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Research Article

Effects of Dephytinized Wheat Bran on Rheological Properties of Dough and Sourdough Fermentation

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ABSTRACT

In this study, the rheological properties of flours containing wheat bran or dephytinized wheat bran at different rates (0, 5, 10, 15%) and some physicochemical and microbiological properties of bread doughs produced with sourdough by using these flour mixes were investigated. Four different sourdoughs, which were spontaneous (SS), Vakfikebir (VS), containing *Lactobacillus fermentum* as a starter (LFS) and containing *Lactococcus lactis* as a starter (LCS), were used. The water absorption, softening degree, resistance to extension values of dough increased while the stability, energy and extensibility values decreased as the rate of bran increased for both bran types. The pH and total acidity (TA) values of the bread dough samples generally increased with the addition of bran. The lowest moisture content, TA and LAB count, and the highest pH and yeast count were obtained in VS. The lowest pH and the highest TA values belonged to the bread dough samples containing SS. The number of LAB and yeast counts in bread dough samples increased with addition of bran compared to control sample.

1. Introduction

Wheat bran is a major by-product of milling and a good source of dietary fiber. The consumption of it has several benefits on human health. It reduces the risk of certain cancer types, has positive effects on the digestive system, shortens the intestinal transit time, increases the fecal mass, prevents constipation, cures diverticulosis and irritable bowel syndrome, reduces the risk of obesity, helps weight control, protects against gallstone formation, improves glycemic control, reduces the need for insulin or hypoglycemic substances (Almeida et al., 2013).

The addition of dietary fiber into bread formulation affects the technological properties of dough and product quality. Studies have shown that the water absorption, extensibility and textural properties of flours containing dietary fiber change. Some dietary fiber components such as arabinoxylan, β-glucan have possitive effects on the dough. They increase the dough viscosity and stabilize the gas cells (Rieder et al., 2012).

The bran could be added to flours as a dietary fiber source and used in the production of fiber enriched products. However, the phytic acid content of bran limits the usage. Phytic acid forms insoluble complexes with mineral cations and proteins and reduces their bioavailability and solubility. Phytic acid must be destroyed by an appropriate method before use (Baumgartner et al., 2018). The effects of different biological methods and processes (such as soaking, germination, fermentation, boiling, baking etc.) on phytic acid were investigated in the studies. However, it is stated that these procedures can not completely eliminate phytic acid (Servi et al., 2008). Özkaya et al. (2017) reported that the phytic acid content of wheat bran decreased at the rate of 95.2% by autoclaving for 1.5 h at pH 4.0.

Sourdough, used in bread production, is known to have positive effects on health directly or indirectly. Exopolysaccharides produced by lactic acid bacteria in the sourdough improve the viscoelastic properties of bread dough. It prevents the adverse effects of bran particles on the gluten network and gas cells (Pejcz et al., 2017). The decrease in pH with fermentation increases the endogenous phytase activity and provides a reduction of phytate content by more than 50% (Gobbetti et al., 2019).

There are studies on production and use of dephytinized bran (Baumgartner et al., 2018; Majzoobi et al.,

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2014; Mosharraf et al., 2009; Özkaya et al., 2017; Özkaya et al., 2018; Servi et al., 2008). However, the study about usage of dephytinized wheat bran in sourdough bread dough has not been reported. In this study the effects of wheat bran and dephytinized wheat bran on rheological properties of dough and on some physicochemical and microbiological properties of fermented sourdough were investigated. It was aimed to determine the potential of using dephytinized wheat bran in the production of sourdough bread.

2. Materials and Methods

2.1. Materials

Wheat flour and wheat bran were purchased from commercial companies in Konya, Turkey. Vakfıkebir sourdough was obtained from a local bakery in Vakfıkebir, Trabzon, Turkey. Wheat bran was milled by a lab-scale disc miller (Laboratory Mill 3303, Perten) and particle size was reduced to less than 300 µm. Lactic acid bacteria used as starter culture in the production of Type 2 sourdoughs were obtained from Cereal and Cereal Products Laboratory of Selçuk University Agriculture Faculty.

