AN ULTRACENTRIFUGE FLOUR ABSORPTION METHOD[1]

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ABSTRACT

An ultracentrifuge absorption technique is described which allows the rapid determination of water absorption with small quantities of flour. Results obtained with 28 flours showed high correlations between ultracentrifuge absorption and farinograph absorption, starch damage and protein content. These results indicate that the method may be useful in predicting water absorption where limited quantities of material are available and as a general method of studying factors that contribute to water absorption.

Centrifuge absorption techniques have been shown to be potentially useful in predicting a number of important wheat flour quality parameters, including farinograph and baking absorption (1,2), loaf volume (2,3), and cookie diameter (4). The small sample requirement has made the method particularly suitable for early generation testing. Basically, the method consists of mixing a portion of flour with excess distilled water (1,2,5), acidified water (3), or alkaline water (4) and centrifuging the resulting slurry. After removal of free liquid, the water absorption is calculated from the increased weight of the pellet.

In the present paper, a modified centrifuge absorption technique is described, which, in contrast to previous methods, uses ultracentrifugation (145,000 *g*). The resulting compact pellet allows easier removal of unabsorbed water and use of smaller samples. Results for 28 flour samples that vary widely in absorptions are presented.

MATERIALS AND METHODS

Samples used in the present study consisted of averages of various types and grades of wheat that were moved to and from Canadian export positions between 1975 and 1977. They included 14 samples of Canada Western hard red spring wheat, 9 samples of various utility grades, 2 samples of Canada Eastern soft white winter wheat, and 3 samples of Alberta red winter wheat. Samples were milled in an Allis Chalmers mill to give straight grade flour. Values of farinograph absorption, remix baking absorption, flour protein, starch damage, and flour moisture were obtained by standard methods used in this laboratory (6).

For the determination of centrifuge absorption, the following procedure was chosen. Approximately 1 g of flour was weighed into a centrifuge tube (Oak Ridge type, 10-ml capacity, Canlab.) and 5 ml of water added. The centrifuge tube was capped and vortexed for 10 sec to suspend the flour. Tubes were rotated on a reaction wheel (Roto-Torque, Cole-Parmer Co.) at 12 rpm for 15 min, then centrifuged at 40,000 rpm (145,000 *g*) for 35 min at 20° C in a Beckman Model L2 ultracentrifuge (50 Ti head). Tubes were inverted and allowed to drain, and strips of filter paper (Whatman No. 2) were used to dry the inside of the tubes. The tubes were weighed and the water absorption calculated. All values were corrected to a 14% flour moisture basis.

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RESULTS AND DISCUSSION

Preliminary results indicated that a number of factors affected the results of the test. Vortexing samples for 10 sec to suspend the flour and then rotating samples for 15 min gave the most consistent results. As shown in Fig. 1, longer rotation times resulted in decreased water absorption. Sosulski (1) had previously reported this phenomenon. The cause of this effect is uncertain, although it may be related to a time-dependent formation of protein-protein bonds that results in displacement of water or to the hydrolysis of damaged starch by amylases.

Similarly, increasing centrifugation time decreased absorption. Changes were rapid up to about 30 min (at 145,000 *g*) and then decreased slowly. Centrifuging samples for 35 min at 145,000 *g* (40,000 rpm) gave the most consistent results.

Due to the compactness of the pellet and the lack of adhesion of solid sample to the sides of the centrifuge tube after ultracentrifugation, efficient removal of unabsorbed water was accomplished by simply inverting the tube to drain and then wiping the inside of the tube with filter paper. Accurate determinations with samples containing as little as 0.5 g of flour were possible with this method.

