Investigation note

Quality characteristics of whole and refined flour dough and its relationship with bread volume

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Abstract

Within the flour wheat genetic improvement program, bakery quality as a selection criterion is delayed and expensive, so variables that help to select it indirectly must be identified. The objective of this research was to relate the kneading variables in whole wheat flour with the industrial characteristics of the doughs and their volume of bread in refined flour. Protein content and sedimentation volume in refined flour, kneading time and stability, kneading tolerance and mixogram height in whole and refined flour, dough strength, tenacity-extensibility relationship and bread volume in refined flour were measured. The average value and Pearson correlations were obtained, genotypes were classified based on their bread volume, and an average comparison was made. The volume of bread was positively correlated with kneading time in whole meal flour (0.6). In addition, the stability to kneading in whole meal wheat flour was correlated with kneading time in refined flour (0.5) and dough strength (0.5). Bread volumes greater than 800 cc had kneading times of 2.4 to 2.9 min in whole flour. So, the use of time and stability of kneading in whole meal flour would help to efficient the selection of genotypes with masses of baking characteristics.

Keywords: *Triticum aestivum* L., bread volume, kneading characteristics, whole meal flour.

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One of the most important selection criteria within the flour wheat improvement program (*Triticum aestivum* L.) of the National Institute of Agricultural and Livestock Forestry Research (INIFAP) is the selection of lines with higher bakery quality (Espitia-Rangel *et al*., 2017). This bakery quality is measured as a volume of bread which is commercially estimated as the highest number of pieces of bread per quantity of flour used. The determination of this volume is carried out in a loaf originating from 100 g of refined flour so that at least 200 g of grain are required to obtain the amount of flour indicated, likewise the test requires approximately 4 h for its realization, in addition to the use of specialized equipment such as the fermenter and electric oven.

Therefore, due to the sample size used, the time used to carry out the test and the use of specialized infrastructure, it is important to identify dough variables that indirectly help to select lines with a greater bread volume using less grain, time, and equipment. In this context several authors have indicated significant correlations of bread volume with variables determined in refined flour such as protein in flour (Dowell *et al*., 1989), sedimentation volume (Takata *et al*., 1999) kneading time in the mixograph (Miles *et al*., 2020) as wellas, dough strength and the relationship between tenacity-extensibility determined in the alveograph (Guzman *et al*., 2017). However, the ratio of bread volume to kneading properties in whole meal flour needs to be further studied. The objective of the research was to relate the characteristics of kneading using the mixograph using whole meal flour with the mixographic, alveographic variables and bakery quality determined in refined flour.

39 lines of the flour wheat improvement programme of the Bajío Experimental Field (CEBAJ) were used. To obtain the whole meal flour, 50 g of grain was ground without adding water in a UDY-type mill using a 0.5 mm mesh, then the samples were sifted with an 8xx mesh for two minutes to obtain a flour with homogeneous particle size. To obtain refined flour grinding was carried out in a Bhuler mill (Brabender OHG, Germany) according to method 26-31 of the AACC (2005). The protein content (%) was determined in refined flour with the near-infrared reflectance analyzer (NIR Feed & Forage 5000) using 39-00 method of the AACC (2005).

As well, with refined flour was obtained by Zeleny test the sedimentation volume (ml) (56-61A method; AACC, 2005) with 3.2 g of flour in the presence of bromophenol blue and isopropyl alcohol. Kneading time (min), tolerance to over kneading (mm), kneading stability (min) and mixogram height (mm), was estimated by the mixographer (National Manufacturing Co., Lincoln, NE) using the 54-40A method of the AACC (2005) in samples of 10 g of whole meal and refined flour. The strength (W) and tenacity/extensibility ratio (PL) of the dough were calculated from the alveogram which was obtained from 60 g of refined flour using Chopin alveographer (Tripette & Renaud, France) using 54-30A method of the AACC (2005).

The volume of bread (ml) was made using the direct mass method (10-09 method, AACC, 2005) from 100 g of refined flour and determined in a volutometer by displacement of canola seeds (*Brassica campestris* L.). The average value, standard deviation, and range were obtained for each of the analyzed variables and correlations were made using Pearson testing between variables. In addition, from the groups generated based on their bread volume, group 1 greater than 900 cc, group 2 from 800 to 900 cc, group 3 from 700 to 800 cc and group 4 from 600 to 700 cc, the Tukey test (α= 0.05) was performed to identify the differences.