2.2. Dephytinization of wheat bran

Wheat bran was mixed with distilled water at a ratio of 1:15 (w/v) and pH of bran slurry was adjusted to 4.0 with acetic acid. After keeping for 30 minutes at 121°C in autoclave, pH of bran slurry was increased to inception pH value with 6 N NaOH. The slurry was filtered thorough by a sieve (with an opening of 200 µm), rinsed five times with water and dried at 60°C in an oven to a maximum of 10% moisture content (Özkaya et al., 2017).

2.3. Sourdough production

For the production of spontaneous sourdough, the wheat flour and water were mixed at a ratio of 1:1 (w/v) so that the dough yield (DY = [(weight of flour + weight of water)/weight of flour]*100) was 200 and left to fermentation at 30°C. In every 24 hours, 10% of the mixture was taken and back-slopping performed not to the way that deteriorate dough yield. Fermentation of sourdough continued until pH of sourdough dropped to 3.6-3.8 and TA reached 0.72-0.90%.

For the production of sourdoughs produced by using starter culture, wheat flour and water were blended in a steril jar at a ratio of 1:1 (w/v). The starter culture was inoculated at least in an amount of 10^6 kob/g of lactic acid bacteria in mixture and left to fermentation at 30°C for 24 hours. For the preparation of starter cultures, bacteria, kept at -20°C, were inoculated at a rate of 2% into MRS broth medium for reactivation and incubated at 30°C for 24 hours by providing the proper incubation conditions with Anaerocult C (Merck, Germany). After the incubation, cells were harvested by centrifugation at 6000 rpm for 10 minutes. The pellet was washed twice with sterile ¼ Ringer solution (Merck, Germany) and the number of LAB was determined by spread plate technique. The liquid phase was removed by last centrifugation, cell pellet was resuspended in sterile 20% glycerol solution and kept at -20°C until usage as a starter for sourdough production.

2.4. Bread dough-making

For bread dough making, wheat flour was blended with wheat bran or dephytinized wheat bran at the different rates (0, 5, 10, 15%). 1 g sugar, 1.5 g salt, 1 g yeast, 30 g sourdough and water based on water absorption determined in farinograph (the amount of flour and water from sourdough were taken into account) were added to 100 g of flour mixture and kneaded for 10 minutes in a kitchen-type dough kneader (KitchenAid, 5KSM45, ABD) at slow speed. The dough was fermented for 120:35 min (punching, proofing) at 30°C and 80±5% relative humidity.

2.5. Rheological analyses

The rheological characteristics of flour and bran mixes were tested with the farinograph (Brabender GmbH & Co KG, Germany) using Approved Method 54-21 and extensograph (Brabender GmbH & Co KG, Germany) using Approved Method 54-10 (AACC, 2000).

2.6. Physicochemical analyses

Ash, protein and fat contents of flour, wheat bran and dephytinized wheat bran were determined according to AACC Standard Method No: 08-01.01, 46-12.01 (AACC, 2010) and ICC Method No: 136 (ICC, 2002), respectively. Moisture contents, titratable acidity and pH values of flour, wheat bran, dephytinized wheat bran, sourdoughs and bread doughs were determined according to AACC Standard Method No: 44-01.01, 02-31.01 (AACC, 2010) and AOAC Standard Method No: 943.02 (AOAC, 2012), respectively. Falling number and sedimentation test of flour were performed by using AACC Standard Method No: 56-81.04 and 56-61.02 (AACC, 2010), respectively. The phytic acid contents of bran samples were calculated according to Haug and Lantzsch (1983) by measuring the phytate phosphorus spectrophotometrically.

