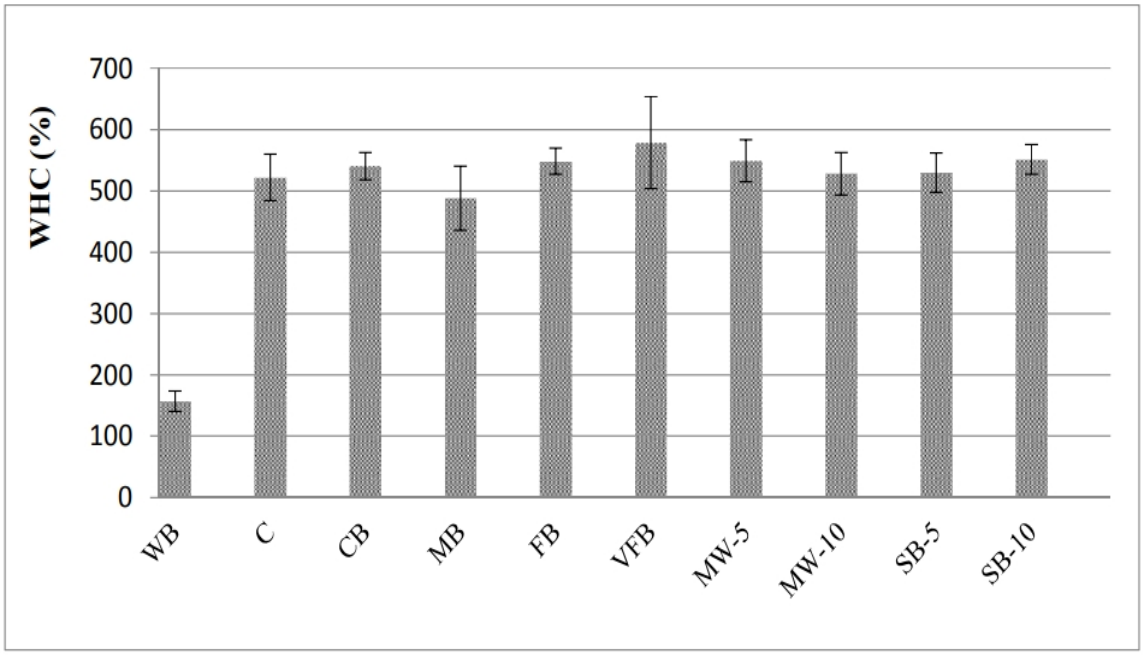

Fig. 1. Effect micronization, microwave heating and steaming of bran on water holding capacity.

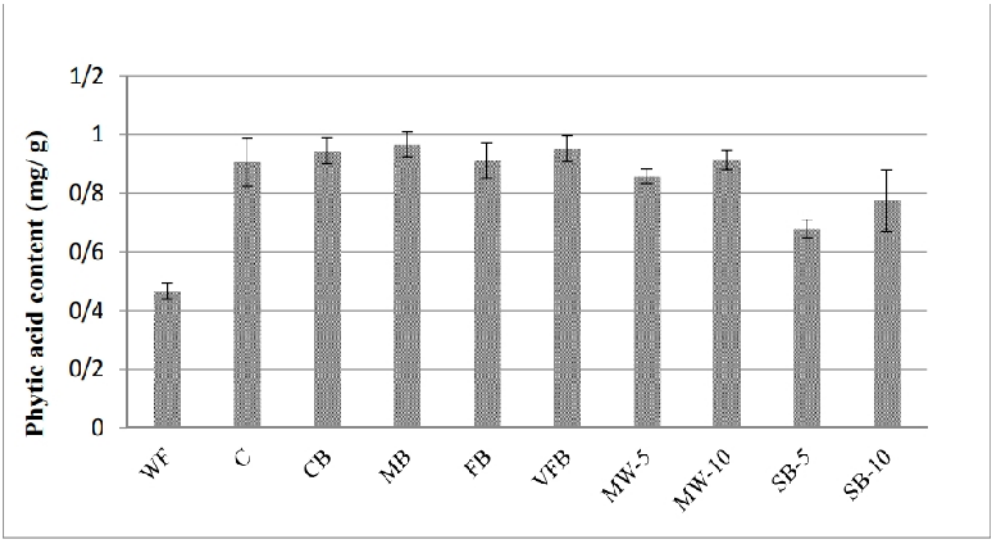

Fig. 2. Effect micronization, microwave heating and steaming of bran on phytic acid content.

Steaming treatments were more effective to reduce phytic acid content than microwave treatments (0.680 for SB-5 and 0.775 mg/100gr for SB-10). Wheat bran contains high amounts of phytate which could disturb mineral absorption under certain dietary circumstances. The phytate content of the bran was related tocultivar and kernel size (Dintzis *et al* 1992; Garcia-Estepa *et al*. 1999).It is reported that phytic that phytic acid degraded when heated to 150°C for 1 hour. lower phytic acid in WA5 and WA10 can attributed to higher temperature of steaming (121°C) as compared with microwave treatment (max 100°C) (Daneluti *et al* 2013). Similar reduction was reported by Servi *et al*. (2008), Khan *et al* (2009) and Avanza *et al*. (2013) in heat treatment of brans.

