Comparative Mixing and Baking Properties of Wheat and Triticale Flours[1]

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ABSTRACT

Samples of both spring and winter wheats and triticale were compared in their chemical analyses and mixing and baking properties. Triticale grains were generally higher in protein than the wheats, but the flours milled from the wheats showed a higher protein content than the triticale flours. The mixograph indicated shorter mixing times and less mixing tolerance for the triticale samples. Bread of very acceptable quality was produced from triticale flour. Changes in absorption and mixing time from those indicated by the mixograph and modifications in the mixing procedure were required to produce such bread.

For human nutrition, cereal grains supply the major portion of both protein and energy for the world population. Cereals are generally low in protein and may be deficient in certain essential amino acids, especially lysine. As certain segments of the world population are almost totally dependent on these grains as the source of dietary protein, improvements with respect to crop yield, increased protein quantity, and better essential amino acid balance are highly desirable. The rapid increase in world population, especially in the developing nations, emphasizes an urgency to the problem, particularly regarding wheat (1). Triticale, a hexaploid hybrid cereal produced by cross-breeding wheat and rye, was found to have such qualifications (2,3). Although both wheat and rye are first limiting in lysine, rye was found to have a slightly higher protein quality than wheat, and this may have been inherited in triticale (1).

One of the problems in the development of triticale lines has been the poor kernel characteristics, resulting in a low bushel weight (4). This characteristic is improving through selection for meiotic stability and fertility (5).

The amino acid composition of triticale and the results of animal feeding experiments indicated that this cereal has a higher protein value than wheat (6). The lysine and sulfur amino acid contents of triticale have been found to be higher than those of wheat. Comparison of protein nutritive value for adult humans of wheat grain and triticale grain showed a statistically significant difference at each level of nitrogen intake, suggesting a higher protein nutritive value for the triticale grain (6,7). More laboratory and field studies with humans have been suggested for valid application to human nutrition (6).

Crosses of cereal grains have been shown to produce varieties with good baking characteristics. The crossing of a durum-wheat variety with a common bread-wheat variety followed by back-crossing to the bread-wheat variety and then selecting for

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28-chromosome plants has resulted in a durum-type wheat with high breadmaking quality (8). The crossing of wheat and rye varieties has thus far not produced a triticale variety of good bread-baking properties (2,9). However, the genetic base of newer varieties is constantly being made more diverse. Therefore, conclusions on earlier and present lines can only be tentative.

This paper discusses some general analytical results for a number of spring and winter wheat varieties in comparison with triticale varieties, their rheological properties as measured with the mixograph, and their baking properties.

MATERIALS AND METHODS

Eight grain samples, all grown on irrigated sites at Fort Collins and Center, Colorado, were selected for this study. The two winter wheats – Scout and Caprock; two spring wheats – Inia Res. and Ciano Sib; two spring hexaploid triticales – 6-TA-204 and 6-TA-206; and the two winter hexaploid triticales – TR-385 and TR-386–were milled on a Brabender Quadrumat Junior mill. Triticales 6-TA-204 and 6-TA-206 were moderately shrivelled, whereas TR-385 and TR-386 were normal seeds. All triticale samples were tempered to 13.5 to 14.0% moisture for 18 hr.; and the wheat samples were tempered to a moisture content of 15% for 18 hr. For this study the amounts of flour collected by sifting through a 100-mesh screen were expressed as percent yield. These flours were used for the study without further treatment.

Moisture and ash were determined by AOAC procedures (10) and whole-grain and flour protein contents by the standard Udy Protein Analyzer method (11).

The flours were tested on a mixograph at a spring setting of 10 at absorptions of 50 and 68%, respectively. An absorption of 68% was used for the baking experiments for both the wheat and the triticale flours. To center the mixograph curve at approximately 5.5 cm. above the base line, which was the center of the curves of the wheat-flour controls, the absorption of the triticale samples was decreased to 50%. The flour weight was constant for each mixograph test at 30 g. The temperature was maintained at 25°±0.2°C.