To determine the relation between the ultracentrifuge method and a number of flour quality parameters, 28 flour samples were selected that covered a wide range of farinograph absorption (50.5 to 70.4%). Ultracentrifuge absorption

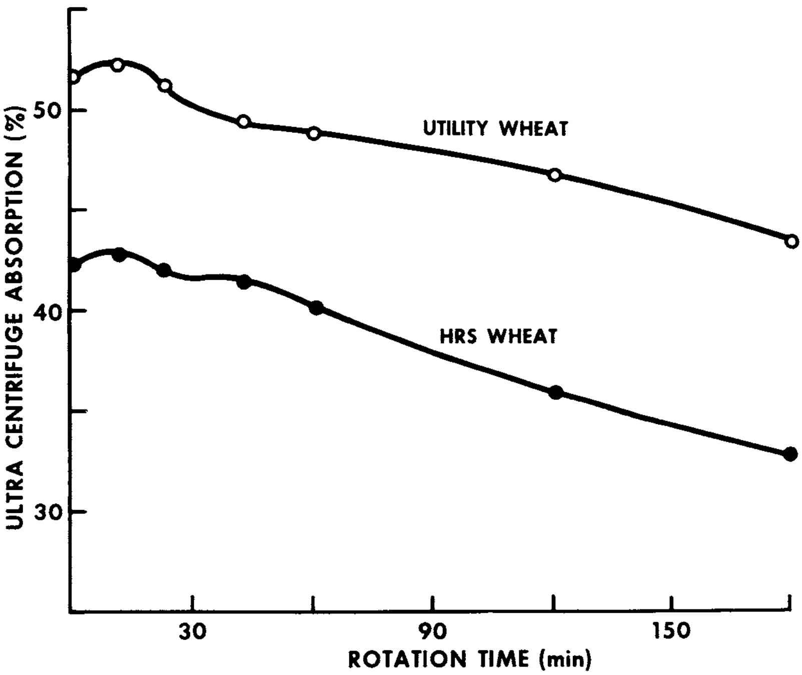

Fig. 1. Relation between ultracentrifuge absorption and rotation time for hard red spring (HRS) and utility wheat sample.

values obtained from the samples ranged from 30.9 to 55.8%, with a standard deviation for the average of duplicate values of 0.3. Relevant data for the samples are presented in Table I.

Means, standard deviations, and correlations obtained between various flour quality parameters and the ultracentrifuge absorption method are shown in Table II. A straight-line relation with a high correlation coefficient (r=0.962) was found between farinograph absorption and ultracentrifuge absorption as shown in Fig. 2. This correlation is significantly higher than that found in previous studies (1,2) and indicates that the ultracentrifuge method is a good predictor of farinograph absorption. The equation relating the two parameters for the samples tested was determined by linear regression analysis as

$$FA = 23.7 + 0.85\ UA \pm 0.6$$

TABLE I
Analytical Data for Flours[a]

Sample[b] / Grade	Ultracentrifuge Absorption (%)	Farinograph Absorption (%)	Baking Absorption (%)	Flour Protein (%)	Starch Damage (Farrand units)
CEWW 2	30.9	50.5	49	8.5	2
CEWW 1	32.7	51.2	49	8.9	3
CU (Pitic) 1	36.7	54.8	49	10.6	3
ARW 2	41.9	57.9	57	10.2	20
ARW 2	40.9	58.4	57	9.8	22
ARW 1	42.9	59.3	58	10.8	20
CU (blender) 1	46.3	60.7	61	11.6	31
CU (blender) 1	47.6	60.9	62	12.0	32
CU (blender) 1	47.2	61.1	62	12.5	31
CWRS 2	44.0	61.9	59	10.9	28
CU 2	47.7	63.1	64	12.2	36
CWRS 1	43.9	63.2	61	11.9	28
CWRS 1	46.8	63.6	61	11.3	30
CWRS 1	46.2	63.7	62	13.0	27
CWRS 2	47.0	64.0	64	12.9	24
CWRS 2	46.8	64.0	63	12.0	25
CWRS 2	45.9	64.5	64	12.9	28
CWRS 1	48.8	64.9	64	13.1	28
CWRS 2	46.2	65.0	62	11.4	32
CWRS 2	47.8	65.4	64	13.2	28
CWRS 1	49.2	65.7	63	11.6	35
CWRS 3	48.3	66.3	64	12.1	34
CWRS 2	48.6	66.5	63	11.3	35
CWRS 2	50.2	66.6	63	11.1	40
CU 3	49.6	67.3	64	11.5	45
CU 3	53.2	69.4	64	11.6	50
CU 3	54.3	69.8	64	11.7	55
CU 3	55.8	70.4	65	11.7	57

[a]Results reported on basis of 14% flour moisture.
[b]CEWW, Canada Eastern white winter; CU, Canada utility; ARW, Alberta red winter; CWRS, Canada Western red spring.

where FA is farinograph absorption and UA is ultracentrifuge absorption.

