MICROTESTS FOR FLOUR QUALITY[1]

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ABSTRACT

Flour quality characteristics are predicted from tests using 0.4 g. of the coarse flour available from a 5-g. micromill. Strength, i.e., loaf volume and cookie diameter, are predicted from the relation of the gas-retention properties of a fermenting dough made from the flour extracted with a dilute sodium chloride-potassium bromate solution compared to that made from the unextracted flour. Mixing time is determined on a grooved spindle rotating in a close-fitting glass tube. Absorption is determined from the water retained, after centrifuging, in the flour extraction procedure. The predictions are based on the highly significant correlations of the results of the microtests with those obtained from well-known varieties by conventional experimental baking laboratory methods.

Recently this laboratory developed a 5-g. mill (8,9) for use in wheat breeding programs in which an improvement in milling quality was one of the objectives. Such early screening enables the wheat breeder to concentrate his performance tests on strains of suitable milling types. The flour obtained from milling 5 g. of wheat on this mill resembles a coarse middlings stock, as it passes through a 38-wire sieve, and contains some bran particles. The purpose of the work described in the present paper was to develop tests which could be used to predict the baking quality from the 2 to 3 g. of flour obtained from milling a 5-g. sample of wheat.

The nature of the flour and the amount available per sample were limiting factors in determining the type of tests to be developed. Pre-

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liminary results on the meal indicated that lactic acid sedimentation (Zeleny's test, 7,11) and viscosity measurements (apparent acid viscosity, 1) would be of little value. The granularity of the meal and the relative high ash value apparently made measurements of this nature meaningless. The alkaline water-retention capacity (AWRC, Yamazaki, 10) was satisfactory for samples between the two extremes of good and poor cookie diameter. Since practically the same information could be obtained by determining the water absorption of the sample, the AWRC test was not pursued further.

One of the most important quality properties of flour is its ability to produce a dough that has good gas retention. Various methods have been described for determining this property (4,5,6). Varying degrees of success have been reported. Miller *et al.* (6), working with spring wheat, found a correlation of 0.81 to 0.90 between gas retention and loaf volume. Harris (4), working with North Dakota and Mexican selections, found a low correlation. These results indicated that reliable differentiation between samples of one type of wheat was obtained, but differentiation was poor when several types were included. In spite of this situation and the fact that the Pacific Northwest wheat breeders have used all types of wheat in their work, gas-retention investigations were undertaken.

Materials and Methods

The 228 wheat samples used consisted of 24 varieties commonly grown in the Pacific Northwest and were from the 1952 through 1958 crops. To illustrate the characteristics of the samples studied, quality data of the maximum and minimum protein levels of four of the 24 varieties are given in Table I. These data are typical and represent the range in properties of the other varieties. The weakest was Brevor, and the strongest was Itana. Since all of these samples had been

TABLE I
QUALITY DATA FOR TYPICAL VARIETIES

VARIETY	MARKET CLASS [a]	FLOUR PROTEIN	LOAF VOLUME	COOKIE DIAMETER	WATER ABSORPTION	MIXING TIME
		%	ml	cm	%	minutes
Brevor	SW	5.4	610	9.11	55.0	4.20
		11.4	873	...	65.0	2.50
Idaed	SW	6.7	700	9.00	53.0	3.70
		13.7	1,035	...	68.0	3.80
Kharkof	HRW	5.5	625	8.34	61.0	3.60
		13.2	980	...	75.0	3.90
Itana	HRW	7.5	...	7.91	65.0	...
		12.9	910	8.25	67.0	7.75

[a] SW, soft white; HRW, hard red winter.

tested for baking quality by conventional experimental milling and baking methods (2), detailed quality data were available for comparison with results from the microtests. The meal used for development of the tests was obtained from the 5-g. mill by Seeborg and Barmore's method (8). The following solutions were used:

1) Dilute salt solution: 0.5% sodium chloride plus 0.05% potassium bromate;
2) Yeast solution: 1.5 g. dried yeast in 10 ml. distilled water which had been standing at room temperature for 12 hours;
3) Concentrated glucose-salt solution: 61 g. anhydrous glucose and 2.4 g. sodium chloride in 100 ml. water; and
4) Dilute glucose-salt solution: 6 g. glucose and 0.5 g. sodium chloride in 100 ml. of water.

