Jordan Journal of Agricultural Sciences, Volume **19**, No.**1 2023**
DOI: https://doi.org/10.35516/jjas.v19i1.155

Effect of Wheat Bran Levels and Particle Size on the Rheological Properties of Wheat Flour Dough

Amr, A. [1]***, Saleh, M.**** [1]***, Taibi, A*** [2] ***and Alkhamaiseh, A*** [3]

[1] Department of Food Science and Technology, School of Agriculture, The University of Jordan, 11942, Amman, Jordan

[2] Department of Nutrition and Food Technology, School of Agriculture, The University of Jordan, 11942, Amman, Jordan

3 Clinical Nutrition and Dietetics, Allied Medical Sciences, Applied Science Private University, Amman, Jordan

Received on 14/6/2022 and Accepted for Publication on 22/8/2022.

ABSTRACT

This study sheds light on the effects of wheat bran on dough rheological properties, especially gluten index and gassing power. To this end bran with three particle sizes (coarse≥ 300um, medium 300-180um, and fine ≤180um) at three levels (10%, 20%, and 30%) was added to straight-grade flour, which was also used as a control. Proximate analysis, rheological and physical properties of the bran particles and doughs were determined using the approved official methods of Farinograph, Extensograph, Risograph, and gluten index instruments. Farinograph results showed that water absorption capacity (WAC) increased by increasing bran levels, while dough stability decreased by increasing bran particle size. Extensograph results revealed that dough resistance, extensibility, and resistance to extension (R/E) ratio showed a nonlinear behavior between bran levels; and a significant decrease ($P \leq 0.05$) in resistance value (R50) compared to an increase in the control straight-grade flour (SGF) after 135 minutes of fermentation. Carbon dioxide production using Risograph was significantly ($P \leq 0.05$) higher in the fine bran compared to the other samples after four fermentation times (30, 60, 90, and 120 minutes). There was a significant ($P \leq 0.05$) inverse relationship between the gluten index of the dough and the bran particle size.

Keywords: Wheat bran, Risograph, Farinograph, Extensograph, Dough rheology, Gluten index

INTRODUCTION

Wheat bran is considered an attractive by-product of the milling industry due to its valuable dietary fiber and content of significant amounts of good-quality proteins, minerals, and antioxidants (Majzoobi *et al.,* 2013, Balandrán-Quintana, 2015). The growing interest in producing high-fiber foods by adding wheat bran enhanced this product's value in improving human health, including delaying gastric emptying, decreasing blood glucose and insulin levels, and increasing satiety and fecal mass (Aktas-Akyildiz, 2020). Additionally, bran-rich

* Corresponding author E-mail: ayedamr@ju.edu.jo

fiber diets were reported to aid in binding bile acids and short-chain fatty acid production, thus, lowering blood cholesterol levels (Packkia-Doss *et al*., 2019).

Despite the nutritional advantages of wheat bran, it is used on a limited scale in food products and is usually used as animal feed or for paper production (Coda *et al*., 2014). This was probably related to the negative impacts of bran on the sensory, rheological, and physical properties of bread and dough during processing. In addition, bran with abundant phytic acid binds divalent ions, thus putting some vulnerable population groups at risk of anemia, which hinders its use in bread production (Amr, 1986; Amr, 1987).

Packkia-Doss *et al.* (2019) reported an inverse relationship between bran level and gluten network strength, the interaction between them leads to coalescence or disproportionation of the gas cells during fermentation, hence reducing gas retention by the dough. The authors also indicated that wheat bran decreased dough extensibility and resistance to extension. Thus, the increased bran concentration in wheat bread formulation reduced the dough's strength and extensibility by interrupting the gluten network and minimizing the force required to rupture the dough. Therefore, overcoming such downfalls would greatly improve wheat bran utilization in bakery products and enhance the economic and nutritional aspects of dietary fiber intake. Modifying wheat bran structure, surface area, and bran function by reducing their particle size is a promising solution to avoid detrimental bran drawbacks (Hemery *et al*., 2011).

Therefore, the objectives of this work are to determine the effects of bran particle size (i.e., coarse, medium, and fine) and levels (10%, 20%, and 30%) of addition to wheat straight-grade flour on the physical, rheological, and viscoelastic characteristics of its dough.

Materials and methods

Sample collection and preparation

Flour sample:

Straight-grade flour was purchased from a local commercial mill in Zarqa/ Jordan, with a 72 to 78 % extraction rate, and stored at room temperature in the cereal technology laboratory, Department of Nutrition and Food Technology/ The University of Jordan, until use.

Bran sample preparation:

Wheat bran obtained from a local commercial mill in Zarqa/ Jordan was first ground using a laboratory hammer mill, then hand sieved using a multi-tray sieve (Endcotts test sieves, London, England) to obtain three different fractions (i.e., coarse>300 um, medium 300- 180 um and fine <180 um).

Preparation of bran-flour mixtures:

The coarse, medium, and fine bran samples were added to the straight-grade flour at three substitution levels (i.e., 10%, 20%, and 30% wt/wt). Thus, nine samples (combinations, treatments) were obtained.

Characterization of bran particle size and control flour:

Proximate analysis

Moisture, protein, fat, and ash of the three particle sizes of the bran sample and the control flour were determined according to the approved AACC Methods: 44-19, 46-10, 30-25, and 08-01, respectively (AACC, 2000). Fiber content also was determined according to AOCS-approved procedure Ba 6a-05. All measurements were performed in triplicates.

Physical analysis of bran-flour mixtures:

Farinograph:

Farinograph (300 gram, Brabender® instrument, Germany) was used according to the AACC Method 54–21.01 (AACC, 2000) to measure the dough rheological properties of the treatments. A 300g of treatments (14% moisture basis) was loaded into the mixing bowl, after which an appropriate amount of distilled water was added from the titration curve to reach a final dough consistency of 500± 20 BU. The dough was then mixed, and the Farinograph parameters were recorded. Farinograph testing was run in duplicates.

