THE CENTRIFUGE METHOD FOR DETERMINING FLOUR ABSORPTION IN HARD RED SPRING WHEATS[1]

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ABSTRACT

A study of factors influencing centrifuge absorption when applied to hard spring wheats has been made. Greater precision was obtained by increasing the size of sample and oven-drying the centrifuge tubes before weighing. Higher correlations with baking and farinograph absorption were obtained using eight mixing periods as compared to four mixing periods.

The modified procedure gave sufficiently high correlations with baking and farinograph absorption to indicate its possible usefulness in selection for flour absorption among plant breeders' samples. An analysis of 17 hybrid populations in the F_4 generation indicated that a wide range in centrifuge absorption existed among single plant segregates in many of the crosses. Certain varieties appeared to be particularly useful as parents in breeding for flour absorption.

The most specific method presently available for estimating flour absorption during the baking process is the farinograph test. It is of general interest to find a more simple and rapid technique which might furnish data on the comparative absorption of water by flour.

Finney and Yamazaki (2) established a relationship between the loaf volume of hard red spring wheats and the amount of water held by a flour against a centrifugal force applied to the flour when suspended in a lactic acid medium. Maes and Pirotte (4) related the water held against a centrifugal force with the baking absorption of flour. Their procedure for estimating flour absorption in small samples involved the addition of excess water to 1.5 g. of flour in tared centrifuge tubes. The suspension was mixed vigorously four times with a fine glass rod, allowing 10-minute rest periods between each mixing. After centrifuging at 3,250 revolutions for 25 minutes, the supernate was decanted and the tubes air-dried. The centrifuge absorption was calculated from the increase in weight of the flour. Belderok[3] found that eight mixing times and centrifuging at 2,300 r.p.m. ($750 \times g$) was more satisfactory for flours with strong gluten.

The present study was initiated to determine the usefulness of the centrifuge method in selecting for flour absorption in plant breeders' samples of hard red spring wheats. An investigation of factors affecting

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centrifuge absorption was made and further modifications of the procedure are proposed.

Materials

The flour samples used in the early part of this study were milled from plant breeders' hybrids grown in the 1958 and 1959 Saskatoon yield trials. For the most part the parentage of these hybrids included several backcrosses to the variety Thatcher, and the flour samples were typical of the hard red spring wheats in quality. The range in protein content of the 58 hybrids from the 1958 test was from 13.7 to 17.5%, with an average of 15.8%. The 24 hybrids in the 1959 trial had a range in protein of 13.9 to 17.4% and averaged 16.0%. These wheats were milled in an Allis-Chalmers experimental mill to a standard flour yield of 73% and the baking absorption was determined.

In addition, composite flour samples of 37 varieties grown at several stations in Western Canada in 1959 were analyzed for centrifuge, farinograph, and baking absorption. The entries in this regional variety trial represented a wide range of quality types from weak soft wheat to strong hard wheat varieties. Their protein content ranged from 11.0 to 16.5% and averaged 14.5%.

To illustrate the utility of the centrifuge method of determining flour absorption, the progeny of 17 crosses were grown in bulk for three generations. Five hundred F_4-generation seeds from each cross were space-planted 1 ft. apart in a field nursery in 1959. About ten single plant selections from each cross were individually harvested and threshed. The seed yields ranged from 25 to 40 g. per plant. These samples were micromilled on a Geddes and Frisell experimental flour mill (3) to 65% extraction and analyzed for centrifuge absorption by a modified procedure. The remaining single plants were bulked before threshing and the seed milled on the Allis-Chalmers mill. Sufficient flour was obtained for the farinograph and centrifuge absorption determinations.

Standard procedures were used in making the baking and farinograph tests (1). The method used to calculate all flour absorption values reported in this paper was the constant flour weight procedure, 14% moisture basis. Unless otherwise stated, all samples were analyzed in duplicate.

Modification of the Test

The values obtained by the centrifuge procedure on the 58 samples from the 1958 Saskatoon yield trial ranged from 56.5 to 67.3%, with a mean of 60.1%. The range in baking absorption among these flours was from 61.5 to 65.5%. The correlation coefficient (r = +0.357) between the two methods of determining flour absorption was not significant. When the test was applied to the 37 varieties from the regional variety trial, the correlation between the farinograph and centrifuge absorption was significant but too low for prediction purposes (r = +0.437**). Further experiments were then directed toward studying some of the factors affecting centrifuge absorption values.