E. Farinograph parameters

Table 6 demonstrates farinograph results of WB supplemented dough and control sample (no bran addition). The results showed that water absorption has notably increased by WB addition (59.8% for WB and 63.1% for C samples). The result is in agreement with result of WB water holding capacity in Fig. 1.

Similar results were observed in other studies and with different kinds of fibers and hydrocolloids (Rosell *et al*. 2001). The result was expected due to the hydroxyl groups in the WB structure, which allow more water interactions through hydrogen bonding. In addition, higher levels of pentosans present in bran can increase water absorption (Sanz Penella *et al*., 2008). The lowest and highest water absorption was observed with the heat treatment by MW-10 and FB respectively with 62.2 and 65.7%. Totally, significant differences in water absorption were detected between steaming and microwave treatments. Longer microwave treatment time reduced water absorption (65.4 to 62.2 %) while steaming treatment increased it (63.8 to 65.5). Development time of WB supplemented dough was longer than control sample. Particle size reduction had a significant effect on the parameter so that smaller particle size reduced development time (1.7 to 1.1 min).

Table 6: Effect of micronization, microwave heating and steaming on dough farinograph properties.

Sample	Water adsorbtion (%)	dev time (min)	Stability (min)	dos 12 (HE)	dos 10 (HE)	dos 20 (HE)	Pqn (HE)
WF	59.8	1.3	3.5	118	90	141	13
C	63.1	1.7	2.6	129	85	155	18
CB	63.7	1.6	3.9	118	74	149	15
MB	65.2	1.3	1.8	147	108	167	14
FB	65.7	1.3	4.2	111	65	140	14
VFB	64.7	1.1	4.2	104	68	106	11
MW-5	65.4	1.8	1.2	125	91	163	19
MW-10	62.2	1.3	2.9	113	82	146	12
SB-5	63.8	1.5	3.3	102	70	138	16
SB-10	65.5	1.6	4.5	100	63	132	18

Longer microwave treatment time decreased dough development time (1.8 to 1.3 min). The results showed that reducing of particle size and heat treatment increased dough stability. The effects could attribute to physicochemical properties of wheat bran and its interaction with other ingredient of flour (Messia *et al.* 2016). Fiber fractions of bran caused the formation of a weaker gluten network, which was less stable during mixing. Behavioral features of WB and other dietary fibers during mixing using farinograph and extensograph measurement has been extensively studied and reviewed (Wang *et al.*, 2002; Hadnadev *et al*., 2011; Ahmed *et al*., 2013). The increase of development time was attributed to the effect of the interaction between bran particles and gluten that prevents the hydration of the proteins (Sanz Penella *et al.*, 2008).

F. Extensograph parameters

Both of good resistance and good extensibility are desirable dough properties (Walker and Hazelton, 1996). Extensograph value of WB measured in 45, 90 and 135 min (data of 90 were not shown). Addition of WB into white wheat flour significantly changed dough extensograph parameters (Table 7). The energy or area under the curve reduced from 46 to 42 cm^2 with decreasing particle size from CB to VFB. Both microwave and steaming treatments decreased dough energy from 45 to 43 and 48 to 40 cm^2 respectively for 45 min. There was no significantly change in dough energy when flour supplemented by heat treated bran after 135 min. The noticeable date were observed in FB and VFB samples that energy increased after 135 (41 and 44 HE) than 45 mins (41. and 42 cm^2) the same result were observed for heat treated except SB-5 brans that area under curve after 135 min were same or bigger than 45 min. Resistance to extension parameter decreased by size reduction (225 HE for CB to 185 HE for VFB). Heat treatment improved dough resistance extension properties. Extension parameter of dough decreased in all samples. Both particle size reduction and steaming treatment had negative effect on dough extension (Moradi *et al.*, 2016).

Table 7: Effect of micronization, microwave heating and steaming on dough extensograph properties.

NAME	Time(min)	Energy (cm^2)	res to ext* (HE)	Ext (mm)	max.res(HE)
WF	45	67	229	153	279
	135	48	377	83	379
C	45	44	193	138	195
	135	37	204	118	206
CB	45	46	225	128	226
	135	27	295	103	297
MB	45	46	210	136	212
	135	42	269	104	269
FB	45	40	177	139	178
	135	41	226	115	230
VFB	45	42	185	138	187
	135	44	244	106	272
MW-5	45	45	197	142	203
	135	45	271	106	273
MW10	45	42	202	131	207
	135	43	267	101	270
SB-5	45	48	258	118	251
	135	47	305	99	305
SB-10	45	40	225	107	227
	135	40	263	97	263

* Resistance to extention

CONCLUSIONS

Undesirable technological and sensorial effect of wheat bran limited its application for dough formulation and bakery products. Micronization, microwave and steaming treatment have significant effect on the physicochemical properties of wheat bran and WB supplemented breads. Particle size reduction of WB particle size significantly decreased bran water holding capacity and its b* value, yellowness and whiteness while increasing its lightness, bulk and tapped densities. Wheat bran samples had negative effect on dough development time and stability and resistance extensibility. Reduction of bran particle size had positive effect on dough development time stability, stability and maximum resistance while coarse bran had higher energy and resistance to extension. Wheat bran seaming can reduce phytic acid content and water holding capacity and improved dough stability, maximum resistance and resistance to extension. Finally, according to results, limit milling of bran as well as steaming treatment offered for bran treatment.

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