A Micro Centrifuge to Determine Water-Retention Properties of Wheat Flour[1]

H. MILLER, Ottawa Research Station, Research Branch, Canada Department of Agriculture, Ottawa, Ontario, Canada

ABSTRACT

The apparatus described was constructed to determine the water-retention properties of wheat flour. It is a perforated basket made of stainless steel. The basket fits into a holder attached to the drive shaft of a small centrifuge. The base portion of the basket is not perforated and is shaped inside to form a mixing cup. The basket is lined with filter paper; flour and water are added and mixed to a slurry. The basket is then rotated at high speed for 2 min. After centrifugation, the basket, with contents, is weighed and the retained water is calculated. Wheat flours with retention properties from 30 to 75% have been tested. These data correlate well with absorptions determined by the Brabender Farinograph.

One of the important properties of wheat flour is its ability to absorb water. Ratings of this property are generally determined by adding increments of water to a flour and mixing it into a dough. The optimum water requirement of a flour will vary according to flour type and strength, ingredients used, and the degree of dough development during mixing. It is expressed as percent absorption.

Water retention, though an expression of the same property, is measured in a different way. An excess of water is added to the flour and the whole is mixed to a slurry with little dough development. Free liquid is centrifuged from the slurry, and the resulting retention figure agrees with absorption data.

A number of workers (1, 2, 3, 4) have measured the water-retention properties of wheat flour by use of centrifuge techniques. Some of these workers (1, 2, 3) were seeking micro techniques that could be used to evaluate early-generation wheat selections for baking quality. The present investigations were undertaken for the same reason.

The new centrifuge method differs from those of Finney, Yamazaki, and Sosulski (1, 2,3) in three ways: 1) normal distilled water is used, 2) the supernatant liquid is thrown off, and 3) weighing takes place immediately after centrifugation. In this way the present method agrees with that of Fifield (4), but the newer technique is simple to perform and smaller amounts of flour are required.

DESCRIPTION OF APPARATUS

The instrument consists of a basket and holder. The holder is attached to the shaft of a standard haemocrit centrifuge adapted to this work. The parts are shown in Fig. 1, the bowl of the centrifuge having been removed for the photograph. The basket and holder are fabricated from Type 304 stainless steel. The basket is 66 mm. high and 55 mm. in diameter o.d. The lower 16-mm. part of the basket is hollowed to form a mixing cup; the upper part is perforated. A retaining ring projects 1.5 mm. from the inner

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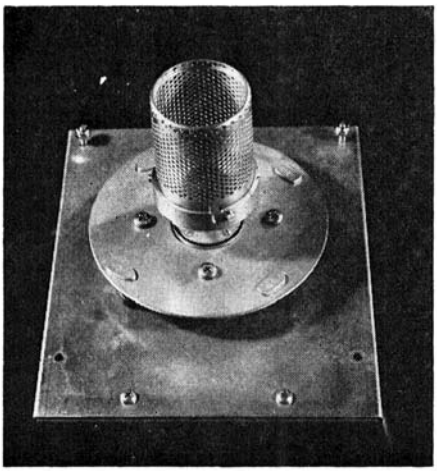


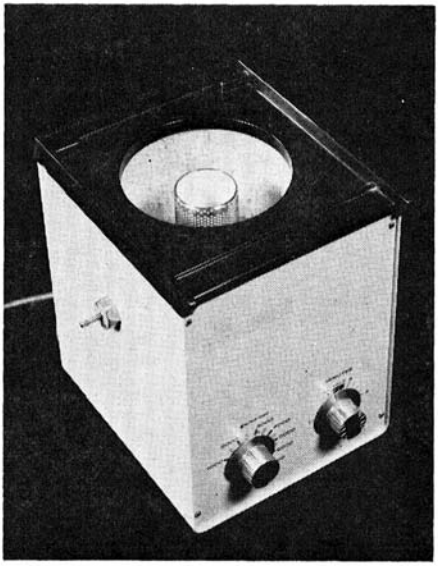


Fig. 1 (left). Centrifuge basket and holder.
Fig. 2 (right). Modified centrifuge ready for use.

wall, 5 mm. from the upper rim of the basket. Projecting from the outer wall of the basket, 4 mm. from the base, are three holding lugs. The lugs are made in two parts, the outer part threaded into the inner part. This permits the addition of thin washers to give balance to the basket and to maintain the basket weight at 87 g.