Gluten index:

The wet and dry gluten content of flour mixtures was determined as gluten index according to the AACC method 38-12.02 (AACC, 2000) using Glutomatic-2020, Perten instrument, Sweden). The gluten index was run in duplicates.

Risograph:

The gassing power of flour-bran treatments was measured using Risograph (National Manufacturing, Lincoln/ Nebraska USA) following the AACC method No. 89-01.01 (Lesaffre Group, yeast Industries Co., Jordan). The instrument was connected to an automatic thermostat immersion circulator (Lauda -Brinkman, Eco silver, Model No. L001078, Konigshofen, Germany). Gassing power was measured over 30, 60, 90, and 120 minutes of fermentation and expressed as ml CO_2/min/35g weight of the dough. All dough samples were prepared to complete development with a final dough temperature of 30 ± 1°C and given 5 minutes of bench rest. Then a 35-gram portion of each dough was placed into one of the Risograph jars, closed, and immersed in the water bath. The gas pipes connected to the device and the leavening process were started at 30 ± 1°C, and gas production was reported as total carbon dioxide evolved after 120 minutes of leavening as an average of three parallel measurements.

Extensograph analysis:

Dough resistance, extensibility, resistance to extension (R/E) ratio, and energy were measured using an Extensograph instrument (Brabender Extensograph®-E Model No. 7900041, Duisburg Germany), according to the AACC Method 54-10.01 (AACC, 2000) at three proofing times (45, 90 and 135 minutes) at 30°C. The test was run in duplicate.

Statistical analysis

Analysis of variance (ANOVA) was carried out on the physicochemical and rheological characteristics of the treatments using JMP release 10.0 (SAS Institute, Cary, NC). RCBD design was followed in the design of the experiment with blocking on replicates. Least Significant Difference (LSD) test separation at a 5% probability level.

Results and discussion:

Chemical composition of flour and wheat bran samples

The chemical composition of the control flour and bran are shown in Table 1. Results indicate significant ($P \leq 0.05$) differences between the straight-grade flour and the bran in most proximate components. Regardless of size fractions, bran had significantly lower moisture content than wheat flour, although coarse bran had somewhat higher moisture than the medium and fine ones, which can be attributed to the heat generated by the hammer-milling process of the last two. A similar observation was reported by Anjum *et al.* (2003), who stated a lower moisture content than control flour. Balandrán-Quintana *et al.* (2015) reported 9.8% moisture and about 16% protein on a dry matter basis, while Caprez *et al.(*1986) reported 14.4% protein in coarse bran on a dry matter basis. Both coarse and medium bran particles had significantly higher protein content than both the fine fraction and the control flour. This is because the coarse and medium fractions have more of the protein-rich aleurone and less of the adhering low-protein starchy endosperm. Bran usually has about 6% more protein than pure flour (Oghbaei and Prakash, 2013). All other chemical components are within the ranges reported by other workers (Caprez et al., 1986; Balandrán-Quintana *et al*., 2015) although a reduction in bran particle size was accompanied by a reduction in fiber and ash content. A similar observation was recorded by Jin *et al*. (2020).

Table 1: Chemical composition of straight-grade flour (control) and wheat bran with different particle sizes *

Samples	Moisture	Protein	fat	Ash	Fiber
Control(SGF) **	11.61±0.02^{a}	11.6±0.13^{d}	1.82±0.14^{c}	0.50± 0.01^{d}	0.29±0.01^{d}
Coarse	9.21± 0.08^{b}	16.1 ±0.14^{a}	5.33 ±0.09^{b}	4.03±0.03^{a}	8.05 ±0.06^{a}
Medium	8.81±0.26^{bc}	15.6 ±0.06^{b}	5.60 ±0.23^{ab}	3.36± 0.05^{b}	6.90±0.07^{b}
Fine	8.68±0.06^{c}	12.3 ±0.56^{c}	6.00 ± 0.06^{a}	3.11±0.04^{c}	4.28 ±0.01^{c}

*Values are the means of three replicates ±standard error on a wet matter basis. This means in the same column with different matching letters is significantly (P ≤ 0.05) different according to LSD test.
**SGF: Straight Grade Flour

Effect of bran on Farinogram profiles:

Effect of bran particle size:

Table 2 exhibits the effects of the bran particle size on the dough behavior as determined by the Farinograph instrument. Results indicate a significant (P ≤0.05) increase in **water absorption** of the large and medium particle size bran-treated samples over the control and the fine fraction. Fine bran treatment resulted in a decrease in the water absorption but was still higher than the control. This is because the 180u sieve allowed the flour and the fine bran to go through, which made the fine fraction behave in a manner between the flour and the medium bran. Bran was reported to increase water absorption of flour due to its high content of hydroxyl groups which compete with flour particles for water through hydrogen bonding (Wang *et al.,* 2002; Rosell *et al*., 2010) and due to its hydrophobicity (Packkia-Doss *et al*., 2019*)* with the result of increased water absorption. On the other hand, the addition of fine bran contains less fiber (Table 1) which means less water absorption. Liu *et al*. (2016) found that the presence of several numbers of small micro-pores in fine bran would have resulted in less water retention.

