THE "REMIX" BAKING TEST[1]

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ABSTRACT

A "Remix" baking test, designed to measure strength, is described. A malt-phosphate-bromate formula is used, and the dough is mixed for 3.5 minutes in the GRL mixer or 2 minutes in the Swanson mixer. After fermenting for 165 minutes without punching, the dough is remixed for 2.5 minutes in the GRL or 80 seconds in the Swanson mixer. A recovery time of 25 minutes is allowed, and the dough is then sheeted, molded, panned, proofed for 55 minutes, and baked.

The new method requires no skilled punching, facilitates mechanized molding, is reproducible, and is relatively insensitive to minor variations in timing. The Remix method detects extreme strength more readily, and discriminates more widely between strong and weak flours, than the regular malt-phosphate-bromate straight dough method. Typical results comparing the Remix method with other methods of assessing strength are presented.

The baking test described in this paper was developed specifically to provide a measurement of flour strength in terms of loaf volume at satisfactory levels of loaf appearance and crumb characteristics. Interest shown in this test by others, since publication of a brief note (3), suggests that it may prove a useful addition to test baking methods now in use in various countries.

The meaning of "strength," as applied to wheat or flour, is elusive; the concept is difficult to define in general terms and more especially in terms of measurable properties. Throughout some countries, and in certain parts of other countries, the indigenous wheat is incapable of producing a loaf of the quality demanded by local consumers. A stronger wheat must then be used to blend with the indigenous wheat, and this practice gives rise to a general classification of wheats in terms of strength; the strongest wheat may be defined as the one required in smallest amount to yield a loaf of a given standard quality when blended with the indigenous wheat. We believe that this general definition would be widely accepted in many countries.

Although the hard wheats of the world vary widely in strength, depending on the variety and the environment in which they are grown, the strongest types generally have a number of qualities in common in addition to their ability to support weaker wheats. They tend: to be of high protein content; to have a high water absorption which persists throughout baking; to give doughs that are springy,

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elastic, and extensible; and to show wide tolerance to conditions of mixing, of fermentation, and of dough handling. The concept of strength includes these associated characteristics in varying degree, depending upon what is required of the strong wheat in its supporting role. More detailed definitions of strength, in terms of measurements of these properties, can thus be developed, but tend to differ in emphasis from country to country.

In this laboratory, measurements of strength are required for assessing new varieties, the quality of each new crop, and the qualities of the individual grades currently being exported. While a wide range of analytical and dough-testing methods have been used, emphasis has traditionally been placed in the results of baking tests.

The test baking method which has long been in use in this laboratory is a fixed-formula, fixed-mixing-time, straight-dough method following the AACC straight-dough procedure (2) using 100 g. of flour; the ingredients are the same as those listed for the Remix method in a later section, except that the bromate level is 1.0 mg. Although it has probably been recognized as one of the best of the baking tests for strong wheats (1,7,8), this method has not proved entirely satisfactory. Medium-strength wheats of high protein content often give better results than strong wheats of equally high protein content. It thus appears that the method is not sufficiently rigorous for proper development of strong wheats. However, increasing the mixing time or speed yields bucky doughs that do not rise sufficiently during proofing and baking to produce loaves of good volume. Moreover, if the time schedule and conditions for punching, fermentation, molding, and proofing are fixed, the experimental baker avoids buckiness by reducing mixing time; the method then becomes even less satisfactory for the strongest wheats.

Some two years ago, a new baking test, the "Remix Method," was developed in this laboratory and briefly described in the Annual Report for 1957 (3). The Remix method is a rigorous fixed-procedure method that, with strong flours, gives loaves of excellent volume, appearance, crumb grain, texture, and color; weakness in the flour is reflected first in lower volume and ultimately in poorer dough-handling qualities and poorer crumb characteristics as well. The method is designed primarily to provide better differentiation among strong and medium-strong flours. Specifications for the method, comments on its main characteristics, and some comparisons of the Remix method with the baking method formerly used (hereinafter referred to as the MPB method) and with other methods of assessing strength, are reported in this paper.

Method

Equipment: (1) Mixer. The GRL mixer (9) run at 130 r.p.m. is preferred, but the Swanson mixer is also satisfactory. (All other equipment as for the AACC Straight-Dough Method (2).)