Table 1 presents the average, maximum, and minimum values for each of the variables evaluated. The average values for kneading time in whole meal and refined flour were similar (2.5 and 2.6 min, respectively) and their ranges were 1.6 to 3.5 and 1.3 to 3.9 min, respectively. Based on the alveogram the average dough strength was 252 and varied from weak dough (84 x10^{-4} J) to strong dough (524 x 10^{-4} J). The tenacity-extensibility ratio (PL) had an average of 1.1 and ranges from 0.2 to 4.3. So based on force variables there are masses in the genotypes analyzed as weak (W<200 x 10^{-4} J), medium (200 to 300 x 10^{-4} J) and strong (>300 x 10^{-4} J).

Table 1. Mean, minimum and maximum values and standard deviation (DS) of industrial quality of bread wheat genotypes.

Variable	Mean	Minimum	Maximum	DS
Kneading time in whole flour (min)	2.5	1.6	3.5	0.5
Tolerance to over-kneading in whole flour (mm)	10	3	14	2.6
Stability when kneading in whole flour (min)	3.4	2.3	5.3	0.7
Mixogram height in whole flour (mm)	74.9	62	91	6.8
Protein in refined flour (%)	10.3	9.3	11.9	0.6
Sedimentation volume (ml)	29.1	20	38	4.7
Kneading time in refined flour (min)	2.6	1.3	3.9	0.6
Tolerance to over kneading in refined flour (mm)	4.9	1	10	2.3
Stability when kneading in refined flour (min)	4.1	2.1	5.6	1
Mixogram height in refined flour (mm)	62.2	52	72	5.5
Dough force (x10^{-4} J)	252	84	524	109.5
Tenacity-extensibility ratio	1.1	0.2	4.3	0.8
Bread volume (cc)	804.6	620	1010	108.2

While due to their tenacity-extensibility relationship, they were classified as extensible by their P/L < 1, balanced by their PL= 1 and tenacious by their P/L> 1.2. For the characteristics of the dough, previously noted, the volume of bread had an average of 804.6 cc and a range from 620 to 1 010 cc, which indicates that in the group of genotypes there are wheat lines with a volume of bread classified as regular from 500 to 600 cc, up to excellent > 900 cc.

Table 2 presents Pearson correlations between the variables analyzed. The important parameter that defines bakery quality is the volume of bread, which was highly and positively correlated with sedimentation volume (0.7), kneading time in wholemeal flour (0.6), dough strength (0.6) and kneading time in refined flour (0.5), Table 2. similar results in refined flour were found for kneading time in the mixograph by Baasandorj *et al*. (2020); in addition, Villaseñor *et al*. (2017) indicated that greater force associated with dough extensibility, determined in the alveograph, favors the volume of bread.

Table 2. Pearson correlations between industrial-quality variables of flour wheat genotypes.

	TSAHI	EAMHI	AMHI	pH	VS	TAHR	TSAHR	EAMHR	AMHR	W	PL	VP
TAHI	-0.4*	0.4**	0.1ns	0.01ns	0.7**	0.8**	-0.1ns	0.3*	0.08ns	0.7**	0.02ns	0.6**
TSAHI		-0.7**	0.3ns	0.1ns	-0.3*	-0.4*	0.03ns	-0.2ns	-0.01ns	-0.5**	-0.1ns	-0.2ns
EAMHI			0.1ns	-0.1ns	0.4*	0.5**	-0.3ns	0.4*	0.1ns	0.5**	0.03ns	0.2ns
AMHI				0.5**	0.3*	0.2ns	-0.2ns	0.3*	0.1ns	0.2ns	0.1ns	-0.01ns
PH					0.1ns	0.01ns	-0.1ns	0.1ns	-0.07ns	0.2ns	-0.2ns	0.03ns
VS						0.7**	-0.3ns	0.4*	0.1ns	0.7**	-0.2ns	0.7**
TAHR							-0.3ns	0.4*	0.1ns	0.7**	0.04ns	0.5**
TSAHR								-0.8**	0.4*	-0.4*	0.2ns	-0.3*
EAMHR									-0.2ns	0.5**	-0.05ns	0.3*
AMHR										0.01ns	0.3*	-0.1ns
W											-0.01ns	0.6**
PL												-0.5**

