Strength Requirements of Doughs Destined for Repeated Sheeting Compared with Those of Normal Doughs

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ABSTRACT

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One hundred and sixty-one flours, experimentally milled from Australian wheat, were used in a conventional baking test and also in a baking test in which the dough was repeatedly sheeted before molding and panning. Greater strength was required in the doughs destined for sheeting, whereas protein content and extensibility were the factors limiting the volume of conventional loaves. Repeated sheeting gradually reduces a dough's resistance to deformation.

The practice of repeatedly sheeting yeasted wheat flour dough before dividing and molding was considered by Kilborn and Tipples (1974) to represent an energy efficient method of dough development, even though it was labor intensive. Stenvert et al (1979) also described the process and the effects of sheeting on dough and bread structure. The flour quality requirements for bread making by this procedure are of interest because of its widespread application in Peru, Spain, Southeast Asia, and parts of Africa. This procedure requires flour with dough properties somewhat different from those required for the conventional bread-making systems, which depend more on mixng for the development of dough. Because little information was available on this point, a broad selection of experimentally milled flours was examined by small scale reproductions of each baking system, and the results were interpreted in terms of protein content and dough qualities.

MATERIALS AND METHODS

Flours

One hundred sixty-one flours milled from Australian wheats with a Buhler experimental mill were examined. These comprised an orthogonal set of 84 and 77 others. The 84 flours, on which an analysis of variance was conducted, were from seven cultivars each grown in four trials in the Narrabri area of New South Wales in 1976, 1977, and 1978.

Measurement

Protein content (Kjeldahl), ash, diastatic activity, and falling number were determined by AACC methods, except that a 5-g sample was taken in the last test. Flour color grade was determined with the Kent-Jones and Martin flour color grader. Dough characteristics were also determined using the Brabender farinograph and extensigraph. The extensigraph was set so that 1 BU corresponded to a load of 1.25 g. Flour water absorption, dough development time, extensibility, and maximum resistance after a 45-min rest were recorded.

Baking Methods

Test loaves were baked from each flour, both by the normal fermented baking test procedure, as practiced at the Bread Research Institute of Australia, and by a procedure that was as close as practicable to a reproduction on a small scale of baking methods practiced in such countries as Indonesia, Malaysia, Peru, the Philippines, and Singapore. These two methods are hereafter referred to as the conventional and the sheeted dough systems, respectively. Optimum potassium bromate, water, and mixing time were chosen in each case in the conventional system, but only water addition was varied in the sheeted dough test.

Conventional Method. The formula was 120 g of flour, 1% malt extract, 2% compressed yeast, 2% salt, 0.5% ammonium chloride, and such potassium bromate and water as were required in each case. Dough was mixed to optimum development (1.5–3.5 min) in a National mixer and fermented at 27° C for 165 min. Dough (170 g) was taken, passed through a Mono universal table molder (D. Ayres Jones and Co., Ltd., Swansea, Great Britain) to form a cylinder, rested for 15 min, molded with the "mono" molder, and panned. After 50 min proof at 32° C, it was baked for 15 min in a reel oven at 230° C.

Sheeted Dough Method. The formula was 100 g of flour, 2 g of sugar, 3 g of fat, 1.5 g of salt, 1.5 g of compressed yeast, 3 mg of potassium bromate, 1 g of malt extract, and such water as was required in each case. Dough was mixed for 2 min in a National mixer, proofed at 27° C for 165 min, and sheeted 15 times through steel laboratory sheeting rolls of 14-cm length and 9.5-cm diameter, having a gap of 2.8 mm and turning at 82 rpm. (In some cases sheeting was abandoned at 12 passes when doughs became very sticky.) The sheet of dough was folded twice (book-folded) between successive passes and sheeted in the direction of the folds. After sheeting, it was rested 10 min, molded in the "mono" molder, panned, and proofed for 75 min at 90% relative humidity and 32° C. The doughs were baked for 15 min at 230° C.

The different dough weights were chosen so that the loaf volumes were appropriate to the sizes of the baking tins and approximately the same by both methods.