Formula:

Flour (14% moisture basis)	100.0 g.
Water, distilled	variable
Yeast, compressed	3.0 g.
Sugar	2.5 g.
Salt	1.0 g.
Malt syrup (250° Lintner)	0.3 g.
Ammonium dihydrogen phosphate	0.1 g.
Potassium bromate	1.5 mg.

Procedure: (1) Mix ingredients for 3.5 minutes in GRL mixer or 2.0 minutes in Swanson mixer.
(2) Ferment for 165 minutes at 30°C.
(3) Remix for 2.5 minutes in GRL or 1 minute 20 seconds in Swanson mixer.
(4) Ferment for 25 minutes (recovery time).
(5) Sheet and mold.
(6) Proof for 55 minutes at 30°C.
(7) Bake 25 minutes at 220°C.

Comments. The formula for the Remix method is identical with that for the MPB method, except that the bromate level has been increased from 1.0 to 1.5 mg. Total time for the test is increased by 10 minutes. Initial mixing time and speed were increased to obtain proper development with strong flours, and the resulting buckiness is removed by remixing after fermentation. Hand punching is eliminated, an important advantage since considerable skill and experience are required to obtain reproducible results. Moreover, the remixed doughs, even from strong wheats, are softer and more extensible, and are thus better suited for mechanical molding.[2] By eliminating hand punching and hand molding, the human factor in test baking can be substantially reduced if not entirely eliminated.

TABLE I
VARIATION OF LOAF VOLUME WITH BROMATE LEVEL AND REMIXING TIME

REMIXING TIME	BROMATE LEVEL (mg.)			
	0	1.0	2.0	3.0
minutes	*cc*	*cc*	*cc*	*cc*
1.5	675	755	795	760
2.5	665	770	760	715
3.5	730	740	690	690

Experiments made while the method was being developed led to the following conclusions. With strong flours the method is not sensi-

[2] All results reported in this paper were obtained with hand molding. Subsequently a modified version of a standard laboratory molder was constructed and is now in routine use with this method.

tive to small variations in the amount of initial mixing, nor is there any appreciable interaction between initial mixing and bromate level. As would be expected from the well-known studies of Freilich and Frey (6), there is an interaction between bromate level and remixing; this behavior is shown in Table I. As the bromate level is increased up to about 3.0 mg., the remixing time required to produce optimum loaf properties is decreased. A good loaf is produced with no bromate by longer remixing, but the volume is not as large as that obtained with some bromate and shorter remixing. As the bromate level is increased at a given remixing time, or as remixing time is increased at a given bromate level, doughs become more slack and sticky. These considerations led to adoption of 2.5 minutes' remixing and 1.5 mg. bromate as practical working levels.

The method is not sensitive to excess bromate; increases in bromate beyond the optimum do not severely affect loaf properties. This is in marked contrast to the MPB method which is quite sensitive to bromate level, particularly with high-protein flours (1). The beneficial effects of remixing overbromated or bucky doughs have, of course, been known for many years (5,6).

There is a differential response to fermentation time (time between mixing and remixing) with differences in the bromate level, as shown in Table II; this phenomenon is common to most baking methods (1,4). With no bromate, loaf volume increased as fermentation time increased. With 1.0 mg. bromate, optimum loaves were obtained at 2.75 hours; and at 2.0 mg., loaf volume did not vary over the range of fermentation times. A compromise of 2.75 hours with 1.5 mg. of bromate was selected.

TABLE II

VARIATION OF LOAF VOLUME WITH BROMATE LEVEL AND FERMENTATION TIME

Fermentation Time	Bromate Level (mg.)		
	0	1.0	2.0
hours	*cc*	*cc*	*cc*
2.25	715	850	920
2.75	740	885	915
3.25	755	865	915

Immediately after remixing, doughs tend to be slack, sticky, and difficult to handle, and this tendency is greater with weaker flours. After a 25-minute recovery time, even weak doughs can be readily handled, and there appeared to be no advantage in shortening this time for medium and strong doughs.

With strong flours and no bromate, loaf volume, texture, and color improve with increasing mixing time, fermentation time, and remixing time. But for any bromate level between 1.5 and 3.0 mg., loaf characteristics change little over reasonable ranges of mixing, fermentation, and remixing times. Moreover, as pointed out earlier, the method also tolerates excess bromate. For these reasons it appears that the method is reproducible without close standardization; minor variations in procedure and formula do not tend to disturb the rank order in which a series of samples are placed by the Remix method.