2.7. Microbiological analyses

For microbiological analyses, 10 g of sourdough or bread dough was weighed into sterile stomacher bag and homogenized in 90 ml of 0.1% peptone water. After homogenization, appropriate serial decimal dilutions, prepared with 0.1% peptone water, were used for inoculation by spread plate technique and the results were expressed as $\log_{10}$ colony forming units per gram sample ($\log_{10}$ CFU/g). Total lactic acid bacteria were cultured on MRS agar containing 0.05 g/l of cycloheximide to prevent yeast growth and incubated anaerobically at 30°C for 48 h. Yeast was counted on Potato-Dextrose Agar (PDA, Merck, Germany) acidified by sterile tartaric acid (1.4 g/l) after incubation at 27°C for 5 days.

2.8. Statistical analysis

The results were expressed as the mean of two independent replicates with at least triplicate measurements. MINITAB release 18.0 was used to analyse data by performing one-way analysis of variance (ANOVA), followed by Tukey Multiple Comparison Test to verify any significant differences among the means at a 5% significance level ($p<0.05$).

3. Results and Discussion

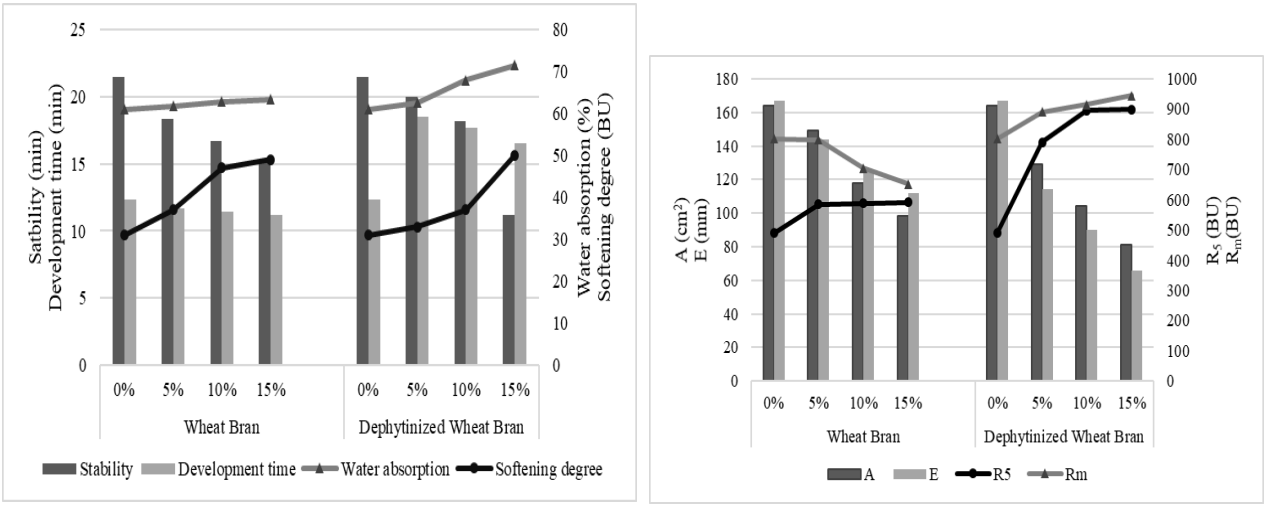
3.1. Rheological properties

The changes in the rheological properties (stability, development time, water absorption, softening degree, energy (A), extensibility (E), resistance to extension at constant deformation (R_5) and dough maximum resistance (R_m) values) of flour added with wheat bran or dephytinized wheat bran are shown in Figure 1.

The water absorption and softening degree values of flour increased while the stability value of flour decreased as the bran rate increased for both bran types. However, considering the development time values, it was seen that the both type of wheat bran utilisation lead to reduce the development time of dough. Additionally, increasing bran addition levels caused decreasing the development time.