Table 2 : Effect of bran particles size and level of addition on the farinogram variables of straight grade flour

Parameters	Particle Size	10%	20%	30%
WAC (%)	Control**	58.40±0.1$^{c}_{a}$	58.40±0.1$^{c}_{a}$	58.40±0.1$^{c}_{a}$
	Coarse	62.55±0.05$^{a}_{c}$	63.8±0.21$^{a}_{b}$	58.40± 0.1$^{d}_{a}$
	Medium	62.40±0.1$^{a}_{c}$	63.45±0.05$^{a}_{b}$	65.15±0.05$^{a}_{a}$
	Fine	61.10±0.1$^{b}_{c}$	62.60±0.1$^{b}_{b}$	64.6±0.1$^{b}_{a}$
AT	Control	1.25± 0.1$^{c}_{a}$	1.25± 0.1$^{c}_{a}$	1.25± 0.1$^{c}_{a}$

	Coarse	$1.75\pm0.05^{b}_{b}$	$1.73\pm0.21^{b}_{b}$	$2\pm0.05^{a}_{a}$
	Medium	$2\pm0.1^{a}_{a}$	$2\pm0.05^{a}_{a}$	$2\pm0.1^{a}_{a}$
	Fine	$1.5\pm0.1^{b}_{b}$	$1\pm0.05^{c}_{c}$	$1.75\pm0.1^{c}_{a}$
DDT (min)	Control	$1.37\pm0.12^{c}_{a}$	$1.37\pm0.12^{c}_{a}$	$1.37\pm0.12^{b}_{a}$
	Coarse	$2.25\pm0.1^{b}_{c}$	$3.72\pm0.02^{a}_{a}$	$3.35\pm0.15^{a}_{b}$
	Medium	$4\pm0.02^{a}_{a}$	$3.25\pm0.1^{b}_{b}$	$3.5\pm0.16^{a}_{b}$
	Fine	$1\pm0.062^{d}_{b}$	$1\pm0.03^{d}_{b}$	$1.25\pm0.1^{c}_{a}$
Stability(min)	Control	$13.12\pm0.12^{a}_{a}$	$13.12\pm0.12^{a}_{a}$	$13.12\pm0.12^{a}_{a}$
	Coarse	$9.25\pm0.03^{c}_{a}$	$7.72\pm0.02^{c}_{b}$	$9.25\pm0.25^{d}_{a}$
	Medium	$10.5\pm0.02^{b}_{b}$	$10.5\pm0.01^{b}_{b}$	$10.75\pm0.04^{c}_{a}$
	Fine	$13\pm0.04^{a}_{a}$	$10.5\pm0.01^{b}_{c}$	$12.25\pm0.02^{b}_{b}$
DEP (min)	Control	$14.37\pm0.12^{a}_{a}$	$14.37\pm0.12^{a}_{a}$	$14.37\pm0.12^{a}_{a}$
	Coarse	$11\pm0.01^{c}_{a}$	$9.47\pm0.02^{d}_{b}$	$11.25\pm0.25^{c}_{a}$
	Medium	$12.5\pm0.01^{b}_{b}$	$12.5\pm0.02^{b}_{b}$	$12.75\pm0.04^{b}_{a}$
	Fine	$14.5\pm0.03^{a}_{a}$	$11.5\pm0.03^{c}_{b}$	$14\pm0.03^{a}_{a}$
M.T.I (B.U)	Control	$6.25\pm0.01^{c}_{a}$	$6.25\pm0.01^{c}_{a}$	$6.25\pm0.01^{c}_{a}$
	Coarse	$7.25\pm0.02^{b}_{b}$	$7.22\pm0.02^{b}_{b}$	$8.40\pm0.1^{b}_{a}$
	Medium	$9.75\pm0.01^{a}_{a}$	$8.25\pm0.23^{a}_{b}$	$8.5\pm0.04^{b}_{b}$
	Fine	$6\pm0.05^{d}_{b}$	$6\pm0.01^{d}_{b}$	$9.25\pm0.01^{a}_{a}$

*.Means within the same column within each farinogram variable and within the same row with the same matching superscript or subscript, respectively are not significantly ($P\leq0.05$) different according to the LSD test. All values are means of 2 replicates ±Standard error. WAC= water absorption; AT= arrival time; DDT= dough development time; DEP= Departure time; MTI= mechanical Tolerance index; control:100% straight grade flour

Arrival time(AT) is the time required for the top of the curve to reach the 500 BU after the mixer has been started and the water introduced. This parameter reflects the speed by which the flour takes up water, i.e., ease of hydration. Upon bran addition, arrival time increased compared to the control flour (Table 2). At all levels of addition, the effect of fine bran was closer to that of the control flour. This is due to the high protein content of the medium and coarse bran samples compared to the control flour and fine sample (Table 1).

As indicated in Table 2, there was no significant difference ($P\geq0.05$) between coarse (1.75min) and medium bran size(1.73min) at a 10% level of addition, as well as between coarse, medium, and fine bran at 20% level of addition. While a significant difference ($P\leq 0.05$) between all bran particles at a 30% level of addition. The delaying effect on the arrival time was more pronounced when bran was added at higher levels (20&30%); here, this variable increased, reflecting the delay of the dough development time.

Dough development time (DDT) indicates the time from the start of water added until the formation of dough with optimum elastic properties at which maximum energy is required to develop the gluten network (Jin *et al*., 2020; Packkia-Doss, *et al.,* 2019). This can be explained by the significant increase (P≤ 0.05) in DDT when bran was added compared to the control sample (Table 2) at most levels of addition. Marti et al. (2015) reported similar results, who suggested that the DDT increased upon the addition of wheat bran, mainly due to the higher dough resistance to the mixing blade.

Dough Stability: highest dough stability value (ST) was recorded for the control sample, followed by the fine bran particle, as shown in Table 2 at all addition levels. Table 2 shows that at all levels of addition, the stability of the dough decreased by increasing the particle size of the added bran compared to the control dough. This result agrees with the finding that Autio *et al.* (2001) related the reduction of dough strength to the falling-off in dough stability due to the disturbance of disulfide bridges responsible for the long dough stability. In addition, De Bondt *et al*. (2021) suggested that the numerous small bran particles found in the fine bran size result in a non-perturbation of the gluten network structure due to less interaction.

Departure time (DEP) is the time from the first addition of water until the curve leaves the 500BU line. Arrival time plus the stability gives the value of DEP. Table 2 shows an increase in DEP by decreasing the bran particle size at all levels of addition except at the 20% level. This could be due to human or experimental error as this variable is cumulative of both the arrival time and the stability.