Comparisons of the Remix and Other Tests

The differential response of flours of various baking strengths to the Remix method, the MPB method, and certain other tests is illustrated in the following subsections. Comparisons of the two methods were made with: 1) 14 wheat varieties; 2) two sets of samples representing the principal grades of Canadian spring wheat; 3) five types of commercial winter wheat; 4) four commercially milled domestic flours.

All wheats were milled on an experimental Allis-Chalmers mill to yield a standard feed flour based on an extraction of 73% for top-grade Canadian wheat. Loaf volume, Zeleny tests, and extensigraph areas were determined in duplicate, but farinograph data represent single tests.

Varieties. Composite samples of each of 14 varieties, grown at several stations in Western Canada, were studied: 1) Rescue × (Renown × S615); 2) Ceres; 3) Saunders × CT 219; 4) Rescue; 5) Rescue × Cadet; 6) (Renown × S615) × Rescue; 7) Cadet; 8) Timstein; 9) S615; 10) Mida × (McMurachy × Exchange); 11) Egypt NA95; 12) Exchange; 13) 1088 × Yaqui; 14) Kenya 321 BT1B1. These varieties were selected, from a larger series in use in the Canadian plant breeding program, as typical of various degrees of baking strength. Protein contents of flour, loaf volumes by the two baking methods, and the results of Zeleny, farinograph, extensigraph, and absorption tests, are given in Table III.

The varieties are listed in order of decreasing Remix loaf volume and are divided into four groups tentatively classed as very strong, strong, medium, and weak. The better-known varieties Thatcher, Selkirk, and Marquis fit into intermediate places in this classification, with Thatcher between the strong and very strong and Selkirk and Marquis between the strong and medium groups. Though there are discrepancies within each group, the mean data for groups show that the Zeleny test, farinograph development times and weakening, and

TABLE III

BAKING AND SUPPLEMENTARY DATA ON VARIETY SERIES

Group No.	Variety No.	Flour Protein	Loaf Volume		Zeleny Test	Farinograph		Extensigram Area	Absorption		
			Remix	MPB		Dev. Time	Weakening		Farinograph	Remix	MPB
		%	cc	cc		minutes	B.u.	cm^2	%	%	%
1. Very strong	1	14.0	985	730	68	7.2	34	198	64	58	60
	2	15.4	975	760	62	6.8	47	144	72	63	66
	3	13.5	965	665	68	8.0	14	200	65	61	61
	4	14.7	950	760	69	6.0	37	203	63	56	59
	Mean	14.4	969	729	67	7.0	33	186	66	60	62
2. Strong	5	15.3	915	930	61	6.2	33	170	67	61	63
	6	15.0	915	955	71	6.8	31	206	65	59	61
	7	14.8	865	910	69	6.8	42	134	72	65	66
	Mean	15.0	898	932	64	6.6	35	170	68	62	63
3. Medium	8	14.6	635	920	51	5.0	81	102	69	54	65
	9	15.0	555	915	42	3.2	107	55	67	53	63
	10	14.6	525	840	43	3.2	100	60	67	51	63
	11	14.7	510	830	38	3.8	80	29	70	53	62
	Mean	14.7	556	876	44	3.8	92	62	68	53	63
4. Weak	12	12.6	490	630	26	2.0	165	26	62	49	58
	13	14.0	470	660	23	2.2	150	...	64	48	55
	14	12.5	455	665	39	2.8	131	46	61	49	57
	Mean	13.0	472	652	29	2.3	149	36	62	49	57

extensigraph area all agree in placing the four groups in the same order as does the Remix loaf volume. Moreover, for the first three groups, which differ little in mean protein content, all these tests obviously reflect some strength factor (or factors) other than protein content. Indeed, this conclusion also applies to the fourth group, since the mean loaf volume by the Remix method is lower than would be expected solely from consideration of the lower mean protein level.

In comparison with all other tests, the MPB loaf volumes establish a different rank order for the four groups. The strong group is placed first, followed closely by the medium group, with the very strong group substantially lower in third position, and a further substantial decrease for the weak group in fourth position. Thus it seems reasonable to infer that the MPB method favors the strong and medium-strong groups, penalizes the very strong group, and does justice to the weak group. The differential response of samples to the two baking methods is worth emphasizing. For the very strong wheats, Remix volumes are larger than MPB volumes; for the strong types, both methods give similar volumes; for the intermediate-range and weak wheats, however, Remix volumes are smaller than MPB volumes. This pattern is also consistent in the series that follow.

