Chemical, rheological and bread making characteristics of bran duster flours from roller flourmills

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Abstract Bran dusters are used in the wheat flour milling process to increase flour extraction rate. Chemical, rheological and bread characteristics of bran duster flours (BDR1, BDR2, BDR3) and straight run flour (SRF) obtained from two commercial roller flour mills were analyzed. Important chemical characteristics such as ash, dry gluten content, sedimentation value, damaged starch and falling number of bran duster flours were determined. Rheological behavior was tested using farinograph and alveograph equipments. The results showed an increase in ash, dry gluten content and Zeleny's sedimentation value for bran duster flours compared to SRF. Rheological characteristics indicated higher farinograph dough development time and stability values for bran duster flours. Alveograph characteristics indicated higher extensibility and lower elasticity values for bran duster flours. Over all quality score of bread for BDR1 from A and B roller flour mills ranged from 73.4 to 74.7, BDR2 (79–81.8), BDR3 (69–70.4) as against SRF (85.4–86.3).

Keywords Wheat · Roller flour milling · Bran duster flour · Rheology · Bread making quality

Introduction

Wheat kernel structure broadly consists of three main constituents: Endosperm, bran and germ. Endosperm, the major constituent, contains mainly starch granules embedded in a proteinaceous matrix and accounts for 81–84 % of the grain.

Germ contains the embryo and the scutellum and amounts to 2–3 % of the grain. Bran, which forms 14–16 % of the grain, consists of all outer layers including the aleurone layer, which is usually removed along with the other bran layers during milling, although botanically the aleurone layer is the outer layer of the endosperm (MacMasters et al. 1964).

The wheat flour milling process involves breaking open the grain, scraping the endosperm from bran & germ by break rolls and then gradually reducing the chunk of the endosperm into flour by a series of grindings by reduction rolls, with intermediate separation of products by sifters & purifiers (Bass 1988).

The objective of the break system is to open the wheat kernel and remove the endosperm and germ from bran coat with least amount of bran contamination. The break system can be divided into two parts, primary or head break system, which releases relatively pure particles of endosperm and secondary or tail break system, which cleans up the bran and releases smaller pieces of endosperm (Posner and Hibbs 2005). The number of stages used in the break system is usually four or five. The flour produced by tail passages is fine and sticky in nature, hence sticks to the bran and goes along with it. This results in the loss of endosperm and lowering the extraction of flour. To recover the adhering endosperm from the bran, the bran dusters are used in the roller flour mills. The bran dusters remove from the bran skin any endosperm that may still be adhering and recover it as a flour thus increases the flour extraction rate in the mill. The bran duster uses rotating beaters to seize the tangentially incoming stream of bran and fling it against the impact wall and the screen. The bran is repeatedly picked up by the rotor, gradually causing flour particles to become completely detached. Endosperm passes through the aperture while bran overtails the machine. There are small pieces of very fine bran particles in the throughs, which are further dressed out to get flour. The bran dusters are designed as either

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horizontal or vertical. In the horizontal duster, stock travels from end to end, while in the vertical duster stock travels from top to bottom or bottom to top.

These impact bran dusters are also used between the breaks ahead of the roll to shorten the system to reduce the number of rolls. It is common for soft to have during milling of soft wheat and many hard wheat milling a four break steps in combination with impact dusters to reduce the roll surface used in the break system (Posner, and Hibbs 2005). The aim of the present study was to analyze the chemical, rheological and bread making characteristics of bran duster flours obtained by commercial roller flour milling of wheat.

Materials and methods

Bran duster flour

The bran duster flours and straight run flours were obtained from two commercial mills. (mill A and mill

B) with the capacity of 120 tonnes/day. The roller flour mills consisted of five break passages (B1 to B5), three sizing passages (1R to 3R), four purifier passages (S1 to S4) and three bran dusters (BDR1 to BDR3). The positions of the bran dusters in the flow sheet of the mills are shown in the Fig. 1. The location of first bran duster (BDR1) was in between scalping of the B3 break to B4. The second bran duster (BDR2) was before the coarse bran packing and third bran duster (BDR3) was before the fine bran packing.