Mechanical tolerance index (MTI): This value is the difference in Brabender units from the top of the curve at the peak to the top of the curve measured 5 minutes after the peak is reached. Table 2 shows that for the coarse bran, the higher value was recorded at the higher bran level (30%) with no significant difference (p ≥ 0.05) between 10% and 20% levels of addition. These results are justified by the fact that the higher the MTI value, the weaker the dough. Consequently, the lower the MTI value, the better tolerance of doughs to mixing. Fine bran particle size showed the lowest and closest to the flour in its MTI. Again, this is because fine bran contains more flour due to the milling and subsequent sieving in a 180u sieve.

Effect of level of bran addition: water absorption (WAC) of the dough increased by increasing the level of addition regardless of the particle size of the bran. This is logical as the effect of bran is magnified by increasing its level. The addition level significantly affected Arrival time (AT) as 30% level significantly increased this variable, especially in the case of fine and medium particle sizes(Table 2). No effect of all levels of addition was observed in the case of the medium particle size. Again here, the fine particle had a similar arrival time to that of the flour for the same reason elaborated earlier, i.e., the high flour content of the fine bran. The dough development time (DDT) increased by increasing the level of addition to 30% in the case of both the large a fine particle sizes and in the case of the medium size only when the level was increased from 20% to 30%. The highest dough stability was observed in the case of the fine particle size bran, which is closer to the control flour. However, there was no observed regular pattern concerning the relationship between the level of addition and stability in the case of the three particle sizes, although a consistent reduction was observed upon increasing the levels from 10% to 20% in the case of the fine and coarse particle sizes. Similarly, the level effect on departure time (DEP) was evident only when 10% and 20% levels of the coarse and fine particle sizes were added to the flour. Due to the dilution effect of bran on gluten which results in its weakening, i.e., higher MTI indicates weaker gluten, the mechanical tolerance index (MTI) is proportionally correlated with the amount of bran added to the dough. This effect pattern was observed in the case of fine and coarse bran particle sizes but only when the level of addition was increased, though non significantly, from 20% to 30% in the case of medium-size bran which means weaker samples which is, again due to the higher starch content of the fine fraction.

Gluten index:

From the obtained results (Table 3), GI of the fine bran particles at all levels of addition (10%, 20%, and 30%) were slightly higher than that of the control sample. This is due to the dilution effect of the large- surface coarse and medium particles on the gluten which reduced the GI of these samples In addition, with the increase in all bran treatment levels and particle size, gluten index was significantly ($P \leq 0.05$) decreased, which might be due to the high amount of the free sulfhydryl groups and lower disulfide bonds due to the high fiber content which alters the strength of gluten network (Noort *et al.* ,2010).. However, this was not observed in the case of the fine particle size bran, which had a gluten index higher than the control due to the fact that finer flour particles have less protein than medium and large ones (Kent and Evers,2017).

Table 3: Gluten index of doughs prepared with different bran level levels and particle sizes.

Samples	Gluten index (%)
Control	91 ± 0.01^{d}
Coarse10%	89.4 ± 0.01^{e}
Coarse 20%	86.9 ± 0.1^{g}
Coarse 30%	84.3 ± 0.02^{h}
Medium	88.8 ± 0.17^{f}
Medium	82.2 ± 0.07^{i}
Medium	79.2 ± 0.08^{j}
Fine 10%	92.5 ± 0.06^{c}
Fine 20%	93.5 ± 0.03^{b}
Fine 30%	95.7 ± 0.13^{a}

Means with the same matching letters are not significantly ($p \geq 0.05$) different. Each mean is the average of 3 replicates ±standard error.

Dough gassing power:

Figure 1 shows the dough gassing power of various bran treatments. With the progression of fermentation time (30, 60, 90, and 120 minutes), carbon dioxide production in all bran dough samples increased, reflecting the positive effect of fermentation time on gas production. Most control samples, at all fermentation times, recorded significantly ($P \leq 0.05$) higher carbon production values than bran dough treatments, indicating the suppression effect of bran. Only in the case of 120 minutes of fermentation time there was a slightly higher though non-significant difference between the gas produced from the control and the 30% coarse treated sample. At 10% bran levels of addition, fine bran recorded the highest value, followed by coarse and finally medium bran particles at all fermentation times. No significant difference ($P \geq 0.05$) between dough with fine and coarse bran (32.67, 33.21 ml/CO_2/min/35g weight of dough), respectively, followed by the medium particle at a 20% level of addition in the first fermentation time. At the same level of addition (20%), the highest value was recorded by coarse bran (161.71 ml/co_2/min/35g weight of dough) followed by fine (159.37 ml/CO_2/min/35g weight of dough) and medium with the lowest value by the end of the fermentation period (120min). As the bran addition increased to 30%, the progression of fermentation periods had a similar influence on gas as the 20% addition, which recorded a higher gas volume for the fine particles (186.06 ml/CO_2/min/35g weight of dough) followed by coarse (150.96 ml/CO_2/min/35g weight of dough) and lastly medium bran particles(141.30 ml/CO_2/min/35g weight of dough). During the preparation of bran samples the fine fraction had more starch thus greater fermentable sugars. However, the integrity of the large bran fraction allows it to hold more of the free sugars than the medium one which was more violently disrupted during impact milling.

However, compared to the generation of numerous gas bubbles that lose their stability throughout the heat process during bread preparation, the stabilization of gas cell formation in the dough is regarded as the more important aspect. This was in line with Chung *et al.*

(2009), who concluded that the stabilization of gas bubbles in the dough might be related to the lipids content. Fine bran had the highest lipid content (Table 1); consequently, it gave gassing power very close to flour. It seems that the suppression effect of the bran is counteracted by the amount of flour present in the fine bran fraction.