The following five readings were made from the mixograph curves: a) maximum curve height in cm. at the center of the curve, b) length of the curve in cm. from the starting point to maximum height, c) time in minutes to reach maximum height, d) the weakening angle of the curve in degrees after maximum height was reached, and e) the area under the curve in $cm.^2$ for 7 min. of mixing by totalling the height of the curve after 1, 2, 3, 4, 5, and 6 min. of mixing and multiplying the sum by 0.44 (Chart paper = Esterline-Angus Record chart No. 4300 X).

Pup loaves were baked from each of the flours by the straight-dough procedure and the following formulation: 6% sugar, 4% nonfat dry milk, 3% shortening, 2.5% yeast, 2% salt, 1% yeast food, 0.5% mono- and diglyceride emulsifier, and 0.3% calcium propionate. The yeast food was increased from the usual 0.5% based on flour to 1.0%, to increase the level of oxidizing agents to that of a dough made with a bromated flour. Wheat-flour doughs were mixed in a 12-qt. bowl of a Hobart A-120 mixer at speed 2 for 13 min., using a dough hook. Triticale-flour doughs could not be developed with the dough hook, but use of the flat-paddle agitation was sufficient to develop a manageable dough. Therefore, triticale-flour doughs were mixed by the paddle on speed 2, with 7 min. for the winter varieties and 8 min. for the spring varieties. Fermentation time was 120 min. at 30°C. and 85% r.h. The loaves were scaled 200 g. each, four loaves per batch. They were mechanically molded, proofed to height at 35°C. and 95% r.h., and were baked at 218°C. for 18 min. Specific loaf volume was measured by rapeseed displacement approximately 2 hr. after baking, followed by an evaluation of external and internal bread characteristics. The breads were scored as follows: for crust color - 7, symmetry - 7, break and shred - 6, crumb color - 10, volume - 15, flavor - 15, grain - 20, and texture - 20, the maximum number of points being indicated after each bread characteristic. The baking experiments were repeated twice. The data presented are the averages from eight pup loaves.

RESULTS AND DISCUSSION

Analytical Data

Analytical data of the cereal grains and of the flours milled from these grains are presented in Table I. The spring varieties, both wheat and triticale, had a higher protein content than the winter varieties. But although the protein content of the spring triticale grains was higher than that of the wheat samples, the protein content of the wheat-sample flours was higher than that of flours milled from the triticale samples on a 14% moisture basis. This indicates that a larger proportion of the triticale protein than of the wheat protein is in the bran. Of the winter triticale varieties, only TR-385 showed a higher grain protein than the two winter wheat samples. However, both triticale flours again had a protein content lower than the wheat flours. The ash content of the flours from the spring varieties was found to be higher than those of flours milled from the winter varieties in both the wheats and the triticales. The triticale flours had a higher ash content than the wheat flours.

Mixograph Results

The mixograph curves obtained with the wheat and triticale flours are shown in Fig. 1. All the mixograph data are compiled in Table II. At a constant spring setting of 10 and a constant absorption of 68%, which was the absorption used for baking of all flours, the wheat flours had a greater maximum curve height than the triticale flours, and in each case the spring varieties showed a greater maximum curve height than the winter varieties. The lengths of the curves to maximum height and the mixing times to maximum heights were longer for the spring than for the winter wheat varieties. However, at 50% absorption these two values were both larger for the winter than for the spring triticales.

TABLE I. ANALYTICAL DATA FOR TWO WINTER AND TWO SPRING WHEAT AND TRITICALE VARIETIES

	Winter Varieties				Spring Varieties			
	Scout	Caprock	TR-385	TR-386	Inia Res	Ciano Sib	6-TA-204	6-TA-206
Grain protein, %[a]	12.0	11.2	12.0	10.8	12.7	13.2	14.6	14.5
Flour protein, %[a]	11.6	11.0	8.7	8.6	12.4	12.5	11.3	11.7
Flour ash, %	0.43	0.41	0.47	0.47	0.46	0.48	0.53	0.54
Flour yield, % (through a 100-mesh screen)	57.0	44.4	33.9	32.7	45.2	45.8	42.1	42.8

[a]On 14% m.b.