A high correlation coefficient (0.923) was also found between ultracentrifuge absorption and baking absorption. This value was similar to the correlation between farinograph and baking absorption. However, these relations may be

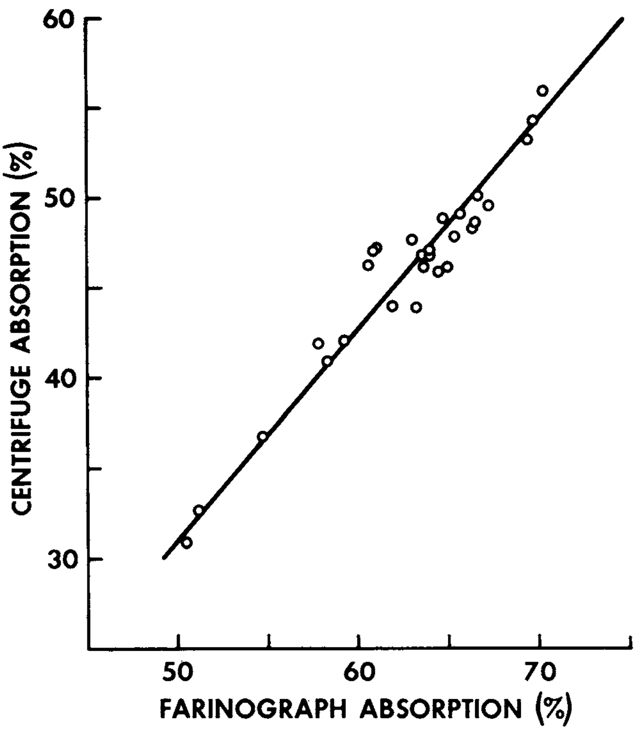

Fig. 2. Relation between centrifuge and farinograph absorptions.

TABLE II
Mean, Standard Deviation, and Correlation Between Parameters

	Centrifuge Absorption	Farinograph Absorption	Baking Absorption	Protein	Starch Damage
Centrifuge absorption	1	0.962	0.923	0.692	0.947
Farinograph absorption		1	0.918	0.681	0.917
Baking absorption			1	0.817	0.832
Protein				1	0.489
Starch damage					1
Mean	46.0	62.9	60.8	11.5	29.6
Standard deviation	5.6	4.9	4.7	1.2	13.3

more variable than those between ultracentrifuge and farinograph absorption due to the varied contributions of protein and damaged starch (see below).

Previous studies have shown that protein and damaged starch are the principal flour components contributing to differences in water absorption (7-10). Table II shows that farinograph and ultracentrifuge absorptions were highly correlated with damaged starch ($r>0.9$), while correlations with protein were lower but significant. The similarity in the correlations between the two flour components and the two water absorption methods indicates that both methods respond similarly to changes in protein and starch damage. This conclusion was supported by multiple linear regression analysis, which indicated that the relative contributions of protein and damaged starch were similar for farinograph and ultracentrifuge absorption with

$$FA = 1.30P + 0.29SD + 39.44$$
$$UA = 1.45P + 0.34SD + 19.27$$

where FA is farinograph absorption, UA is ultracentrifuge absorption, P is protein, and SD is damaged starch. Multiple correlation coefficients for the samples studied were 0.951 and 0.982, respectively, for the above equations.

In contrast to the above results, simple correlations between baking absorption and protein and between baking absorption and starch damage (Table II) were similar. The multiple linear regression equation relating baking absorption to starch damage and protein was

$$BA = 2.17P + 0.20SD + 29.85$$

which gave a multiple correlation coefficient with the samples studied of 0.952. From the above data, baking absorption appears to be more dependent on protein and less dependent on starch damage than does farinograph or ultracentrifuge absorption. Similar results have been found in previous studies and have been attributed to a number of factors, including the liquefaction of damaged starch by amylases during fermentation and the instability of the air/dough interface due to increased water-starch mass at higher starch damage levels (10,11).

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