The reason for the increase in water absorption is that there are more hydroxyl groups in bran compared to flour, and these groups allow more hydrogen bonds to be established with water molecules (Rosell et al., 2006). The porosity of the insoluble fiber fraction of bran is higher than the soluble fiber fraction. As porosity increases, the number of hydrogen bonds made with water molecules increases, so water absorption increases too (Kethireddipalli et al., 2002). The increase in insoluble fiber concentration of bran by dephytinization process could had caused higher increase in water absorption of flour samples containing dephytinized wheat bran than flour samples containing wheat bran.

The number and strength of the bonds between gluten proteins affects dough stability value. Some physical and chemical interactions during long-term kneading and the weakening of the gluten network with bran addition can lead to a decrease in dough stability value. The flours with high amount and quality of gluten have low softening degree and long development time (Özkaya et al., 2018). It is thought that the dilution of gluten concentration with the addition of bran caused increase in the softening degree values and decrease in the development time values of samples. However, the addition of dephytinized wheat bran compared to control group increased development time values. It has been reported that the long development time in whole wheat flour is due to the interaction between gluten and bran particles and preventing of the protein hydration by bran particles, therefore the kneading process is needed to be applied for a longer time in order to reach maximum consistency (Penella et al., 2006). The high water absorption capacity of bran particles can also be effective in prolonging of the development time. In addition some chemical bonds can not form because of intervention of bran particles between gluten molecules and a decrease in intermolecular attraction force. So it is delayed for the dough to reach the appropriate consistency (Özkaya et al., 2017). The number of disulfide bonds in dough can increase as a result of the washing away of reducing agents by dephytinization process. Therefore, the flour containing dephytinized wheat bran has longer development time, higher stability value and lower softening degree than wheat bran added flour. The heat treatment applied during the dephytinization process increases lipoxygenase activity by inactivating the lipase enzyme, thus disulfide bond formation increases and dough rheology improves (Mosharraf et al., 2009).



(a) (b)

Figure 1
The stability, development time, water absorption and softening degree values (a), and the energy (A), extensibility (E), resistance to extension at constant deformation (R_5) and dough maximum resistance (R_m) values (b) of flour mixtures containing wheat bran or dephytinized wheat bran at different rates

It can be seen in the extensogram values (Figure 1) that the R_5 value increased along with an increase in addition rate for both bran types and this rise was higher in the flour containing dephytinized wheat bran. The R_m value increased with an increase in dephytinized wheat bran rate, but it decreased as wheat bran rate increased. As the amount of bran added increased, the A and E values decreased for both bran types and this decline was higher in dephytinized wheat bran added flours compared to wheat bran added flours.

It has been reported that hemicelluloses being in the structure of bran particles, compete with gluten proteins and starch for water, which prevents the complete formation of gluten structure (Hoseney, 1986). In addition, the release of ferulic acid from arabinoxylanes being in the bran fraction and the formation of cross-links between arabinoxylanes and gluten proteins also affects the gluten network. As a result of this effect, the gluten network becomes more resistant to extension (Le Bleis et al., 2015). Therefore, dough resistance to extension value increased while extensibility of dough decreased with the bran additive.

3.2. Physicochemical properties

Moisture, ash, protein, fat, pH and TA values of the flour sample were determined as 12.17%, 0.63%, 13.99%, 1.66%, 6.11 and 0.22%, respectively. These values were 11.39%, 6.14%, 15.53%, 3.76%, 6.48 and 1.21% for wheat bran, while were 5.77%, 6.22%, 14.60%, 3.98%, 6.82 and 1.14% for dephytinized wheat bran, respectively. The sedimentation and falling number values of the flour sample were found as 45 ml and 585 s. The dephytinization process decreased the phytic acid content of wheat bran from 3043.55 mg/100 g to 145.64 mg/100 g (Figure 2). The reason for the lower moisture content of dephytinized wheat bran than wheat bran is the drying process applied after autoclaving. As a result of dephytinization process, while the amount of ash and fat of wheat bran increased, the amount of protein decreased. The decline in protein content may be resulted from the high temperature applied during dephytinization (Khatun et al., 2007), and the washing and filtration processes applied after autoclaving. It has been reported that while the pH values of samples were high, the high titratable acidity values may be due to the buffer effect of the bran proteins (Seiuml et al., 2011). Van Bockstaele et al. (2008) found that the ash, sedimentation and protein values (in dry matter) of wheat flour samples were ranged from 0.56-0.90%, 34-70 ml and 11.6-16.9%, respectively. Prückler et al. (2015) established the ash, fat and protein contents of wheat bran as 5.8%, 5.7% and 15.5%, and these of wheat flour as 0.8%, 1.3% and 13.9%, respectively. Özkaya et al. (2018) determined the ash and protein contents of wheat flour as 0.50%, 13.25% and these of wheat bran as 5.6%, 14.2%, respectively. The differences between data obtained in the studies may arise from the climate, soil and variety and vary in a wide range (Peterson et al., 1992).