The absorption data are also interesting. Baking absorption, as measured by the feel of the dough at panning, is much the same for the first three groups with the MPB method, though lower for the fourth group. This order also applies for farinograph absorption. For the Remix method, baking absorption falls off more rapidly for the third group and especially for the fourth group; these flours would be unmanageable after remixing at higher absorptions.

Spring Wheat Grade Samples. Studies were made of two sets of samples representing grades of Canadian Hard Red Spring wheat. The first set comprised composites of grades 1 to 4 Manitoba Northern and No. 5 wheat collected at Vancouver in 1958; the second set comprised composites of wheat of the 1959 crop for grades 1 to 4 Manitoba Northern, and No. 4 Special. The two sets differ by about 1.5 percentage units in average protein content.

Data for the first set are given in the upper half of Table IV. The Remix loaf volumes rank the samples in order of grade, although some of the differences between grades are too small to be significant. The MPB method responds best to grade 3 and does not reflect the true difference in strength between grade 1 and No. 5. In this set, extensigram areas are not related to grade. Absorption data are included mainly to show that these were the same for the two methods for each of the top three grades, but differed by 1% for the last two.

TABLE IV
BAKING AND SUPPLEMENTARY DATA ON CANADIAN SPRING WHEATS

Grade	Flour Protein	Loaf Volume		Farinograph		Extensigraph Area	Absorption	
		Remix	MPB	Dev. Time	Weakening		Remix	MPB
	%	cc	cc	minutes	B.u.	cm^2	%	%
No. 1 Northern	12.0	765	710	6.0	45	123	61	61
No. 2 Northern	12.1	745	710	6.0	45	111	60	60
No. 3 Northern	12.2	740	760	5.5	55	119	60	60
No. 4 Northern	12.1	690	710	5.5	60	111	61	62
No. 5 Wheat	11.7	680	680	5.5	70	117	60	61
No. 4 Special	15.9	980	900	7.5	20	161	63	63
No. 1 Northern	13.3	850	765	6.0	45	134	60	60
No. 2 Northern	13.6	865	830	6.0	35	131	61	61
No. 3 Northern	13.5	775	815	6.0	50	123	61	61
No. 4 Northern	13.0	725	760	6.0	55	96	59	59

The lower half of Table IV shows data for a set of grade composites representing higher protein levels. Number 4 Special, which has the highest protein content, is listed first; this grade contains mature wheat degraded because of low bushel weight (53 to 55 lb.) caused, in this case, by drought.

With an advantage of over 2% in protein, No. 4 Special is sufficiently strong to be placed first by all methods including MPB loaf volumes. For the remaining grades, Remix volumes follow grade quite well, except for a slight perturbation due to protein content. The Remix method, farinograph weakening, and extensigram area agree. The MPB method favors the lower grades at the expense of No. 1 Northern and shows similar volumes for the highest and lowest grades. The spread in loaf volumes between No. 4 Special and No. 4 Northern for the Remix method is 255 cc., whereas with the MPB method it is only 140 cc. Thus, this set of data indicate the superior ability of the Remix method to discriminate between samples of similar character but of slightly different strength.

Winter Wheats. Data for five types of winter wheat, from three different countries, are given in Table V. The Remix loaf volumes and the farinograph data place these samples in the same order; extensigram areas also agree, save for reversing of Argentine Southern and U.S. Dark Hard Winter. These wheats were composites made up from samples of seven to ten individual cargoes of each type unloaded in Europe in late 1957 or in 1958 and are reasonably representative of these classes of wheat as imported into Europe during this period. They comprise wheat types whose general order of strength is well known to European millers; we believe that these millers would agree to the rank order of strength established by the Remix method. Dur-

TABLE V
BAKING AND SUPPLEMENTARY DATA ON WINTER WHEAT CARGO COMPOSITES

Type	Flour Protein	Loaf Volume		Farinograph		Extensigraph Area	Absorption	
		Remix	MPB	Dev. Time	Weakening		Remix	MPB
	%	cc	cc	minutes	B.u.	cm²	%	%
Argentine Upriver	11.6	760	670	7.0	35	162	58	58
Argentine Southern	10.8	720	635	6.5	50	122	59	59
U.S. Dark Hard Winter	13.3	700	770	5.5	80	130	57	59
U.S. Hard Winter	11.6	665	715	5.5	85	117	55	57
Russian	11.5	625	660	4.5	95	74	51	57

ing the period specified, Argentine Upriver was generally classed as the strongest winter wheat imported into the European market, followed by Argentine Southern and U.S. Hard Winter of high protein content. Imports of Russian wheat were generally of lower baking strength than imports of U.S. Hard Winter of average protein content. This classification is in substantial agreement with data published by Shellenberger (11) in his study of wheats imported into Europe during 1955 and the early part of 1956.

