Comparison of Gluten Properties of Four Wheat Varieties[1]

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Cereal Chem. 56(3):159-161

ABSTRACT

The amount of gluten, stretching properties, and effect of the glutens on mixograph curves were compared in four wheat varieties, ranging in mixing strength from weak to very strong. The weight of the wet and dry gluten obtained from each flour increased as the protein increased. A stretching test revealed that the rate of elongation decreased with the mixing strength of the flour. Small additions of freeze-dried glutens from the four wheat varieties improved the mixograph curve in the order of mixing strength of the flour. Glutens from strong wheats had greater resistance to stretching and were more resistant to mixing breakdown than glutens from weak flours.

Wheat flour from various classes and varieties of wheat display great diversity in their stretching properties (Johnson et al 1946) despite similarity in amino acid composition (Tkachuk 1966). Experiments with air-classified flour fractions showed that resistance and extensibility, as measured by the extensigraph, increase with protein content (Gracza 1959, 1960). Aitkens and Geddes (1939) working with flour-gluten mixtures reported that stability, as measured by the farinograph, increase with protein content. The farinograph was adopted to study the mixing properties of crude gluten (Bushuk 1963). Using this technique, Doguchi and Hlynka (1967) reported that the farinograph mixing curve for gluten of a hard red spring wheat was stronger than that of a soft winter wheat.

Muller et al (1965) reported that addition of various solvents, expecially alcohols to doughs, modified both the extensigraph extensibility and resistance. Work done on gluten by Ponte et al (1967) showed that the small quantities of certain organic solvents affected gluten extensibility and gluten expansion properties. In that study, organic solvents were shown to have a "strengthening" effect on the gluten in the stretching test and this was attributed to the generation of high molecular weight aggregates in gluten. Recently, Huebner and Wall (1976) found the ratio of high molecular weight glutenin to lower molecular weight glutenin was generally higher in bread wheat flours exhibiting long mixing times and strong dough.

Our purpose was to investigate the stretching properties of glutens from wheat varieties differing widely in mixing properties. The effect of glutens from these varieties on the mixograph properties of a weak flour was also investigated.

MATERIALS

The four wheat varieties were grown as check varieties in yield trials at the University of Manitoba during 1974. After harvest, the protein content of samples from the various plots was determined and found to cover a fairly wide range. For each of two varieties (Manitou and Glenlea, both hard red spring wheats), grain samples were placed in high, medium, or low protein category. The protein content of a category within either Manitou or Glenlea depended on the range of protein content. The grains for the varieties Norquay (a hard white spring wheat) and Talbot (a soft white winter wheat) were pooled to form a single sample for each variety.

The grain of the four varieties was milled into flour using the Buhler experimental mill (AACC Method 26-20) after overnight tempering to 16.5% moisture content.

[1]Contribution 505, Department of Plant Science, University of Manitoba, Winnipeg, Manitoba, R3T 2N2, with financial assistance from the National Research Council of Canada and the Canadian International Development Agency.

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0009-0352/79/000021$3.00/0

METHODS

Technological Properties of Flour

The flour samples were analyzed for protein, ash, extensibility, mixing properties, and Zeleny sedimentation according to AACC Methods (54-21, 10, 40, and 60). Loaves of bread were obtained according to the remix procedure (Irvine and McMullan 1960). Extensibility of dough was measured on a Brabender extensigraph.

Effect of Gluten on Mixograph Properties of Weak Flour

Glutens were isolated from the flour samples using the Theby gluten washing machine (AACC Method 38-11). Glutens were freeze-dried, ground with a pestle and mortar, and stored in a room at 0–4° C until required. Mixograms of the control (Talbot, a weak flour) and the control flour plus 0.5, 1.0, or 2.0 g of freeze-dried gluten were determined using 35 g of control flour according to AACC Method 54-40.

Gluten Stretching Test

A 2-g portion of wet gluten was molded with the fingers to a uniform round ball and rested in distilled water at 30° C for 20 min. The gluten ball was allowed to stretch under constant 9.9-g load in an apparatus similar to that described by Kaminski and Halton (1964).

RESULTS

Technological Properties of the Flour Samples

The technological properties of the flour samples are presented in Table I. The Zeleny sedimentation values showed progressive increases with flour protein in the Manitou and Glenlea samples. However, sedimentation values were greater for the Glenlea samples than for the Manitou samples. Talbot had the lowest sedimentation value; the values of Norquay and Glenlea were comparable.