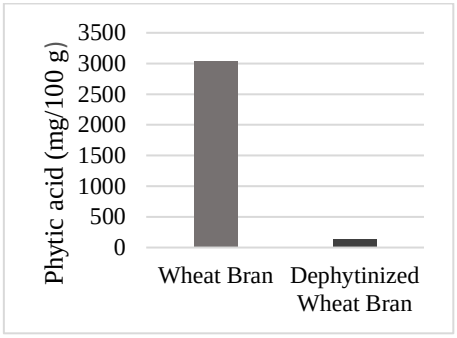


Figure 2
The phytic acid contents of wheat bran and dephytinized wheat bran

In spontaneous sourdough production, while pH decreased by the fermentation progress, TA value increased. pH and TA values, being 6.16 and 0.14% at the beginning, reached 3.62 and 0.99%, respectively, at the end of fermentation. The changes over time of pH and TA values determined before each back-slopping during fermentation is shown in Table 1. It has been reported that the pH and TA values of sourdough, growing proper ripe, were ranged between 3.6-3.8 and 0.72-0.90% (lactic acid), respectively (Gobbetti and Gänzle, 2012). When the pH and TA values of the sourdough sample are examined at the end of the 5th day, it is seen that it is compatible with data in the literature. Wehrle and Arendt (1998) determined that while the initial pH value of spontaneous sourdough was 6.4, it dropped to 3.7 at the end of 40 hours of fermentation. The pH and TA values of VS, LFS and LCS were 4.97-0.23%, 3.66-1.03% and 3.63-1.01%, respectively.

Table 1
The changes over time of pH, TA and LAB count during spontaneous sourdough fermentation (mean ± std. dev.)

Days	pH	TA (%) (lactic acid)	LAB count (log10 cfu/g)
0	6.16 ± 0.05	0.14 ± 0.01	0.00 ± 0.00
1	4.64 ± 0.05	0.61 ± 0.08	6.66 ± 0.10
2	3.73 ± 0.01	0.94 ± 0.00	8.58 ± 0.05
3	3.64 ± 0.01	0.97 ± 0.02	8.63 ± 0.05
4	3.63 ± 0.02	0.98 ± 0.02	8.68 ± 0.10
5	3.62 ± 0.00	0.99 ± 0.01	8.77 ± 0.01

The moisture contents, pH and TA values of sourdough bread dough samples containing wheat bran or dephytinized wheat bran are given in Table 2. The addition of bran increased the moisture content of bread samples, but the effect of the bran addition rate was generally insignificant ($p>0.05$). When the effect of sourdough type on the bread dough moisture content was examined for both bran types, it is seen that the highest results belonged to samples produced with LFS and the lowest results belonged to samples containing VS ($p<0.05$). Although the moisture contents of the bread doughs containing dephytinized wheat bran were higher than the wheat bran added samples, the effect of the dephytinization was generally insignificant ($p>0.05$), except for the samples produced with LCS. The pH and TA values of the bread dough samples generally in-

creased with the addition of bran ($p<0.05$). It was determined that the highest pH and the lowest TA values belonged to the samples produced with VS, the lowest pH and the highest TA values belonged to the bread dough samples containing SS ($p<0.05$). While the pH values of the samples containing wheat bran were higher than the samples containing dephytinized wheat bran, the effect of the dephytinization on the TA value was generally found to be insignificant ($p>0.05$).