Chemical and rheological characteristics of SRF and DBR flours

Chemical characteristics of DBR flours and SRF such as moisture, total ash, dry gluten, Zeleny's sedimentation value, damaged starch, falling number and rheological characteristics using farinograph and alveograph were determined using American Association of Cereal Chemists (2000) methods. Each analysis was carried out in triplicate.

Fig. 1 Location of bran duster in the mill flow diagram. *BK* break roll, *BDR* bran duster

Bread making characteristics

Bread making characteristics were studied using the following formulation: flour 100 g, compressed yeast: 2.0 g, salt: 1.0 g; sugar: 3.0 g, hydrogenated fat: 1.0 g and water: farinograph water absorption. Breads in quadruplicate were prepared by mixing the ingredients in a Hobart mixer (Model N-50, Hobart, GmbH, Offenburg, Germany) with a flat blade for 3 min at 61 rpm. The dough was fermented in a chamber maintained at 30 °C and 75 % relative humidity (RH) for 90 min, remixed, rounded, and again fermented for 25 min, moulded, proofed for 55 min at 30 °C, 85 % RH and baked for 25 min at 220 °C, cooled and packed.

Bread weight was recorded; bread volume was determined using rapeseed displacement method. Crumb firmness was measured according to AACC (2000) procedure using texture analyser (Model TaHdi, Stable Microsystems, Godalming, Surrey, UK) under the following conditions: sample thickness –25 mm, load cell –10 Kg, plunger diameter –36 mm and plunger speed –100 mm per minute. Crumb firmness, which is a force at 25 % compression, was measured. Ten panellists (age range 25–55 years both male and female) who were familiar with the quality aspects of bread were further oriented in four sessions involving 2 h of training in each session. 4 samples of bread in 4 replicates were evaluated by each panellist following a score card consisting of various quality parameters like crust color (1= very pale/very dark brown; 10= golden brown); shape (1= flat, uneven; 15= convex shape); symmetry (1= with low end or overlapping; 15= symmetrical); crumb color (1= brown; 10= white); grain (1= very coarse; 20= very fine); mouthfeel (1= doughy/sticky; 20= easy breakdown and clean mouthfeel); taste (1= foreign; 10= typical and pleasant). The overall quality score (max. 100) was taken as the combined score of all the above attributes. The above score card for evaluation of bread was prepared as per the method of evaluation of bread by Indrani et al. (2003).

Statistical analysis

The data related to chemical and rheological characteristics and bread making characteristics were statistically analysed using Duncan's new multiple range tests (DMRT) with different experimental groups appropriate to the completely randomized design with four replicates each as described by Steel and Torrie (1960). The significant level was established at $P \leq 0.05$.

Results and discussion

Chemical characteristics

The data (Table 1) shows that the moisture content of BDR1 and BDR2 flours are higher than the SRF. The SRF is a

Table 1 Chemical characteristics of straight run flour and bran duster flours

	Mill A			Mill B		
	SRF	BDR1	BDR2	BDR3	SRF	BDR1
Moisture (%)	11.5 ^a ±0.05	12.6 ^b ±0.04	12.2 ^b ±0.01	11.4 ^a ±0.04	11.3 ^a ±0.02	12.3 ^b ±0.03
Ash (%)	0.54 ^a ±0.012	0.69 ^b ±0.014	0.94 ^c ±0.019	0.90 ^c ±0.013	0.56 ^a ±0.018	0.70 ^b ±0.011
Dry Gluten (%)	9.1 ^a ±0.08	9.9 ^b ±0.10	12.2 ^c ±0.09	9.6 ^b ±0.06	9.2 ^a ±0.05	10.3 ^b ±0.06
Zeleny's sedimentation value (ml)	25.0 ^a ±0.05	29.7 ^b ±0.08	32.0 ^c ±0.04	26.3 ^a ±0.05	24.0 ^a ±0.06	28.7 ^b ±0.05
Falling Number (sec)	396.3 ^d ±2.50	380.0 ^c ±1.50	319.7 ^a ±2.00	366.3 ^b ±2.75	377.7 ^d ±1.75	351.0 ^c ±2.00
Damaged Starch (%)	8.0 ^c ±0.04	4.1 ^a ±0.03	4.5 ^a ±0.05	7.0 ^b ±0.05	8.2 ^c ±0.06	5.1 ^a ±0.04