A comparison was made of the absorption values obtained using 1.5 g. of flour in 15-ml. centrifuge tubes with 5 g. of flour in 50-ml. tubes. For 21 flours from the 1959 trial the correlation coefficient between the two methods was high (r = +0.908**), indicating that the size of sample was not particularly critical in the test. However, the 1.5 g. used by Maes and Pirotte (4) gave more variable results (s_m = 0.9%)[4] than the 5-g. sample (s_m = 0.3%). It was found that the quantity of water initially mixed with the 5-g. sample could vary from 20 to 40 ml. without significantly affecting the centrifuge absorption values. Thirty milliliters of water were selected, as this quantity minimized the problem of flour drying on the sides of the 50-ml. centrifuge tubes during rest periods and yet allowed space for rinsing the stirring rods.

It was observed in this study that longer mixing treatments generally resulted in lower flour absorption percentages. Analyses of one flour sample gave the following results:

Number of Mixes	*Centrifuge Absorption* %
2	60.2
4	58.6
6	58.1
8	57.5

Similarly, increasing the length of each rest period from 0 to 20 minutes reduced the eight-mix centrifuge absorption progressively from 60.1 to 57.2%. For 17 hard red spring wheat flours, selected from the regional variety trial, the farinograph absorption was more highly correlated with the eight-mix centrifuge absorption (r = +0.845**) than with the four-mix procedures (r = +0.626**). For the F_4 bulk progeny samples the correlation between farinograph absorption and eight-mix centrifuge absorption was +0.784** compared to +0.712** by the four-mix procedure. An oven-drying method, described in the

[4] Standard error of the mean.

following section, was used to remove excess moisture from the centrifuge tubes in these experiments.

Difficulties were encountered in obtaining a uniform and rapid rate of drying in the sample tubes after centrifugation. Because of the small size of sample used, a film of water adhering to the wet dough surface appeared to contribute to the variability between duplicates. Both drying the inner surface of the centrifuge tubes with blotting paper and heating the samples with an infrared lamp were effective in shortening the drying time but failed to reduce the variability between duplicates. A series of eight flours from the 1959 Saskatoon yield trial were used to compare methods of oven-drying the sample tubes. The flours represented a range in baking absorption from 57.5 to 65.5%. The flours were analyzed in quadruplicate by the eight-mix procedure and then dried in a forced-draft air oven. The sample tubes were dried for 15, 20, and 25 minutes at 50°, 55°, and 60°C. The highest correlation with baking absorption ($r = +0.880^{**}$) was for drying in the air oven at 50°C. for 25 minutes. This correlation was substantially greater than for air-drying ($r = +0.740^{*}$). Centrifuge tubes dried for 15 or 20 minutes at 50°C. were found to have drops of water adjacent to the flour. These were wiped dry before weighing. For drying temperatures above 50°C., there were increasing degrees of yellowing of the flour.

The final procedure adopted for the determination of centrifuge absorption was as follows:

Transfer 5-g. samples of flour (14% m. b.) into tared 50-ml. centrifuge tubes. Eight determinations may be carried out simultaneously. Add 30 ml. of distilled water to each sample, at the same time washing down the inside of the centrifuge tube. Using a glass stirring rod, mix the flour and water for 30 seconds with sufficient vigor to bring all the flour into suspension. Allow the suspension a 10-minute rest, during which the flour adhering to the side of the centrifuge tube should be scrubbed down with the glass rod to prevent it from drying. Make seven additional mixings of sufficient duration to bring all the flour into suspension (20 seconds), with 10-minute rest periods following each mixing. Use 10 ml. of distilled water to wash the flour adhering to the stirring rod into the sample. Centrifuge the suspension at 2,300 r.p.m. (International Centrifuge for 50-ml. tubes, radius 19.7 cm.) for 25 minutes. Decant the supernatant liquid and place the centrifuge tube mouth down at an angle of 15° to 20° in a forced-draft air oven. Allow the tube to drain and dry for 25 minutes at 50°C. Cool in a desiccator and weigh. To calculate the percentage water absorption by the constant flour weight procedure use the following equation:

$$\% \text{ water absorption} = (x + y - 5)\ 20,$$

where x = increase in weight of the flour, in g.;
y = "as-is" weight of flour used, in g.

Utility of the Test

Correlation Coefficients. The modified centrifuge absorption test was applied to hard spring wheat flours for which baking or farinograph absorption data were available. The correlation coefficients obtained between the three methods of determining flour absorption are given in Table I. Because of the uniformity among the hybrids grown at Saskatoon, only 12 samples were selected from each year to represent the range in flour absorption. Sufficient flour was not available to make the farinograph determination on the 1958 hybrids nor the baking test in the case of the F_4 bulk progeny test samples. There were 17 hard wheat types in the regional variety trial.