Table I shows that for the Manitou samples, percent water absorption, dough development time, and stability in the farinograph increased with flour protein. Only water absorption increased with flour protein in Glenlea samples. The mixing properties of Norquay and Glenlea flours were similar; Talbot had a short development time and stability. As measured by the extensigraph, the extensibility of the doughs of all varieties differed. Maximum resistance or maximum height in Brabender units (a measure of elasticity) and area under the curve (a measure of dough strength) showed that Glenlea flours were superior in strength and elasticity compared with all the other varieties examined. Other varieties showed the following order of decreasing strength: Norquay, Manitou, and Talbot.

Norquay flour gave the largest loaf, followed in order of decreasing loaf volume potential by Manitou, Glenlea, and Talbot flours. The effect of increasing flour protein content in Manitou and Glenlea samples was to improve bread-making potential. In spite of long mixing requirements in the farinograph, Norquay gave a large loaf of bread. These varieties could, therefore, be classified in the following way: Glenlea (very strong), Norquay (strong), Manitou (medium strong), and Talbot (weak).

Gluten Content

Table II shows the weights of the wet and dry glutens obtained from 10 g of each flour sample of the four varieties. The weight of the wet gluten obtained from a flour increased with increase in flour protein. Flours with high protein content yielded more gluten than those with low protein content. This was true in comparisons with varieties but was not strictly true between varieties. For example, Talbot (10.9% flour protein) gave a wet gluten of 3.69 g, but Glenlea (14.6% flour protein) yielded a gluten of only 3.78 g. The weights of the dry glutens (Table II) followed the same trend.

The protein content of the dry glutens showed that the gluten of the long-mixing flour, Glenlea, had a higher protein content than did the weaker flours. The weakest flour, Talbot, had the lowest protein content in the dry gluten.

Effect of Glutens on Mixograph Properties of Weak Flour

Freeze-dried gluten from flours of four wheat varieties was used to replace the same weight of flour in a mixograph test of a weak flour. Gluten levels of 0.5, 1.0, and 2.0 g were selected. The glutens from the four varieties improved the mixograph curve of the weak flour to varying degrees at each level of addition. The greatest improvement was noted in the mixing tolerance index.

Results of preliminary experiments in this study, indicated that, within a variety, glutens obtained from flours differing in protein content showed only small differences in stretching and reconstitution. Accordingly, in subsequent parts of this article, stretching results for the varieties Manitou and Glenlea represent the averages of the glutens from the three flours for each variety.

Figure 1 shows that the glutens from Glenlea, Norquay, Manitou, and Talbot imparted different magnitudes of mixing tolerance to a weak flour. Addition of the same quantity of Glenlea gluten to a base flour produced a dough with greater tolerance to mixing than those containing Manitou, Norquay, or Talbot gluten. Addition of Talbot gluten had the smallest effect on mixing tolerance of the base flour. Norquay and Manitou were intermediate.

By altering the proportion of high molecular weight gluten proteins, MacRitchie (1973) converted a weak flour to a strong one, as measured by physical dough tests. Huebner and Wall (1976) found that the ratio of high-to-low molecular weight glutenin was greater for flours exhibiting long-mixing times and strong doughs. Other findings (Butaki and Dronzek 1979), using the same samples as in this study, suggest that the greater improvement of the mixing

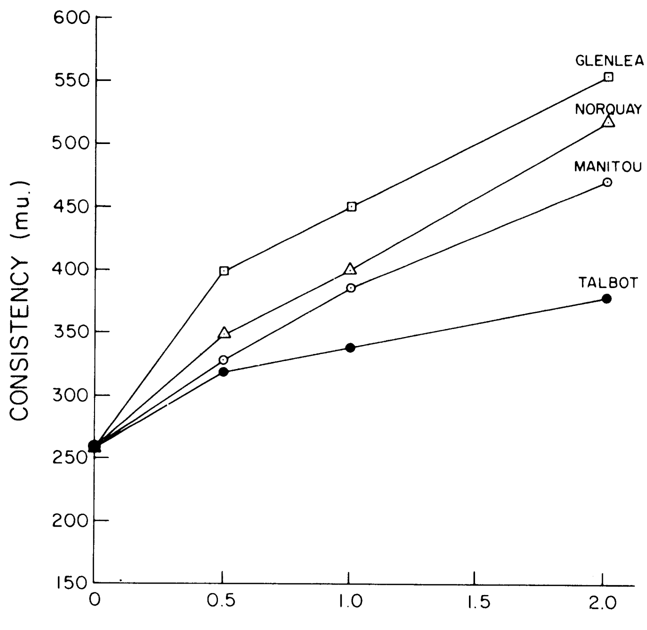

Fig. 1. Mixogram consistency, measured 2 min from onset of mixing, of doughs containing increasing amounts of glutens from four wheat varieties.