Values are means of three replicate±standard deviation

Except moisture, all values are on dry weight basis

SRF straight run flour, BDR1 bran duster 1, BDR2 bran duster 2 and BDR3 bran duster 3

Values of the row (within the mill) with the same letter in the superscript are not significantly different from each other at $p < 0.05$

combination of all flour streams produced in the mill (break passages, sizing passages, reduction passages and bran dust-er flours). In the milling process the milled products are transported by pneumatics, ground into flour by rolls with pressure that results in the moisture loss. The BDR1 and BDR2 located after third break and fourth break respectively, receives the product transported by less pneumatic lifts has shown higher moisture than SRF. The BDR3 located after the last break and last reduction passages which treats products transported by more pneumatic lifts and grinding stages has shown the less moisture content in both the mills.

The ash content of the BDR1 flour is significantly lesser than the BDR2 and BDR3 as it receives the product with more endosperm. During milling, front break passages (B1, B2 and B3) releases relatively pure particles of endosperm and tail break passages (B4 and B5) cleans up the bran by deep scrapping and releases smaller pieces of endosperm along with the more fine pieces of bran and germ. Also the roll gap decreases from the B1 to B5, which has resulted in the higher ash content in BDR2 and BDR3 flours as shown by both the mills. The ash content increases with increase in break and reduction passages (Sakhare and Inamdar 2011). This increase in ash could be also due to partial recovery of aleurone layer by bran dusters, which contain about 60 % of the total mineral content of the wheat kernel (Hinton 1959).

The data show the presence of higher gluten content in the BDR flours than the SRF. The dry gluten content of 9.1 %, 9.9 %, 12.2 %, 9.6 % were observed for SRF, BDR1, BDR2, and BDR3 for mill A; 9.2 %, 10.3 %, 11.6 %, 10.1 % for mill B respectively. This is in agreement with the results reported by Ziegler and Greer (1978); Kent (1966); Dornez, et al. (2006) who also reported higher protein content in tail break streams.

The damaged starch values of BDR flours were lower than the SRF possibly due to the less severity of grinding at break roll passages. However among the three different BDR flours, the damaged starch content of BDR3 was higher than the BDR1 and BDR2 flours as the BDR3 receives the material from the last reduction passage along with break passage. The observation that break rolls produces less starch damage than the reduction rolls, as severity of grinding is more incase of reduction rolls has been made by Holas and Tipples (1978) and Dube, et al. (1987).

Lower falling number in the BDR flours indicated higher alpha amylase activity, which could be due to the presence of bran particles and aleurone layer. These results are generally in accordance with those of Kruger and Tipples (1980) who reported that in fully mature wheat grain alpha amylase activity is mostly located in seed coat, aleurone layer and scutellum and higher level of alpha amylase is present in end breaks. (Rani, et al. 2001; Symons and Dexter 1997)

Rheological characteristics

Farinograph characteristics

The farinograph characteristics of BDR flours and SRF are given in Fig. 2a–d. Farinograph water absorption (FWA) values were higher for the BDR2 followed by the BDR3 and BDR1. The dough development time (DDT) for the BDR flours are higher than the SRF. The DDT values varied