In contrast to the other methods, the MPB loaf volumes fail to reflect the strength of the two Argentine types. Indeed, for this series of samples, MPB volumes appear to be influenced mainly by protein contents.

Commercial Flours. The series of commercial flours comprised three baker's patent flours of 13.4, 12.6, and 12.2% protein, and a straight-grade flour of 12.0% protein milled from No. 5 wheat. The flours were treated at the mill and are more fully matured than the laboratory-milled flours considered in previous subsections; the extensigraph curves indicated that the low-protein patent flour had been given the most oxidation treatment.

Data in Table VI show that both baking methods rank the patent flours in order of their protein content, but that the MPB method ranks the weaker No. 5 flour above all but the high-protein patent, which showed the mildest oxidation treatment. The Remix method, on the other hand, ranks the No. 5 flour considerably below any of the patent flours; the spread between the strongest and weakest flours is 180 cc. by the Remix method but only 25 cc. by the MPB method.

For the patent flours, Remix volumes are higher than MPB volumes. The differences between the two methods are related to the ap-

TABLE VI
BAKING AND SUPPLEMENTARY DATA ON COMMERCIAL FLOURS

Flour	Protein	Loaf Volume		Farinograph		Extensigraph Area
		Remix	MPB	Dev. Time	Weakening	
	%	cc	cc	minutes	B.u.	cm^2
High-protein Patent	13.4	810	740	7.0	45	172
Medium-protein Patent	12.6	765	675	7.0	40	185
Low-protein Patent	12.2	745	615	6.5	45	202
Straight-grade No. 5	12.0	630	715	3.5	90	80

parent degree of oxidation: the low-protein patent shows a difference of 130 cc. in volume, has the greatest extensigram area, the greatest resistance, and the least extensibility; the high-protein patent shows the smallest difference, 70 cc., and has the smallest extensigram area, together with the lowest resistance and greatest extensibility.

These data tend to confirm the belief that the Remix method is relatively insensitive to the degree of oxidation of the flour but is highly sensitive to the type of gluten quality that seems to be associated with flour strength. Thus, differences in gluten quality do not tend to be masked by other factors.

Discussion

In general, test baking methods are of two types: those employing fixed processing conditions and fixed formulas and those in which processing and/or formula may be varied to suit the needs of the flour being tested. In the fixed type of baking test, a rigid standard is, in effect, being set. All flours, to give acceptable results, must be equal to or better than this standard; any flour which differs significantly in type from the standard is penalized although it might be equally useful, for many purposes, to those types which meet the standard. Two very important aspects of such a test are the level of strength at which the fixed procedure gives optimum results, and the latitude or tolerance of the test to variables other than inherent strength.

Both the Remix and the MPB methods are of this fixed type. From the results reported here (and from a great deal of other experience with both methods), it appears that the Remix method as outlined here is "tuned" to a higher level of strength than is the MPB method; it also appears to have a greater degree of tolerance to variables other than inherent strength, so that the results, as measured by loaf volume, reflect this factor principally, and interacting factors such as protein content and degree of oxidation do not tend to interfere seriously with the measurement of this principal objective.

The Remix method has proved to be most useful in the assessment of strength in the areas of testing for which examples are cited in this paper. In some of these areas, notably the variety testing, which involves a very wide range of gluten quality, there are close correlations between Remix loaf volumes and the results of the farinograph, extensigraph, and Zeleny tests. In other series, however, where the general level of strength is more uniform, these latter tests appear to give less useful specific information than the Remix test.

Introduction of remixing gives the test method something in common with the sponge and dough method so widely used in commercial bakeries. It is also interesting that commercial equipment and procedure almost identical with the Remix method has recently been described (10). Moreover, continuous doughmaking processes, insofar as they involve recovery after dough development, are also partially simulated by the Remix method. It may therefore have applications in testing the particular strength requirements of flour for highly mechanized continuous processes. There are other testing areas and other testing objectives which are doubtless better served by variable-procedure baking methods.

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