TABLE I
Technological Patterns of the Flour Samples of Four Wheat Varieties

	Glenlea			Norquay	Manitou			Talbot
% Protein[a]	12.6	13.9	14.6	12.0	10.2	11.6	13.4	10.9
Sedimentation values	65	66	69	62	38	43	50	26
% Ash (14% mb)	0.46	0.44	0.48	0.54	0.50	0.47	0.46	0.48
Farinograph								
Absorption (%)	58.5	59.8	60.8	60.9	63.2	63.9	65.1	54.7
Development time (min)	3.0	3.0	3.0	4.0	2.0	2.5	5.5	1.8
Stability (min)	13.5	13.5	13.5	13.0	4.5	9.0	10.0	2.0
Extensigraph								
Max height (BU)	805	825	900	685	485	570	570	75
Area (cm^2)	294.0	331.2	323.8	264.7	122.0	142.2	133.2	23.8
Remix loaf vol. (cc)	605	645	655	890	730	750	860	510

[a] N × 5.7 on a 14% mb.

TABLE II
Weight of Wet and Dry Gluten Washed from 10 g Flour and Protein Content of Dry Gluten for Four Wheat Varieties

	Glenlea			Norquay	Manitou			Talbot
Flour protein[a]	12.6	13.9	14.6	12.0	10.2	11.6	13.4	10.9
Wet gluten (g)	3.23	3.55	3.78	3.30	2.70	3.17	4.01	3.69
Dry gluten (g)	1.24	1.37	1.43	1.18	0.97	1.13	1.40	1.14
Gluten protein[b]	87.9	87.0	87.6	83.9	83.5	84.8	83.4	79.9

[a] N × 5.7 on 14% mb.
[b] N × 5.7 on 0% mb.

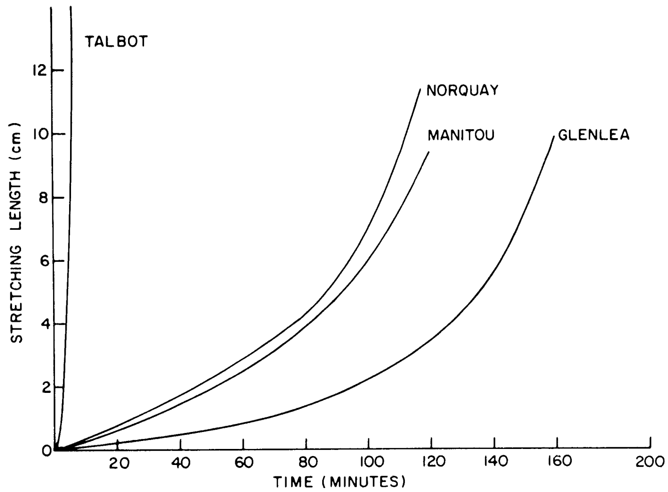

Fig. 2. Increase in length of stretch with time of glutens from four wheat varieties.

tolerance conferred by the long-mixing flour could be due to the greater amounts of high molecular weight proteins in its gluten.

Stretching of Glutens

The curves in Fig. 2 show the increase in the length of stretch with time of glutens washed from flour of four wheat varieties. The gluten of the weak variety, Talbot, had the most rapid rate of stretch of the varieties studied. This was followed in decreasing rate of elongation by Norquay, Manitou, and Glenlea glutens. The curves of Norquay and Manitou glutens had very similar stretching properties.

The order of the rate of stretching of the glutens of the four varieties suggested that stretching properties were related to flour strength. The stronger variety, Glenlea, had more elastic gluten with greater resistance to stretching under a constant load than did the weaker varieties. These findings are consistent with those of Prihoda et al (1971) who found that, at constant stress, the velocity of deformation decreased with flour stength for doughs measured on a Hoeppler consistometer.

The stretching properties determined in this study may suggest that gluten of the weak flour is formed of smaller aggregates of protein of less compact nature that can stretch easily. The gluten of the strong flour consists of larger aggregates of protein that are more compact and not liable to rapid stretch. Others have suggested that strong flour is more heavily cross-linked (Muller 1969) and that the largest protein aggregates of the soft wheat flour are smaller and more liable to disaggregation (Tsen 1967).

DISCUSSION

Our results suggest that gluten stretching properties and resistance to mixing breakdown depend on the mixing strength of the flour (wheat cultivar). Gluten from the strong wheat (Glenlea) was more resistant to stretch and conferred greater resistance to mixing than did glutens from weaker wheats. These results are consistent with stretching (Kaminski and Halton 1964) and mixing (Doguchi and Hlynka 1967) properties of glutens. For the varieties Manitou and Glenlea, results obtained in this study but not reported showed that gluten properties were not affected qualitatively by flour protein content. The mixing and stretching results presented here complement and viscosity and exhaustive extraction results reported in another paper (Butaki and Dronzek 1979).

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[Received October 14, 1978. Accepted August 21, 1978]