The basket holder is attached to the shaft of the centrifuge motor. The shaft is shortened to permit the basket to operate within the centrifuge bowl. Figure 2 shows the centrifuge, basket in place, ready for operation. A locking device is installed through the wall of the centrifuge. This locks the holder rigid while the basket is fitted into or removed from the holder. The centrifuge bowl is lined with cellulose sponge material, moistened to maintain uniform humidity in the bowl and to absorb liquid spun off during test.

METHOD

The basket is lined with a piece of Whatman No. 3 filter paper, 156 × 55 mm. Distilled water at 30°C. (10 ml.) is added while the basket is gently rotated to moisten the filter paper. The basket is then fitted to the holder and the centrifuge lid is closed. When the filter paper is wholly moistened, a 4-g. sample of flour is added to the basket. The flour and water are then mixed with a stirring rod for 17 sec. to produce a smooth slurry. The rod is wiped clean, the adhering slurry returned to the basket, the lid closed, and the centrifuge started. Centrifugation is continued for 2 min., 15 sec. at 11,000 r.p.m. The centrifuge stops without braking in 16 sec., then the basket is removed and weighed immediately on an analytical balance. The following equation is used to calculate water retained by a 4-g. sample: percent water retained = 25 (X–Y–P), where X = water

added, Y = weight loss due to centrifugation, and P = weight of water retained by filter paper.

Figure 3 represents the condition in the basket after centrifugation. When

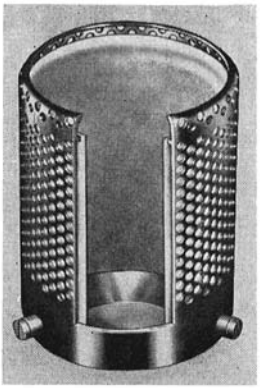


Fig. 3. Cut-away view of basket on completion of test.

centrifuging begins, the slurry moves from the bottom of the basket up the side to the retaining ring. The slurry thickens as the water is driven off and fills the interstices of the filter paper. Further movement of liquid from the dough mass is achieved by centrifugal squeeze, which forces tiny globules of liquid from the dough on the inside of the basket. These move up and are expelled at the upper periphery. Uniform humidity is required when this test is being conducted. A room relative humidity of 60% or less is best suited to this test. Restricting the opening in the lid of the centrifuge reduces the movement of air through the system; this gives a measure of humidity control. The filter paper used should be stored at constant humidity to ensure uniform weight.

RESULTS AND DISCUSSION

The centrifuge procedure outlined in this paper is a simple method of determining water retention in wheat flour. As this property is shown to be related to water absorption, it gives a rating of one facet of flour strength. This rating is influenced by a number of factors, two of which are type and degree of milling and particle size. The table below shows the effect of milling three Ontario winter wheats by three milling systems and the subsequent influence on the centrifuge retention rate of the flours. All flours were

Influence of Milling on Water Retention

Sample No.	*Commercial Mill* %	*Buhler Mill* %	*Ottawa Mill* %
100	38.2	37.9	37.2
101	38.6	38.8	38.3
102	42.0	41.5	41.5

milled within a 10-day period; the commercial samples were untreated,

straight-grade cookie flours. The Ottawa Mill (5) is a multiple two-break, two-reduction mill constructed for prediction test milling.

Flour proteins on the commercial samples were 7.6, 8.0, and 8.1%; viscosities on the same sample ran 19.5, 30.0, and 35.0 MacMichael units.