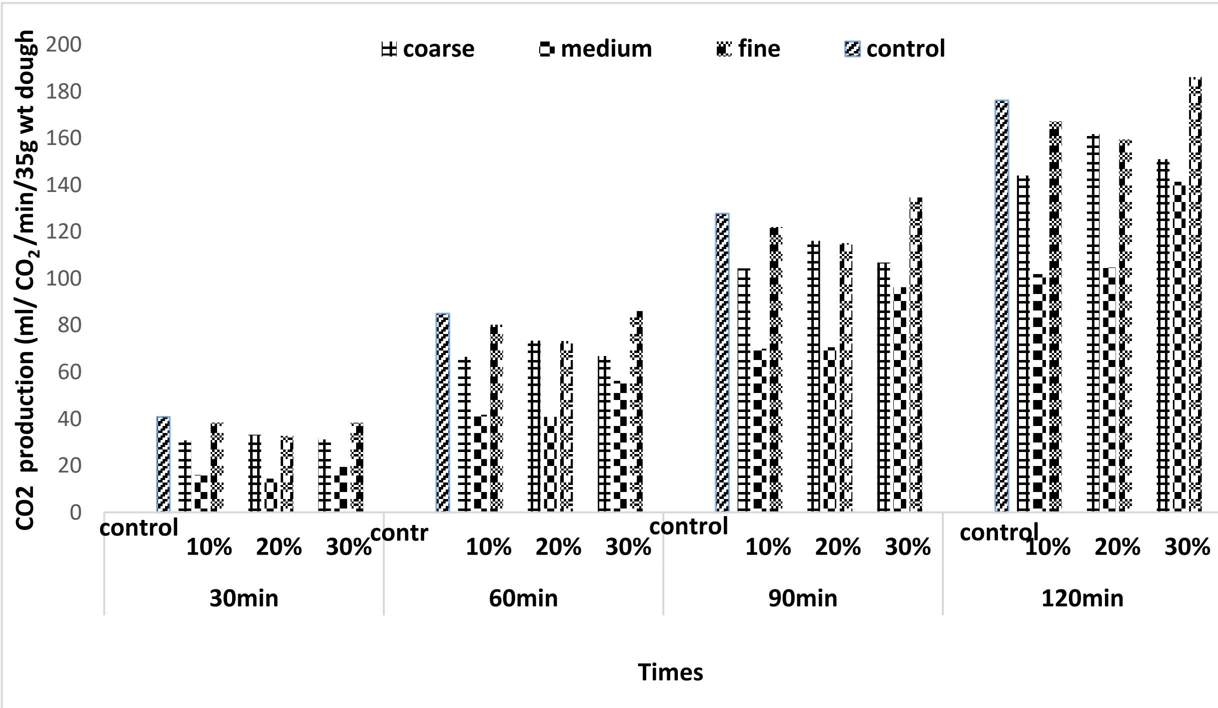

Figure 1: Carbon dioxide production (ml/ CO_2 /min/35g weight dough) upon the addition of bran levels and particles size to the control flour

Effect of bran on the Extensograph results of the dough sample

Energy (A):

Energy is defined as the maximum energy used for dough extension, and the area represents it under the extensogram curve expressed in cm^2 (Abbasi *et al*., 2012). In our study **(figure 2) ,** energy results increased with fermentation time progress from 30 min to 90 min in all bran samples, but by the end of the fermentation period (135 min), all dough samples lost their energy to resist extension except the control sample. The addition of bran resulted in a significant decrease ($P \leq 0.05$) in the energy when increasing bran levels from 10 to 30% with all fermentation periods; this might be justified by the dilution effect of bran which led to the formation of a weak gluten network. The control sample recorded a higher energy value compared to all bran treatments. No sign ($P \geq 0.05$) different value was observed between coarse and medium particles with 20% and 30% of addition at the first fermentation time ($66cm^2$). The same observation at the lastificant fermentation time, between coarse, medium, and fine at 10% ($88cm^2$).

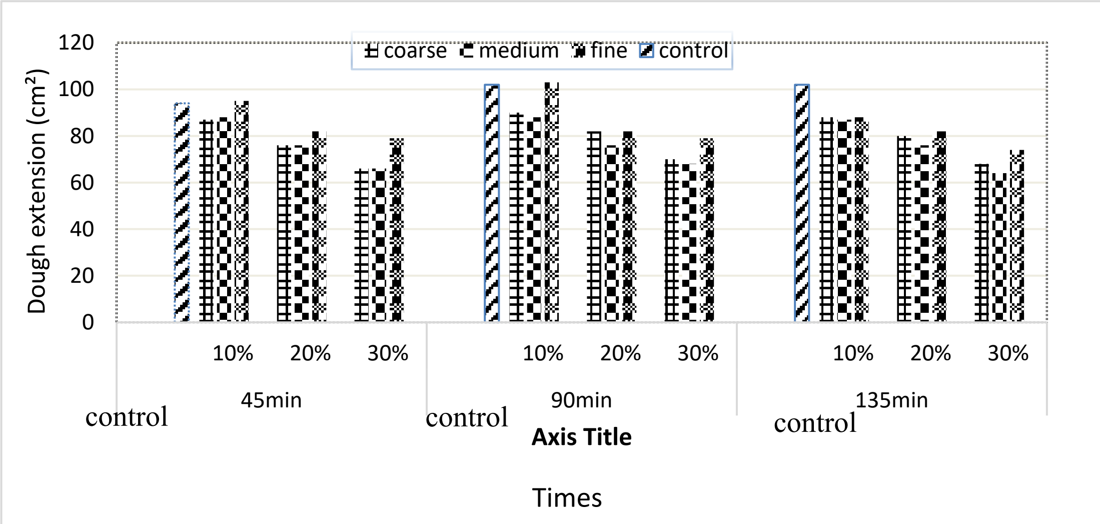

Figure 2: Energy for dough extension during fermentation times

Resistance to extension:

This variable is defined as the maximum height or the capacity of dough to resist the extension, expressed in centimeters (cm) or extensograph units (EU) or Brabender units (BU). In the current research, resistance to extension increased by fermentation times (from 45min to135 min). Figure 3 shows that when bran level was increased from 10% to 30%, there was a general decrease of dough resistance in both medium and fine particles except coarse bran, which showed a complicated behavior probably due to the dilution effect of bran and its interaction with gluten structure. In contrast, when reducing bran particle size from medium to fine, dough resistance to extension significantly (P≤0.05) increased. By the end of fermentation time (135min), control flour recorded the highest resistance to extension values compared to other bran treatments.