The following methods were developed for 0.40 g. of meal:

Dough Method. To the 0.40 g. of meal in a 12-mm. glass test tube was added 0.1 ml. of the yeast solution, 0.06 ml. of glucose-salt-bromate solution, and 0.722 times the water retained in the extraction method less 0.110 ml. The meal was mixed with a stiff wire until wet, allowed to stand for 15 minutes, removed from the tube, kneaded six times, rolled ten times between the palms of the hands, and placed, partially flattened, in the mouth of the mixer tube. The mixing tube and dough were placed over the rotating mixing shaft, and the dough was mixed until it smeared against the side of the tube or wrapped itself around the shaft. During the mixing, the tube was moved back and forth over the mixing shaft about 2 in. each second in order to keep the diameter of the dough relatively constant. Following mixing, the dough was removed from the tube and shaft, kneaded six times, rolled ten times, and put into the high-humidity fermentation cabinet at 37.5°C. for 45 minutes. From this point the extracted-dough procedures were used.

Extracted Flour Dough Method. The 0.40 g. of meal was placed in a preweighed polyethylene centrifuge tube of 6 ml. capacity and 1 by 10 cm. i.d.; 3.5 ml. of dilute salt solution were added; the tube was stoppered, and shaken vigorously on a wrist-action mechanical shaker for 15 minutes to disperse the meal. To this were added 0.1 ml. yeast and 1.0 ml. of the concentrated glucose-salt solutions, followed by hand shaking, centrifuging for 20 minutes (at 5,050 relative centrifugal force), decanting, draining for 15 minutes inclined at an angle of about 15° and weighing. The increase in weight was called $E.H_2O$, although it is obvious that some material was lost in the extraction and some weight gained because of yeast cells. The wet

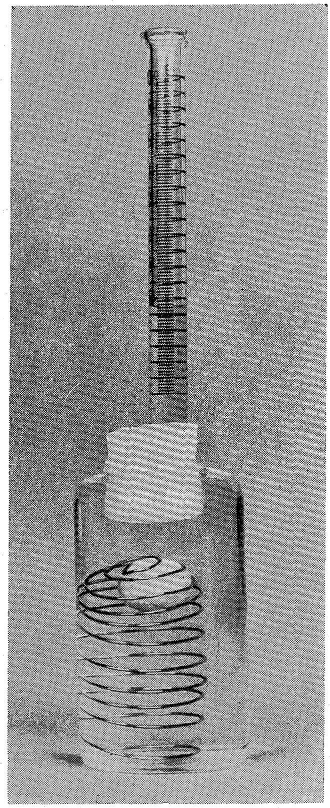

Fig. 1. Gas-retention or Paley bottle with dough and cage in place.

mass was mixed in the tube for 40 seconds, using the motor of the micro mixer and a shaft of 1/8-in. key stock. The dough was then removed from the tube, kneaded, rolled, and placed in the fermentation cabinet.

Gas Retention. Gas retention was measured in a Paley bottle (Fig. 1), which is a flask used to measure the fat content of cheese or ice cream. A cage was developed and inserted in the bottles to hold the dough away from the outlet. The bottles were filled to the zero level of the graduated stem with the dilute glucose-salt solution and held in a water bath at 45°C. The fermented dough was inserted under the cage and allowed to expand in the dilute sugar-salt solution to its maximum size. Gas released from the dough escaped from the bottle and was not measured.

Absorption. Absorption was designated as the amount of water required to produce a soft, pliable dough as determined by appearance and feel during the hand-doughing procedure. Estimates of the amount of water to use were taken from the water retained by the flour in the extraction step ($E.H_2O$).

Optimum Mixing Time and Micro Mixer. The optimum mixing time was determined in a micromixer on the fermented dough in the dough method. This mixer consists of a motor-driven shaft 8 in. long, 0.35 in. in diameter (the last 4 in. tapered from 0.35 to 0.30 in.), operating in a glass tube of 0.45 in. i.d. at about 280 r.p.m. The shaft has a coarse spiral groove cut in it. The small end has a right-hand and the motor end a left-hand groove; this groove tends to keep the dough from stretching along the shaft in an excessive amount. Optimum mixing was the time required to mix the dough until it began to smear on the glass tube.

Results

Data were recorded on optimum micro mixing time, maximum expansion volume by the dough method (DV), maximum expansion volume by the extracted flour method (EV), the amount of water retained by the flour in centrifuging ($E.H_2O$), and the amount of water required to produce a soft, pliable dough ($D.H_2O$). Table II illustrates the degree of association obtained.

From these data, it is obvious that baking absorption, loaf volume, and optimum mixing time can be predicted with considerable reliability, and cookie diameter with somewhat less certainty.