The table below shows the influence of flour particle size on water retention by the centrifuge method. The flours for this study were obtained by

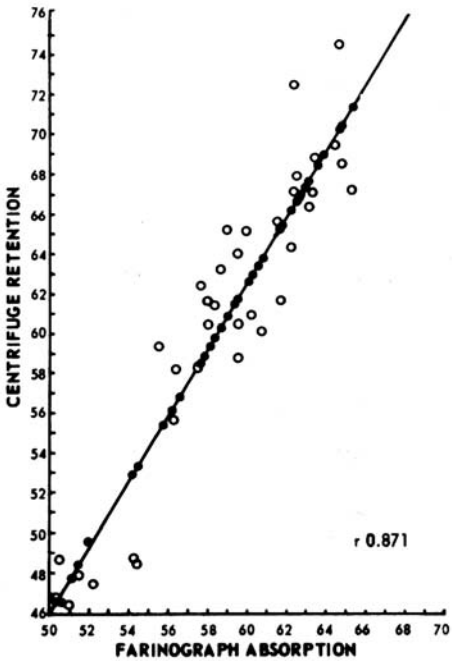
Sieve Size	*Retention* %
Above 10xx	74.3
Through 10xx	75.2
Through 12xx	76.3
Through 14xx	86.3

sieving samples of an untreated, commercial straight-grade flour, made from Canadian hard red spring wheat, that had a water retention value of 75.5%.

The 14xx fraction of the flour, less than 2% of the total, was fluffy and absorbed water quickly but released it very slowly. This resulted in a wet, sticky dough on completion of the test.

The above data indicate that the particle size of a flour influences its water retention capacity. The water retention properties of a flour, however, will not be seriously affected by milling if uniform procedures are used.

Periodic findings have revealed a relation between farinograph absorption data and those from the centrifuge retention test. To illustrate this re-



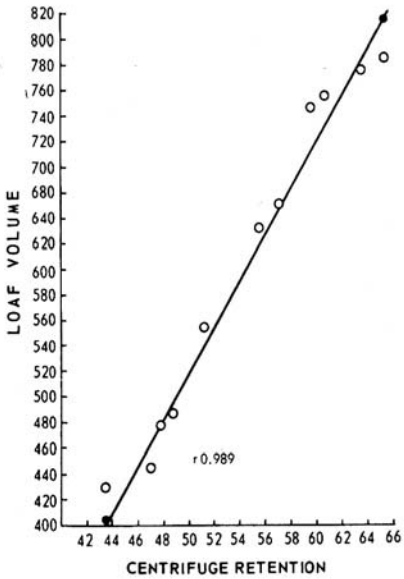


Fig. 4 (left). Correlation of centrifuge data with farinograph data.
Fig. 5 (right). Correlation of loaf volume data with centrifuge data.

lation, a group of experimentally milled flours, from both spring and winter wheats grown in Western Canada, was used. These samples were selected on the basis of their range in farinograph absorptions. Centrifuge retention tests were then made on the flours. The correlation is shown in Fig. 4.

A relation between centrifuge retention value and loaf volume has been noted on numerous occasions in individual samples tested, but studies could not be undertaken to demonstrate the correlation.

Recent collaboration with Voisey (6), however, provided flours identical with those used in his studies. The correlation of loaf volume data with those from the centrifuge retention test on these flours is shown in Fig. 5.

Though the water retention percentage is the most important result in this test, an observant technician soon learns to note other quality characteristics, such as slurry type, the speed at which the liquid is given off, and the type of dough left on the filter paper. Hard red spring wheat flour releases liquid slowly and leaves a soft tacky dough on the filter paper. Soft winter wheat flour, on the other hand, releases liquid rapidly and yields a short dry dough.

The centrifuge water retention test can be used on samples having a wide range in quality without previous knowledge of the retention potential of the flours. As little or no dough development takes place, a more precise measurement of the retention properties can be obtained by this method. Statistically, the standard error of the mean does not exceed 1%. In a short series of three flours replicated three times on six successive days, the standard deviation of the replicates was 0.323 and of days 0.228.

The micro centrifuge test has proved to be a useful tool in quality evaluation work. It is a rapid determination taking less than 5 min. to complete. As it uses a small sample (4 g.) it is particularly valuable in prediction quality testing.

The test has been applied to thousands of Canadian wheat samples at the selection and variety level in the past 3 years. The method has been accepted by the Ontario Winter Wheat Improvement Committee as a test for the evaluation of winter wheat varieties.

Acknowledgments

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