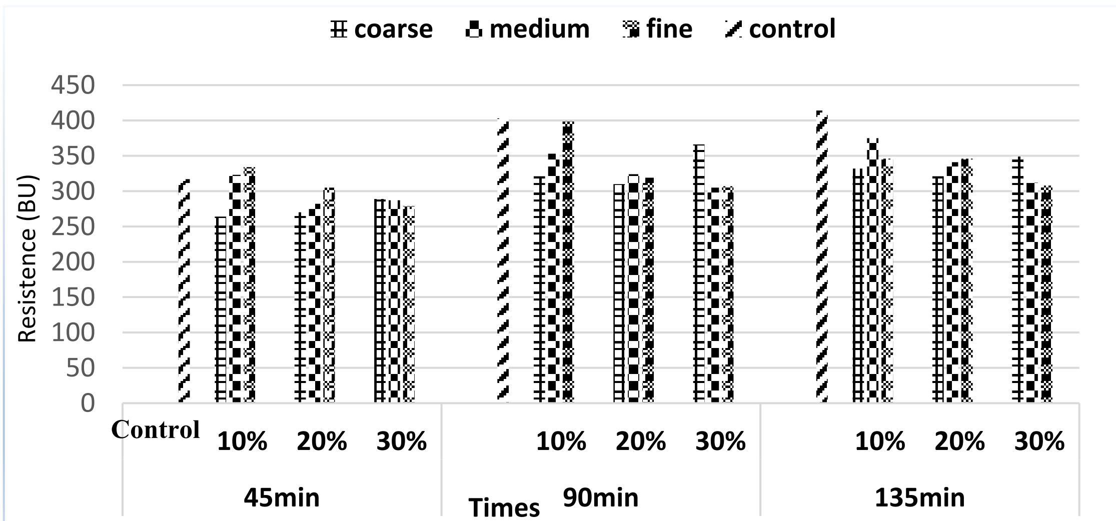

Figure 3: resistance to extension (BU) of dough during fermentation times

Extensibility (E):

Dough extensibility is the most important parameter in the bread-making process used to determine elasticity and dough strength (Jin *et al*., 2020). In this work, at 10% of coarse bran additions, the highest extensibility value (172 mm) was recorded, which decreased when bran levels increased at the first fermentation time (45min) as depicted in figure 3. while, by the end of fermentation time, all bran treatments lost their elasticity. The effect became more pronounced with increased bran addition level from 10 to 30% with no significance (P≥0.05) difference between coarse and medium particles at 20%. In general, there is no intense effect on dough extensibility between all bran treatment samples, as elucidated in figure 4. These results were attributed to the interruption of the starch gluten network with the presence of bran (Gómez *et al*., 2011). Abbasi *et al.* (2012) suggested that the decrease in dough extensible properties might be related to the increase in ash content. Jin *et al*., (2020) found no clear linkage between bran particle size and dough extensibility within the range of 10–30% of wheat bran addition.

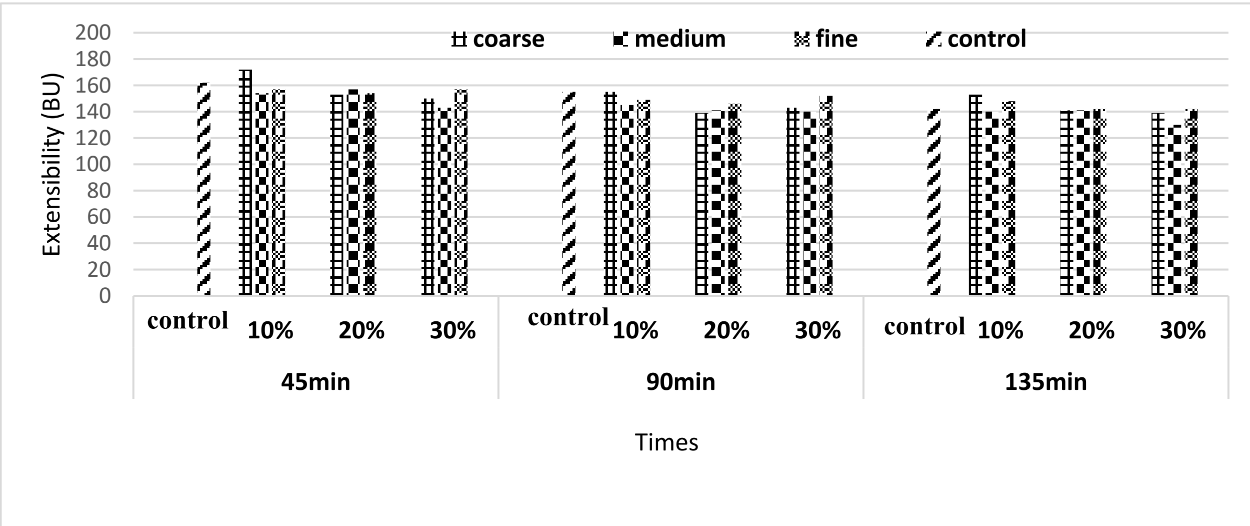

Figure 4: Dough extensibility (BU) of dough during fermentation times

Ratio number (R50/E) (resistance to extension/extensibility): indicates the balance between dough strength (resistance at 50 mm extension distance) and the extent to which the dough can be stretched (extensibility), which gives an estimation of the dough's viscoelastic balance at constant stretching distance.