Fig. 2 Farinograph characteristics of straight run flour and bran duster flours. SRF straight run flour, BDR1 bran duster 1, BDR2 bran duster 2 and BDR3 bran duster 3. $n=4$

Fig. 3 Alveograph characteristics of straight run flour and bran duster flours: P Maximum over pressure, L average abscissa at rupture, P/L curve configuration ratio. *SRF* straight run flour, *BDR1*: bran duster 1, *BDR2* bran duster 2 and *BDR3* bran duster 3. $n=4$

from 5.8 to 6.0 min for BDR1. BDR2 (9.8 to 10.6 min), BDR3 (5.8 to 6.2 min) when compared to SRF (4.9 to 5.0 min) for mill A and mill B. These results shown that the DDT values for the BDR flours are higher than the SRF and among three different BDR flours, BDR2 flours shared highest DDT.

Similarly the dough stability (DS) values for the bran duster flours were higher when compared to SRF. Indicating higher strength for BDR flours which could be due to the presence of higher gluten content of bran duster flours. The DS varied from 6.9 to 9.8 min; 4.9 to 9 min for the BDR flours of mill A and mill B respectively. The highest DS

Table 2 Bread making characteristics of straight run flour and bran duster flours

Bread	Mill A				Mill B			
	SRF	BDR1	BDR2	BDR3	SRF	BDR1	BDR2	BDR3
Volume (ml)	514.8 ^c ±2.55	480.2 ^b ±3.05	524.9 ^d ±2.01	460.4 ^a ±3.25	499.8 ^c ±2.00	465.4 ^b ±1.50	510.1 ^d ±3.05	439.7 ^a ±3.00
Crumb firmness (Force, g)	405.2 ^b ±3.00	444.8 ^c ±2.55	380.4 ^a ±2.00	480.1 ^d ±2.25	414.7 ^b ±4.05	464.8 ^c ±4.00	390.3 ^a ±2.50	500.2 ^d ±2.55
Crust** Color (10)	7.8 ^{ab} ±0.05	6.8 ^a ±0.01	8.1 ^{ab} ±0.02	7.2 ^a ±0.01	7.8 ^{ab} ±0.03	7.1 ^a ±0.04	8.2 ^{ab} ±0.01	7.2 ^a ±0.02
Shape (15)	12.7 ^c ±0.10	11.2 ^b ±0.11	14.3 ^d ±0.15	9.7 ^a ±0.08	12.1 ^c ±0.05	10.0 ^b ±0.15	12.2 ^c ±0.05	8.9 ^a ±0.10
Symmetry (15)	13.1 ^b ±0.05	11.8 ^a ±0.10	13.2 ^b ±0.11	11.2 ^a ±0.06	12.2 ^b ±0.08	11.2 ^a ±0.07	11.8 ^b ±0.04	10.7 ^a ±0.05
Crumb Color (10)	8.9 ^d ±0.01	7.1 ^c ±0.02	5.2 ^a ±0.01	6.1 ^b ±0.03	8.8 ^c ±0.02	6.2 ^b ±0.03	5.1 ^a ±0.02	4.9 ^a ±0.02
Grain (20)	17.8 ^d ±0.15	14.8 ^b ±0.05	16.3 ^c ±0.12	13.2 ^a ±0.05	17.7 ^d ±0.08	13.7 ^b ±0.09	16.8 ^c ±0.10	12.3 ^a ±0.12
Mouthfeel (20)	18.0 ^b ±0.15	15.8 ^a ±0.25	16.9 ^a ±0.28	15.8 ^a ±0.30	17.7 ^b ±0.25	17.2 ^a ±0.10	17.1 ^a ±0.15	17.2 ^a ±0.19
Taste (10)	8.0 ^b ±0.05	7.2 ^a ±0.02	7.8 ^a ±0.04	7.2 ^a ±0.03	9.1 ^b ±0.02	8.0 ^a ±0.03	7.8 ^a ±0.02	7.8 ^a ±0.02
Overall quality (100)	86.3 ^d	74.7 ^b	81.8 ^c	70.4 ^a	85.4 ^d	73.4 ^b	79.0 ^c	69.0 ^a