TAHI; TSAHI and EAMHI= time, tolerance, stability to kneading in whole flour, respectively; AMHI= mixogram height in whole flour; PH= protein in flour; VS= sedimentation volume; TAHR; TSAHR and EAMHR= time, tolerance and stability to kneading in refined flour, respectively; AMHR= mixogram height in refined flour; W= dough force; PL= tenacity-extensibility ratio; V= bread volume.

On the other hand, high and significant correlations of kneading time were also found in whole flour with kneading time in refined flour (0.8), sedimentation volume (0.7) and dough strength (0.7). So kneading time in whole flour is a variable that can help to select for greater dough strength and bread volume, as well as kneading time and sedimentation volume in refined flour.

Likewise, the stability of kneading in whole flour was positively correlated with kneading time in refined flour (0.5) and dough strength (0.5). So, the time and stability when kneading in whole flour are adequate to select genotypes with greater dough strength and consequently favor the volume of bread.

Table 3 shows the averages of the variables studied by quality group based on their bread volume. Group 1 of higher bread volume classified as excellent for its value greater than 900 cc presented kneading times of 2.9 and 3.1 min in whole and refined flour, respectively. As well as 33 ml sedimentation volume in refined flour. While for group 2 of bread volume listed as very good from 800 to 900 cc showed kneading time values of 2.4 and 2.5 min for whole and refined flour, respectively. Based on its alveographic variables, the group 1 was characterized by having strong masses (W= 331.1 x 10^{-4} J) associated with extensible masses because of their tenacity-extensibility ratio (PL) less than 1.

Table 3. Comparison of averages of industrial quality variables by group (G) of bakery quality.

G	TAHI (min)	TSAHI (mm)	EAMHI (min)	AMHI (mm)	PH (%)	VS (ml)	TAHR (min)	TSAHR (mm)	EAMHR (min)	AMHR (mm)	W (x10^{-4} J)	PL (0.1-6)	VP (cc)
1	2.9a	9.2a	3.5a	75.4a	10.3a	33.3a	3.1a	4.1a	4.5a	61.5a	331.1a	0.7b	929a
2	2.4b	9.4a	3.7a	74.2a	10.3a	30ba	2.5ba	4.2a	4.4a	62.5a	291.6a	0.9b	848.1b
3	2.2b	11a	3.2a	73.6a	10a	25.2c	2.3b	5.4a	3.7a	60.1a	169.5b	1b	727.2c
4	2.1b	10.7a	3.1a	76.2a	10.4a	26.1bc	2.3b	6.3a	3.6a	65.1a	181.3b	2a	660.5d

Group 1=> 900 cc, group 2 from 800 to 900 cc, group 3 from 700 to 800 cc, group 4 from 600 to 700 cc, TAHI, TSAHI and EAMHI= time, tolerance, stability to kneading in whole flour, respectively; AMHI= mixogram height in whole flour; PH= protein in flour; VS= sedimentation volume; TAHR, TSAHR and EAMHR= time, tolerance and kneading stability in refined flour, respectively; AMHR= mixogram height in refined flour; W= dough force; PL= tenacity-extensibility ratio; VP= bread volume.

Group 2 exhibited medium and strong masses, for its values of W= 291.6 and by its PL it was classified as extensible. On the other hand, groups 3 and 4 with bread volumes less than 800 cc had kneading times less than 2.3 in whole flour and 2.4 in refined flour. On the other hand, they had mass strength values less than 200 x10^{-4} J which classifies them as weak masses. Group four had high values of tenacity PL= 2, which was reflected in its lowest value of bread volume.

Conclusions

Based on the above, the time and kneading stability variables determined in 10 g of whole flour using the mixograph, can be used to select genotypes that favor the strength of the dough and indirectly the volume of bread. This will help to discriminate in shorter time and smaller sample size, genotypes with little strength and consequently lower bakery quality.

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