The larger the R/E value, the stronger the gluten and/or less the extensibility (Preston and Hoseney, 1991). Our results show that the (R/E) ratio disproportionately correlates to the bran addition levels and particle size. Figure 5 shows a significant ($p \leq 0.05$) increase in the ratio by decreasing the bran particle size at all fermentation times, except at 90 minutes, the coarse bran at 20% level recorded higher R/E value compared to medium and fine particles. Although these conditions seem to be the optimum for the gluten strength, the result is perplexing and hard to explain. Moreover, no significant ($p \geq 0.05$) change in the ratio value between coarse, medium, and fine bran particles at the 20% level of addition, also between coarse at 10% and fine at 30%

within the end of fermentation (135minutes). These results might be explained by the interaction with other factors like protein and gluten network formation and interaction, which directly influences the dough rheology and so the end quality of the product.

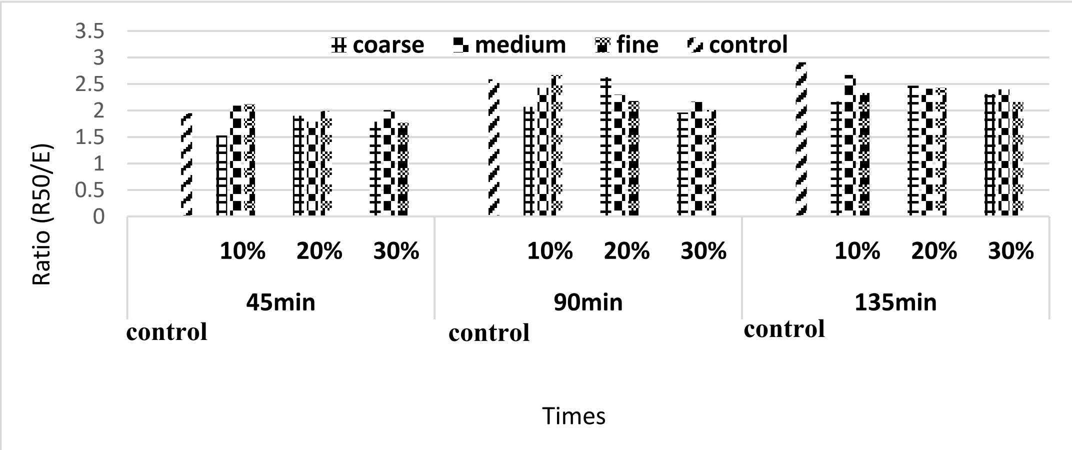

Figure 5: Dough ratio (R50/E) of dough during fermentation times

Conclusions:

In conclusion, adding wheat bran with different particle sizes and levels to straight-grade flour significantly modified dough rheology and viscoelastic properties. Wheat bran impact was characterized by two factors: particle size and level. When bran levels increased, dough water absorption capacity increased, stability decreased, and dough strength and gluten index decreased with a slight difference in carbon dioxide activity ratio. Our results show that fine bran treatments perform better than the other bran particle sizes (coarse and medium) in terms of more dough stability and acceptable viscoelastic properties, especially with a 10% level of addition.

REFERENCES

AACC, (2000). *Approved Methods of the American Association of Cereal Chemists*. AACC International, St. Paul, MN, USA.

Aktas-Akyildiz, E., Tugrul Masatcioglu, M. and Oksel, H. (2020). Effect of extrusion treatment on enzymatic hydrolysis of wheat bran. *Journal of Cereal Scienc* 93,102-941.

Amr, A. (1986). phytic acid content of some local Jordanian cereal foods. *Dirasat.* 13 (8), 75 - 83

Amr A. (1987). Phytic acid content of the milled Jordanian wheat varieties. Dirasat. 14 (11), 197 - 205.

Autio, K., Flander, L., Kinnunen, A., Heinonen, R., (2001). Bread quality relationship with rheological measurements of wheat flour dough. *Cereal Chemistry*. 78, 654-657.

Abbasi, H., Ardabili, S. M. S., Emam-Djomeh, Z., Mohammadifar, M. A., Zekri, M., & Aghagholizadeh, R. (2012). Prediction of extensograph properties of wheat-flour dough: Artificial neural networks and a genetic algorithm approach. *Journal of Texture Studies*, 43(4), 326–337.

Anjum, F. M., Ahmad, A., Pasha, I., & Butt, M. S. (2003). Micronutrients in various mill streams of flour of different wheat cultivars. *Pakistan Journal of Agricultural Sciences*, 40, 180-185.

Balandrán-Quintana, R. R., Mercado-Ruiz, J. N., & Mendoza-Wilson, A. M. (2015). Wheat bran proteins: a review of their uses and potential. *Food Reviews International*, 31(3), 279-293.

Caprez, A., Arrigoni, E. V. A., Amadò, R., & Neukom, H. (1986). Influence of different types of thermal treatment on the chemical composition and physical properties of wheat bran. *Journal of Cereal Science*, 4(3), 233-239.

Coda, R., Rizzello, C. G., Curiel, J. A., Poutanen, K., & Katina, K. (2014). Effect of bioprocessing and particle size on the nutritional properties of wheat bran fractions. *Innovative Food Science and Emerging Technologies*, 25(C), 19–27.

Chung, O., Ohm, J.-B., Ram, M., Park, S.H., Howitt, C., (2009). Wheat lipids. In: Khan, K., Shewry, P. (Eds.), *Wheat Chemistry and Technology*. American Association of Cereal Chemists, Inc., St. Paul, MN, USA, pp. 363-399.