SRF straight run flour, *BDR1* bran duster 1, *BDR2* bran duster 2 and *BDR3* bran duster 3

* Values in the row (within the mill) with the same letter in superscript are not significantly different from each other at $p \leq 0.05$

** The figures in the parenthesis indicate maximum score for crust and crumb parameter

Data are mean of four replicate±standard deviation

value of 9.8 min and 9 min observed for the BDR2 flours of A and B mill. Aitken and Geddes (1938, 1939), and Pfeifer et al. (1958) also reported that, with an increase in protein content, a strengthening of farinograph curve occurs.

Mixing tolerance index (MTI) for bran duster flour ranged between 40 to 46 BU for mill A and 48 to 54 BU for B mill when compared to 51 to 56 BU of SRF. It is clear from the above data the BDR flours are stronger than SRF. Among different BDR flours BDR2 showed the highest strength.

Alveograph characteristics

The alveograph characteristics of BDR flours and SRF are shown in Fig. 3. The maximum over pressure (P), a measure of dough elasticity, was found highest for the SRF when compared to BDR flours. The P value of 66 mm and 60 mm was observed for BDR2 of A mill and B mill respectively. The average abscissa at rupture (L), which is a measure of dough extensibility, was lower for the SRF as compared to BDR flours. The L values of BDR flours varied from 80 to 98 mm and 74 to 86 mm for A and B mill respectively. The values for curve configuration ratio (P/L), indicating the ratio of elasticity and extensibility of the dough were higher for SRF than the bran duster flours. The P/L value was 1.72 and 1.71 for SRF of A and B mill, while the value varied from 0.67 to 0.88 and 0.69 to 0.74 for BDR flours of A and B mill respectively. These results indicate that the SRF are more elastic than the BDR flours, whereas the BDR flours are more extensible than SRF. Banu et al. (2010) and Holas and Tipples (1978) also opined that the flour from end break passages are characterized by high value for area and length with high extensibility and less elasticity.

Baking characteristics

Bread making characteristics (Table 2) of BDR flours and SRF from mill A and mill B showed that, among different BDR flours, BDR2 flour showed highest volume (510.1–524.9 ml) followed in decreasing order by BDR1 (465.4–480.2 ml) and BDR3 (439.7–460.4 ml). The SRF showed volume in the range of 499.8–514.8 ml. The crumb firmness value, a measure of texture showed that the bread from BDR2 flours were softer as indicated by lowest score of 380.4–390.3 g than all other breads. Sensory evaluation showed that the breads from BDR1 and BDR3 flours had brown crust colour as shown by the sensory score ranged from 6.8–7.2 for the maximum score of 10, reduced crust shape ranged from 8.9–11.2, symmetry (10.7–11.8), dense crumb grain with thick cell walls (12.3–14.8) and possessed slight sticky mouth feel (15.8–17.2). The overall quality scores, a measure of combined scores of crust and crumb characteristics ranged from 70.4–74.7 and 69–73.4 for

breads of BDR1 and BDR3 flours from mill A and mill B respectively. However the overall quality of bread from BDR2 was better than BDR1 and BDR3 as indicated by higher sensory scores for crust shape, symmetry, crumb grain, mouth feel and over all quality score (79–81.8). The bread from SRF had the highest overall quality score (85.4–86.3). These results indicate that even though the overall bread making quality of BDR flours showed variation, these flours have a great potential for bread making.

Conclusions

The study observed that the BDR flours are higher in protein content, ash content and showed variation in baking characteristics. The rheological properties of the bran duster flours have shown higher dough development time, dough stability and extensibility as compared to SRF. The above result may be taken in to account, while mixing and blending the BDR flours for getting the flour with certain end use products in the roller flour mill.

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