Methods Used in Sheeting Study

Bread dough fermented for 3 hr was divided into six 150-g pieces. These were sheeted 1, 2, 4, 8, 16, and 24 times, respectively, through commercial steel rollers of 12.6-cm diameter set 12.5 mm apart and turning at 200 rpm. After a 45-min rest, the dough pieces were stretched with the Brabender extensigraph.

RESULTS

Statistical Treatment

The results provided little indication that the relationships between the variates were other than linear, with two major exceptions. A definite limit to dough resistance was found, beyond which conventional loaves became restricted in volume. Dough development time required adjustment to achieve linearity. This was effected by transformation to the square root for subsequent statistical analysis.

No difference was apparent in the relationships between tests from one season to another. Preliminary statistical analysis indicated a change in relationships with changing protein level, however. The 161 samples were therefore divided arbitrarily into three groups: 8.3–11.5% protein (39 samples), 11.6–14.0% protein (75 samples), and 14.1–17.1% protein (47 samples), respectively. The ranges of other variables are shown in Table I. Correlation matrices were constructed for each group; the salient features are shown in Table II. Color grade and ash were generally negatively related to loaf volume by either procedure and in each protein range. They have been omitted from Table II along with the falling

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TABLE I
Ranges of Quality Characteristics of Wheat Flours and Doughs

	All Samples, in Protein Ranges[a]			
	Low	Inter-mediate	High	Selected Group of Samples[b]
Volume (ml)[c]				
Sheeted dough	555–920	538–950	560–990	590–950
Conventional dough	520–800	570–900	450–940	600–900
Ash (%)	0.42–0.60	0.36–0.67	0.44–0.66	0.36–0.64
Color grade	−2.3–+1.7	−2.1–+2.8	−1.1–+3.0	−1.5–+1.5
Protein (%)	8.3–11.5	11.6–14.0	14.1–17.1	12.0–14.0
Water absorption (%)	54.1–67.0	57.0–73.2	56.4–70.5	60.4–69.9
Dough development time (min)	1.7–8.3	3.3–20.1	3.2–36.0	3.3–20.1
Resistance (BU)	150–590	80–640	115–650	110–525
Extensibility (cm)	16.4–25.7	16.4–28.1	20.8–28.4	20.2–27.6
Maltose (mg)	96–285	138–296	88–231	140–238
Falling number (5/25)	181–275	117–303	107–327	150–303

[a]Table II is based on this data.
[b]Figure 1 is based on this data from 47 samples of 12–14% protein, from which flours with extreme characteristics were excluded.
[c]Dough weights of sheeted and conventional doughs were approximately equal.

TABLE II
Linear Correlation[a] of Protein Content and Dough Qualities with Loaf Volume in Three Protein Ranges

Loaf Volume[b] of Dough System	Flour Protein Content	Dough Qualities: Development Time	Maximum Resistance	Extensibility
In protein range 8.3–11.5 (39 samples)				
Sheeted	0.43**	0.46**	0.57***	0.05[c]
Conventional	0.57***	0.16[c]	−0.10[c]	0.60***
In protein range 11.6–14.0 (75 samples)				
Sheeted	0.05[c]	0.64***	0.77***	−0.11[c]
Conventional	0.39***	0.02[c]	0.04[c]	0.51***
In protein range 14.1–17.1 (47 samples)				
Sheeted	−0.4[c]	0.59***	0.80***	−0.13[c]
Conventional	0.34*	−0.30*	0.02[c]	0.34*

[a]* = ($P < 0.05$), ** = ($P < 0.01$), *** = ($P < 0.005$)
[b]Dough weights of sheeted and conventional doughs were approximately equal.
[c]Not significant.

number, water absorption, and maltose values, which provided few significant correlations with bread qualities.