Desmazeaud (1983) reported that the acid production ability of *Lactococcus* species is higher than that of *Lactobacillus* species. When the TA values of bread dough samples are examined, it is seen that the TA values of samples containing LCS were higher than that of bread dough samples produced with LFS. It is thought that the high TA values of bread dough samples containing SS may had been due to the activity of homofermentative lactic acid bacteria which were present in sourdough microflora, but not dominantly and could not be obtained as pure.

Aplevicz et al. (2013) determined that the initial pH values of bread doughs containing sourdoughs produced with two different *Lactobacillus paracasei* strains and two different *Saccharomyces cerevisiae* strains were between 4.51-4.73, and the lowest pH value at the end of 10 hours of fermentation was 3.44. It was reported that the highest TA values (6.42-6.51 ml 0.1 N NaOH/10 g of sample) belonged to bread doughs containing sourdough produced with yeast.

3.3. Microbial counts of sourdoughs and bread doughs

In spontaneous sourdough production, while the number of lactic acid bacteria increased by the fermentation progress (Table 1), no yeast growth was observed. It is considered that the number of yeast was below the limit that can be determined at the beginning of fermentation period and the process conditions negatively affected the yeast growth (Vogelmann et al., 2009). The pH decrease occurred rapidly in the sourdough sample, the increase in the number of yeast did not occur due to the predominance of lactic acid bacteria in the following days and the effect of the acid formed. Gobbetti and Gänzle (2012) stated that the number of lactic acid bacteria in sourdough varied from 7 to 9 $\log_{10}$ cfu/g. In this study, it is seen that the number of lactic acid bacteria in the spontaneous sourdough sample reached 8.77 $\log_{10}$ cfu/g and was within the range given in the literature. The LAB counts of VS, LFS and LCS were 5.48, 9.00 and 8.96 $\log_{10}$ cfu/g, respectively. The yeast count of VS was 4.92 log10 cfu/g while no yeast detected in other sourdoughs.

The LAB and yeast counts of bread dough samples are given in Table 2. It was determined that the addition of bran in dough increased the number of LAB, but the effect of the addition rate and type of bran on the LAB number was statistically insignificant ($p>0.05$). It was seen by considering the effect of sourdough type on LAB number that, the sample group with the lowest LAB count was the bread dough samples containing VS ($p<0.05$). The yeast number of bread dough samples increased with the addition of bran. It is seen that the highest yeast number in general belonged to the samples containing LFS and LCS, while the lowest values belonged to the samples produced with VS ($p<0.05$).

The organic acids formed as a result of the action of lactic acid bacteria stimulate the metabolic activity of yeasts. When Table 2 was examined, the number of yeast was also high in samples with a high number of lactic acid bacteria. In addition, although there was no yeast in other sourdough samples, the yeast count in bread dough produced with these sourdoughs, increased to 6.33-7.64 $\log_{10}$ cfu/g, but the yeast number of samples containing VS of which the initial yeast number was 4.92 $\log_{10}$ cfu/g, reached 7.03 $\log_{10}$ cfu/g and this rise was lower than that of other samples. Aplevicz et al. (2013) determined that the LAB and yeast counts of bread doughs containing sourdoughs produced with two different *Lactobacillus paracasei* strains ranged from 8.66-8.91 $\log_{10}$ cfu/g and 7.08-7.18 $\log_{10}$ cfu/g, respectively.