De Bondt, Y., Hermans, W., Moldenaers, P., & Courtin, C. M. (2021). Selective modification of wheat bran affects its impact on gluten-starch dough rheology, microstructure, and bread volume. *Food Hydrocolloids*, 113, 106348.

Gómez, M., Jiménez, S., Ruiz, E., & Oliete, B. (2011). Effect of extruded wheat bran on the dough rheology and bread quality. LWT - *Food Science and Technology*, 44(10), 2231–2237.

Hemery, Y., Chaurand, M., Holopainen, U., Lampi, A.M., Lehtinen, P., Piironen, V., Rouau, X., (2011). Potential of dry fractionation of wheat bran for the development of food ingredients, part I: influence of ultra-fine grinding. *Journal of Cereal Science,* 53 (1), 1–8.

Jin, X., Lin, S., Gao, J., Wang, Y., Ying, J., Dong, Z., & Zhou, W. (2020). How manipulation of wheat bran by superfine grinding affects a wide spectrum of dough rheological properties. *Journal of Cereal Science*, 96.

Rosentrater, K. A.and Evers, A. D. (2017). *Kent's technology of cereals:* An introduction for students of food science *and agriculture*. Woodhead Publishing.

Liu, T., Hou, G.G., Lee, B., Marquart, L., Dubat, A., (2016). Effects of particle size on the quality attributes of reconstituted whole-wheat flour and tortillas made from it. *Journal of Cereal Science*, 71, 145–152.

Majzoobi, M., Farahnaky, A., Nematolahi, Z., Hashemi, M. M., & Ardakani, M. J. T. (2013). Effect of Different Levels and Particle Sizes of Wheat Bran on the Quality of Flat Bread. *Journal of Agricultural Science and Technology* (Vol. 15).

Marti, A., Qiu, X., Schoenfuss, T.C., Seetharaman, K. (2015). Characteristics of perennial wheatgrass (Thinopyrum intermedium) and refined wheat flour blends : impact on rheological properties. *Cereal Chemistry*, 92, 434-440.

Noort, M. W. J., van Haaster, D., Hemery, Y., Schols, H. A., & Hamer, R. J. (2010). The effect of particle size of wheat bran fractions on bread quality - Evidence for fiber-protein interactions. *Journal of Cereal Science*, 52(1), 59–64.

Oghbaei, M., & Prakash, J. (2013). EFFECT OF FRACTIONAL MILLING OF WHEAT ON NUTRITIONAL QUALITY OF MILLED FRACTIONS. *Trends in Carbohydrate Research*, 5(1).

Preston, K. R. and Hoseney, R. C. (1991). Application of the extent graph. *The stenograph handbook*. Eds: Rasper, V.F., Preston, K.R. AACC International, St. Paul, MN. pp 13-19.

Packkia-Doss, P. P., Chevallier, S., Pare, A., & Le-Bail, A. (2019). Effect of supplementation of wheat bran on dough aeration and final bread volume. *Journal of Food Engineering,* 252, 28-35.

Rosell, C.M., Santos, E., Collar, C., (2010). Physical characterization of fiber-enriched bread doughs by dual mixing and temperature constraint using the Mixolab®. Eur. *Food Research and Technology*. 231, 535-544.

Wang, J., Rosell, C.M., Barber, C.B.D., (2002). Effect of the addition of different fibers on wheat dough performance and bread quality. *Food Chemistry,* 79 (2), 221–226.

تأثير مستوى وحجم حبيبات النخالة على الخواص الريولوجية لعجين طحين القمح

عايد عمرو[1] ومحمد صالح[1] وأسماء طيبي[1] وأشرف خمايسة [2]

[1] كلية الزراعة، الجامعة الأردنية، الأردن

[2] قسم التغذية السريرية و الحميات، كلية العلوم الطبية المساندة، جامعة العلوم التطبيقية الخاصة، الأردن

تاريخ استلام البحث: 2022/6/14 وتاريخ قبوله: 2022/8/22

ملخص

تهدف هذه الدراسة إلى إلقاء الضوء على تأثير نسبة وحجم حبيبات النخالة على الخواص الريولوجية لطحين القمح خاصة قرينة الجلوتين وإنتاج الغاز أثناء التخمير. تم في الدراسة إضافة ثلاث مستويات من النخالة (10% و20% و30%) الخشنة (فوق 300 ميكرون) ومتوسطة الخشونة (180 -300 ميكرون) والناعمة (أقل من 180 ميكرون) لطحين القمح الموحد الذي استعمل كشاهد للتجربة. تم دراسة التحليل التقريبي للنخالة والخواص الريولوجية والفيزيائية للعجين الناتج باتباع الطرق الرسمية لأجهزة الفارينوجراف والإكستنسوجراف والرايزوجراف وقرينة الجلوتين. أشارت نتائج الفارينوجراف إلى أن إضافة النخالة تزيد من امتصاص الماء (WAC) بينما تقلل من ثباتية العجين. أشارت نتائج الإكستنسوجراف إلى عدم وجود علاقة خطية بين مستوى النخالة وكل من مقاومة العجين للمط (R50) والمطاطية ومعدل المقاومة للمط بينما أدت إضافة النخالة الى التقليل معنويا ($P\leq0.05$) من مقاومة العجين للمط مقارنة بالشاهد بعد 135 دقيقة من التخمير. أشارت نتائج الرايزوجراف إلى زيادة إنتاج غاز ثاني أكسيد الكربون بشكل معنوي ($P\leq0.05$) عند إضافة النخالة الناعمة بعد التخمير (لمدة 30 و60 و90 و120 دقيقه) . وجدت علاقة عكسية معنويه ($P\leq0.05$) بين مستوى النخالة المضاف وقرينة الجلوتين.

الكلمات الدالة: نخالة القمح، رايزوجراف، فارينوجراف، إكستنسوجراف، ريولاجيا الطحين، قرينة الجلوتين.