A set of 47 samples was then chosen, excluding flours with extreme characteristics other than extensigraph resistance (R). This set was restricted to flours within the bakery type range, that is between 12 and 14% protein. Other characteristics are shown in the last column in Table I. A multiple regression of loaf volume (V), using the equation

$$V = a + bR + cR^2$$

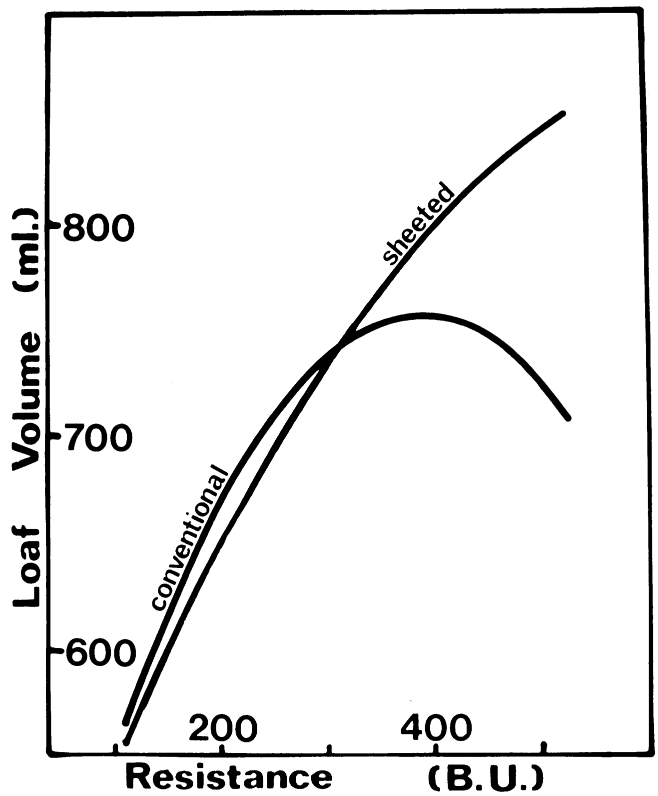

Fig. 1. Relationship between dough resistance (R) and loaf volume (V) according to two methods of dough preparation. Conventional loaf volume was corrected to the same dough weight as that of sheeted loaves. Sheeted dough: $V = 421 + (1.32\ R) - (9.5\ R^2) \times 10^{-4}$; conventional dough: $V = 383 + (1.94\ R) - (2.52\ R^2) \times 10^{-3}$.

TABLE III
Cultivar and Seasonal Effects on Qualities of Experimentally Milled Flours

	Flour Protein (%)	Dough Qualities: Development ($min^{1/2}$)	Resistance (BU)	Extensibility (cm)	Loaf Volume[a] (ml): Sheeted	Conventional
Cultivar						
Timgalen	13.7	2.54	360	25.4	767	807
Songlen	13.8	2.50	343	25.4	751	816
Timson	14.6	2.45	274	25.4	714	798
Kite	12.6	2.47	360	22.4	784	729
Oxley	12.8	2.39	308	26.9	790	762
Shortim	13.6	2.57	395	25.7	812	802
Cook	12.5	2.68	414	24.8	850	792
Standard error	0.2	0.07	20	0.4	20	19
Season						
1976	13.1	2.21	284	24.8	700	775
1977	14.7	2.82	397	24.7	825	801
1978	12.3	2.61	370	25.9	819	784
Standard error	0.1	0.05	13	0.2	13	13

[a]Dough weights of sheeted and conventional doughs were approximately equal.

was constructed for each baking procedure. The relationships are shown in Fig. 1. In this case the conventional loaf volumes have been corrected to the same dough weight as that of the sheeted loaves for a more valid comparison.

Cultivar and Seasonal Effects

An analysis of variance was completed on loaf volume figures from both baking methods applied to flour from seven wheat cultivars each grown in four trials in three years. The analysis of variance indicated significant effects on loaf volume attributable to season and cultivar. Significant interaction effects involving bread-making procedure (between the cultivar and procedure and the season and procedure) were also noted. These effects were largely associated with protein levels and inherent dough resistance. The principal effects are shown in Table III.

Effect of Sheeting on Dough Characteristics

Because of the apparent differential role of dough resistance in these two bread-making procedures, roles suggested by Stenvert et al (1979) and confirmed in the foregoing, the effect of successive passes through sheeting rolls was studied. The effect of sheeting on the load-extension relationship of a fermented bread dough was measured by the Brabender extensigraph. Doughs prepared from different flours were examined, and in each case the strength of the dough was gradually broken down. Resistance to stretching decreased and the extensibility increased with successive passes through the rollers. The results achieved with two Australian commercial flours of 12.0 and 13.8% protein, respectively, are shown in Fig. 2.