TABLE I
AVERAGE PERCENTAGE ABSORPTION (14% MOISTURE) AND CORRELATION COEFFICIENTS BETWEEN METHODS OF DETERMINING FLOUR ABSORPTION

	Saskatoon Yield Trial		Regional Variety Trial	F_4 Bulk Progeny	Mean
	1958	1959			
Number of samples	12	12	17	17	. . .
Farinograph × baking, r	. . . . .	+0.967**	+0.846**	. . . . .	. . .
Farinograph × centrifuge, r	. . . . .	+0.819**	+0.845**	+0.784**	. . .
Baking × centrifuge, r	+0.827**	+0.815**	+0.794**	. . . . .	. . .
Av. farinograph absorption, %	. . . . .	59.2	65.4	63.2	62.9
Av. baking absorption, %	61.0	60.6	59.7	. . . . .	60.3
Av. centrifuge absorption, %	56.3	59.2	56.5	58.0	57.5

For each group of samples studied, the correlations between the three methods of determining flour absorption were highly significant. The farinograph × baking correlation coefficients were generally greater than for the farinograph × centrifuge or baking × centrifuge absorption comparisons. However, the centrifuge test appeared to give good prediction of both farinograph and baking absorption. The average range in farinograph absorption within any one experiment was about 10% compared to 15% by the centrifuge method. Greater ease in making selections for this characteristic among hybrid populations should be possible with the centrifuge method than by the farinograph test.

The mean values for flour absorption among the hard wheats in

Table I indicate that the modified centrifuge absorption test underestimated baking absorption by about 3%. This exceeds the 2% difference reported by Maes and Pirotte (4) for their four-mix procedure.

Inheritance Studies. Sask. 5362, selected from a Mida-Cadet × Lee cross, has been extremely well adapted to the growing conditions of Western Canada. Although generally satisfactory in quality, it was found to be deficient in flour absorption. In a breeding program designed to improve this characteristic in Sask. 5362, crosses were made to observe which parents had the greatest potential for transferring the property of high flour absorption to their progeny. Of the parents used in this study, Ceres, Prelude, and Reward were known to be high in flour absorption. Conley, Selkirk, Lee^{6}-Kenya Farmer, and Kenya 58-$Thatcher^{10}$ had satisfactory milling and baking properties and also contained desirable genes for rust resistance. The progeny of many of these crosses exhibited a wide range in centrifuge absorption percentages, even though only a limited number of plants were analyzed (Table II). Particularly high percentages were obtained in crosses involving either Ceres or Prelude as parents. Since the range in centrifuge absorption among their progeny was also large, these varieties should be very suitable in studies designed to improve flour absorption. Reward proved to be less successful in yielding progeny high in centrifuge absorption. In two of the Reward crosses, the range in centrifuge absorption was only 2%. The generally low flour absorption of Sask. 5362 was evident from crosses in which it was used as a parent. However, a

TABLE II

CENTRIFUGE ABSORPTION IN SINGLE-PLANT F_4 PROGENY

Cross	Number of Plants	Range	Mean
Ceres × Selkirk	6	56.7–63.9	59.5
Ceres × Conley	6	57.3–61.8	59.3
Prelude × Conley	4	56.2–62.4	58.8
Prelude × Lee^{6}-Kenya Farmer	6	54.4–62.0	58.1
Selkirk × Gabo	4	57.1–59.1	58.1
Selkirk × Lee^{6}-Kenya Farmer	7	54.9–61.1	57.7
Kenya 58-$Thatcher^{10}$ × Reward	7	54.3–60.1	57.3
Kenya 58-$Thatcher^{10}$ × Conley	7	53.8–58.8	57.3
Conley × Reward	6	55.0–59.5	57.3
Reward × Conley	7	53.9–61.4	57.0
Reward × Thatcher	7	55.6–57.7	56.7
Reward × Lee^{6}-Kenya Farmer	4	53.3–60.9	56.6
Reward × Selkirk	6	53.9–55.9	54.9
Sask. 5362 × Lee^{6}-Kenya Farmer	12	55.9–61.2	57.8
Sask. 5362 × Reward	11	53.9–58.8	56.1
Sask. 5362 × Kenya 58-$Thatcher^{10}$	11	54.4–58.2	56.0
Sask. 5362 × Conley	10	52.8–59.2	55.7

few of the segregates, particularly in the Sask. 5362 × Lee[6]-Kenya Farmer cross, had reasonably high centrifuge absorption percentages.

From the results of this study the possibilities for selection in segregating populations appeared promising. Seeds of single plants representing the extremes of the range are being increased to determine the effectiveness of this type of early-generation selection for quality.

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