Table 2
The moisture content, pH and TA values, LAB and yeast counts of bread dough samples (mean ± std. error)

Sourdough type	Bran type	Rate of bran (%)	Moisture (%)	pH	TA (%) (lactic acid)	LAB count (log10 cfu/g)	Yeast count (log10 cfu/g)
SS	Wheat bran	0	44.51 ± 0.04^{bAB}	4.07 ± 0.02^{cD}	0.73 ± 0.01^{bA}	8.26 ± 0.00^{bB}	6.33 ± 0.09^{bC}
		5	44.52 ± 0.15^{bBP}	4.17 ± 0.03^{bcCP}	0.80 ± 0.01^{abAP}	8.56 ± 0.03^{aAP}	6.37 ± 0.07^{bCR}
		10	45.39 ± 0.04^{aBP}	4.26 ± 0.02^{bCP}	0.83 ± 0.01^{aAP}	8.65 ± 0.00^{aAP}	6.57 ± 0.09^{bBR}
		15	45.47 ± 0.08^{aABR}	4.58 ± 0.02^{aDP}	0.87 ± 0.03^{aAP}	8.69 ± 0.07^{aAP}	7.08 ± 0.02^{aBR}
	Dephytinized wheat bran	0	44.51 ± 0.04^{bAB}	4.07 ± 0.02^{bD}	0.73 ± 0.01^{aA}	8.26 ± 0.00^{bB}	6.33 ± 0.09^{cC}
		5	45.28 ± 0.11^{abAP}	4.12 ± 0.03^{abCP}	0.74 ± 0.00^{aAR}	8.55 ± 0.09^{aAP}	6.78 ± 0.00^{bBP}
		10	45.67 ± 0.46^{abBCP}	4.20 ± 0.01^{aCP}	0.75 ± 0.02^{aAP}	8.64 ± 0.01^{aAP}	7.42 ± 0.00^{aAP}
		15	46.48 ± 0.16^{aBCP}	4.22 ± 0.02^{aDR}	0.78 ± 0.01^{aAP}	8.67 ± 0.00^{aAP}	7.49 ± 0.04^{aAP}
VS	Wheat bran	0	43.39 ± 0.37^{aB}	5.52 ± 0.02^{cA}	0.36 ± 0.02^{bC}	5.17 ± 0.03^{bC}	6.72 ± 0.01^{aB}
		5	43.65 ± 0.03^{aCP}	5.67 ± 0.01^{bAP}	0.39 ± 0.01^{bCP}	5.41 ± 0.02^{aBP}	6.78 ± 0.04^{aBP}
		10	43.94 ± 0.32^{aCP}	5.72 ± 0.02^{abAP}	0.42 ± 0.01^{bDP}	5.45 ± 0.04^{aBP}	6.85 ± 0.00^{abBR}
		15	44.43 ± 0.42^{aBP}	5.77 ± 0.01^{aAP}	0.50 ± 0.00^{aCP}	5.55 ± 0.05^{aBP}	6.98 ± 0.08^{aBP}
	Dephytinized wheat bran	0	43.39 ± 0.37^{bB}	5.52 ± 0.02^{cA}	0.36 ± 0.02^{aC}	5.17 ± 0.03^{cC}	6.72 ± 0.01^{bB}
		5	43.71 ± 0.19^{bBP}	5.54 ± 0.00^{cAR}	0.36 ± 0.00^{aDP}	5.24 ± 0.00^{bcBR}	6.80 ± 0.03^{bBP}
		10	45.46 ± 0.21^{aCP}	5.62 ± 0.00^{bAR}	0.38 ± 0.00^{aDP}	5.35 ± 0.04^{abBP}	7.01 ± 0.02^{aBP}
		15	45.67 ± 0.05^{aCP}	5.75 ± 0.00^{aAP}	0.41 ± 0.01^{aDR}	5.45 ± 0.01^{aBP}	7.03 ± 0.04^{aBP}

Table 2 (Continue)
The moisture content, pH and TA values, LAB and yeast counts of bread dough samples (mean ± std. error