It was found that EV was significantly correlated with DV for 20 of the 24 varieties. Four of the varieties are shown in Fig. 2 as examples. The "t" test showed that many of the regression coefficients were significantly different. Over the entire range, which varied from

TABLE II
SIMPLE CORRELATION COEFFICIENTS AND STANDARD DEVIATION OF ESTIMATE FROM REGRESSION

Micro Quality Observations		Experimental Baking Observation	Correlation Coefficient	Standard Deviation of Estimate
$D.H_2O$	vs.	100-g. bread-baking optimum absorption	0.95**	1.60%
$E.H_2O$	vs.	100-g. bread-baking optimum absorption	0.90**	2.19%
$D.H_2O$	vs.	cookie diameter	—0.77**	0.28 cm.
$E.H_2O$	vs.	cookie diameter	—0.73**	0.30 cm.
$E.H_2O$	vs.	AWRC	0.73**	4.9%
EV	vs.	loaf volume	0.71**	96 ml.
DV	vs.	loaf volume	0.84**	75 ml.
(EV + DV)	vs.	loaf volume	0.95**	42 ml.
Optimum micro mixing time	vs.	100-g. bread-baking optimum mixing time	0.94**	0.57 minutes

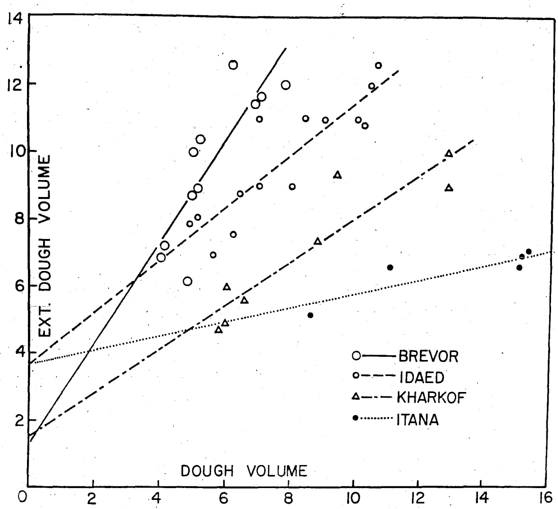

Fig. 2. Relation of extracted (EV) vs. dough (DV) expansion volumes.

1.97 to 0.05, the regression coefficients could be divided into three groups, the extremes of which were significantly different at the 3% level or lower. In Fig. 2, the coefficient for Brevor was significantly different from that of Idaed, and Kharkof from Itana, at the 3% level. That for Idaed was not significantly different from Kharkof, as would be expected from inspection. Thus it was concluded that the regression coefficients characterized approximately the varieties — at least 20 of the 24.

The magnitude of the EV and DV values was significantly influenced by the protein content of the flour, as indicated by the multiple correlation coefficient of 0.945** for EV and DV vs. protein content. This conclusion is also evident from the correlations between protein content and both EV and DV for each variety. These coefficients averaged 0.87 and 0.92, respectively. Thus, as protein content increased for samples of the same variety, the EV, DV values increased proportionally. Since there was a significant correlation between the regression coefficients of the 20 varieties with significant DV vs. EV correlations and the values of EV at a mean value of DV, the equation of a family of lines was determined by a method previously described (2,3), which best represented these 20 varieties. In the light of this generalization, the assumption was made that this same family of lines will represent data obtained from new wheat hybrids. Consequently, EV,DV data on new selections located on this family of lines should indicate their general properties, i.e. their strength. The results indicate that unknown selections can be classified as to their relative strength regardless of protein level; in fact, protein content can be estimated from the multiple regression equation of $EV = 2.287 - 0.839\ DV + 1.426$ protein content.

In the application of the method to the characterization of new selections, The EV and DV values are plotted as in Fig. 2. The line drawn from the EV,DV point to the common origin ($DV = 2.2$ and $EV = 3.6$) subtends an angle with the DV axis that characterizes the new selection; i.e., this angle indicates that the new selection will have flour properties similar to those of a commercial or known variety that yielded a similar angle by the same methods.

One technician can run about 24 samples in an 8-hour day, determining absorption, mixing time, and extracted and unextracted flour dough expansion volumes.

The reason for the relative difference in gas-retention values obtained by the two methods is unknown. It will be noted that the extracted flour doughs give higher gas-retention values for the weak varieties than for the strong varieties; conversely, the unextracted flour doughs give higher gas-retention values for the strong varieties than for the weak ones. Brevor was the weakest variety and Itana was the strongest type. The locations of the EV,DV values in Fig. 2 illustrate the relation of these values to flour strength. The two methods differ only by the extraction procedure used in obtaining the extracted dough gas-retention value. Therefore, one of the factors in wheat flour responsible for its quality must be located in the soluble portion of the flour. In the weak varieties, this fraction reduces the ability of the proteins to retain gas, causing gas-retention values of the unextracted flour to be lower than that obtained when the fraction is removed. For the strong types, the reverse is true. The soluble fraction, being beneficial to the retention of gas, causes the unextracted flour to give higher values than the extracted flour. A study is under way to find the reasons for this difference, because it is believed a much improved micromethod could be developed if that information were available.

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