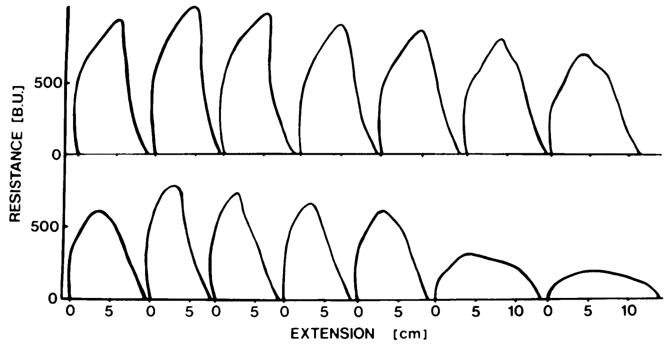

Fig. 2. Effect of repeated sheeting on the load-extension relationships of two fermenting doughs, as shown by extensigraph of fermented dough after (left to right) 0,1,2,4,8,16, and 24 passes through commercial sheeting rolls. **Upper,** Strong flour; **lower,** baker's flour.

DISCUSSION

Factors Governing Loaf Volume

Substantial differences in responses were observed (Table II) in the correlations between loaf volume and dough strength. Loaf volume of bread baked by conventional procedures was dependent on protein content and dough extensibility. This was particularly so at lower protein levels. At higher protein levels, development time became a limiting factor.

Although protein content was also a limiting factor governing the volume of loaves made from sheeted doughs in the lower protein range, development time and resistance to stretching were much more important in each protein range. Multiple regressions were constructed from the pooled results. These confirmed the impression gained from the correlation matrix, but when the square of resistance was introduced, a curved relationship between conventional loaf volume and resistance was apparent. When the loaf volume from each baking procedure was expressed as a quadratic function of dough resistance within a set of samples from which those with extreme qualities had been omitted, the essential difference between the requirements of each method became apparent (Fig. 1). When dough resistance was less than 320 BU, the conventionally molded doughs gave the larger loaves, whereas the sheeted doughs gave the superior loaves above that point. Beyond 400 units, conventional loaves became limited in volume by excessive dough strength.

Selection of Wheat Cultivars

Breeders in many countries have endeavored to produce wheat to satisfy the quality requirements of bread makers. Commercially, the different types are classified to make the most of the wheat available. Table III shows the relative effects of season and cultivar. In 1977 the grain was higher in protein, in dough resistance, and in baking performance by either baking system.

Interest centers chiefly on the relative performance of the cultivars Kite and Timson. The former gave acceptable sheeted loaves but was inferior to the latter in the conventional baking test. On the other hand, Timson gave disappointing sheeted loaves but acceptable conventional ones. The ranking of the cultivars is more or less according to resistance with the sheeted doughs and protein with the conventional doughs.

Kilborn and Tipples (1974) showed the progressive improvement of loaves made by repeated sheeting of an undermixed dough, and Feillet el al (1977) demonstrated the destruction of gluten by repeated fine sheeting of a durum dough. To derive the benefit of the fine crumb structure produced by repeated sheeting, dough of initially extreme strength must be used. If dough is not to be sheeted, a more extensible dough will be required. The effect of sheeting (Fig. 2) necessitates a degree of initial dough strength that would be undesirable in a dough destined for conventional molding. A different emphasis could well be achieved by a different choice of baking methods, sugar, yeast, or bromate levels. The main point is that repeated sheeting requires a strength level much higher than conventional molding, but is capable of providing a superior loaf when the requisite dough strength is available. Where dough is developed in the mixer rather than by sheeting, dough strength has a definite upper limit, beyond which loaves are lower in volume and "gluten bound" in appearance.

CONCLUSION

In order to achieve the exceptionally high volume and fine crumb structure of the commercial bread made by the sheeted dough system, the dough must be too "tough" for conventional systems, where the dough may pass once through a series of sheeting rolls. The best compromise between the systems seems to be a flour with extensigraph resistance of 400 BU on the 45-min pull and with adequate protein and extensibility.

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