LFS	Wheat bran	0	45.37 ± 0.03^{bA}	4.74 ± 0.01^{dC}	0.52 ± 0.02^{bB}	8.49 ± 0.01^{bA}	7.30 ± 0.03^{bA}
		5	46.22 ± 0.09^{abAP}	4.95 ± 0.01^{cBP}	0.56 ± 0.03^{abBP}	8.63 ± 0.03^{aAP}	7.31 ± 0.03^{bAP}
		10	46.43 ± 0.00^{abAR}	5.10 ± 0.01^{bBP}	0.58 ± 0.01^{abCP}	8.69 ± 0.02^{aAP}	7.38 ± 0.04^{abAP}
		15	46.97 ± 0.54^{aAP}	5.22 ± 0.00^{aBP}	0.64 ± 0.01^{aBP}	8.73 ± 0.02^{aAP}	7.50 ± 0.02^{aAP}
	Dephytinized wheat bran	0	45.37 ± 0.03^{bA}	4.74 ± 0.01^{cC}	0.52 ± 0.02^{aB}	8.49 ± 0.01^{aA}	7.30 ± 0.03^{cA}
		5	46.27 ± 0.27^{bAP}	4.84 ± 0.01^{bBR}	0.53 ± 0.01^{aCP}	8.50 ± 0.03^{aAP}	7.34 ± 0.01^{bcAP}
		10	47.87 ± 0.25^{aAP}	4.87 ± 0.01^{bBR}	0.55 ± 0.01^{aCP}	8.66 ± 0.07^{aAP}	7.49 ± 0.05^{abAP}
		15	48.26 ± 0.25^{aAP}	5.01 ± 0.02^{aBR}	0.58 ± 0.01^{aCP}	8.70 ± 0.06^{aAP}	7.53 ± 0.00^{aAP}
LCS	Wheat bran	0	44.43 ± 0.31^{bAB}	4.85 ± 0.00^{cB}	0.56 ± 0.03^{cB}	8.52 ± 0.03^{cA}	7.20 ± 0.00^{bA}
		5	44.85 ± 0.01^{abBR}	4.94 ± 0.00^{bBP}	0.62 ± 0.01^{bcBP}	8.62 ± 0.01^{bcAP}	7.44 ± 0.03^{aAP}
		10	45.53 ± 0.14^{abABR}	5.10 ± 0.00^{aBP}	0.71 ± 0.01^{abBP}	8.65 ± 0.02^{abAP}	7.48 ± 0.01^{aAP}
		15	45.87 ± 0.23^{aABR}	5.12 ± 0.01^{aCP}	0.77 ± 0.02^{aAP}	8.77 ± 0.02^{aAP}	7.54 ± 0.04^{aAP}
	Dephytinized wheat bran	0	44.43 ± 0.31^{bAB}	4.85 ± 0.00^{aB}	0.56 ± 0.03^{bB}	8.52 ± 0.03^{bA}	7.20 ± 0.00^{cA}
		5	45.57 ± 0.00^{bAP}	4.90 ± 0.03^{aBP}	0.57 ± 0.01^{bBP}	8.53 ± 0.02^{bAR}	7.46 ± 0.03^{bAP}
		10	47.30 ± 0.23^{aABP}	4.91 ± 0.01^{aBR}	0.62 ± 0.01^{abBR}	8.58 ± 0.02^{bAP}	7.58 ± 0.03^{abAP}
		15	47.46 ± 0.20^{aABP}	4.92 ± 0.01^{aCR}	0.69 ± 0.00^{aBP}	8.73 ± 0.02^{aAP}	7.64 ± 0.01^{aAP}

Values followed by different superscript letters (series "a-d") within each column (indicating differences among average of bread dough samples at same sourdough type with same bran type and with different addition rate) by different uppercase letter series "A-D" within each column (indicating differences among average of bread dough samples at different sourdough type with same bran type and with same addition rate) and series "P-R" within each column (indicating differences among average of bread dough samples at same sourdough type with different bran type and with same addition rate) are significantly different at $p<0.05$.

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