TABLE II. MIXOGRAPH DATA FOR TWO WINTER AND TWO SPRING WHEAT AND TRITICALE VARIETIES

	Max. Curve Height, cm.		Length of Curve to Max. Height, cm.		Time to Max. Height min.		Weakening Angle of Curve, degrees		Area under Curve for 7 min. of Mixing, cm.^{2}	
	68% abs.	50% abs.	68% abs.	50% abs.	68% abs.	50% abs.	68% abs.	50% abs.	68% abs.	50% abs.
Winter varieties										
Scout	5.5	...	2.5	...	1.8	...	20	...	12.1	...
Caprock	6.0	...	4.5	...	3.3	...	18	...	13.2	...
TR-385	3.3	5.8	0.5	4.0	0.7	2.8	19	20	7.0	11.9
TR-386	3.3	5.5	1.3	4.4	1.2	3.0	21	23	7.0	11.0
Spring varieties										
Inia Res	5.7	...	5.6	...	3.9	...	21	...	13.8	...
Ciano Sib	6.2	...	4.7	...	3.1	...	22	...	12.9	...
6-TA-204	4.0	5.9	2.8	2.8	2.0	2.0	27	31	8.1	12.3
6-TA-206	3.8	5.8	2.1	1.7	1.8	2.0	26	24	7.6	12.2

TABLE III. BREAD-BAKING RESULTS FOR TWO WINTER AND TWO SPRING WHEAT AND TRITICALE VARIETIES

Flour	Proof-times min.	Bread Volume cc.	Specific Volume cc./g.	Volume (15)[a]	Crust Color (7)	Symmetry (7)	Break (6)	Crumb Color (10)	Grain (20)	Texture (20)	Flavor (15)	Total Score (100)
Winter varieties												
Scout	49	780	4.48	10	6	6	6	9	17	16	13	83
Caprock	50	770	4.36	9	6	6	6	9	17	16	13	82
TR-385	52	645	3.71	6	6	5	5	7	14	13	14	70
TR-386	54	640	3.68	6	6	5	5	7	13	13	14	69
Spring varieties												
Inia Res	50	735	4.15	8	6	6	5	8	17	17	13	80
Ciano Sib	51	735	4.14	8	6	6	5	8	17	17	13	80
6-TA-204	50	800	4.58	10	7	6	6	8	16	16	14	83
6-TA-206	50	710	4.03	8	6	6	6	8	14	16	14	78

[a]Numbers in parentheses indicate the maximum score for each characteristic.

The differences in weakening angle were slight between wheat-flour and triticale-flour doughs. The spring wheat and triticale flours had a slightly greater weakening angle than the winter varieties.

The area under the curve, which is indicative of flour strength and flour mixing tolerance (12), showed a great difference between wheat- and triticale-flour doughs at a constant absorption of 68%. The results indicated that the triticale flours have considerably less baking strength and less mixing tolerance than the wheat flours. This has previously been observed by Unrau and Jenkins (2) and by Rooney et al. (9).

Shuey and Gilles (12) reported that mixogram absorption was significantly correlated with baking absorption at spring setting 10 and also that baking absorption was correlated equally well with the height of the mixogram and with mixogram absorption.

The baking absorption of 68% with the triticale flours did not produce the same curve height as that of the doughs mixed from the wheat flours, as seen in Fig. 1 and Table II. Reducing the absorption of the triticale doughs (for both spring and winter varieties) to 50% increased maximum curve height to approximately that of the corresponding wheat-flour controls. This absorption change also increased the lengths of the curves to maximum height, the time to maximum height for the winter triticale flours, and the total area under the curve. The latter indicates greater flour strength and more mixing tolerance for all triticale flours at 50% absorption. That, however, is not the case. An absorption of 50% produced a triticale dough which was putty-like, very inelastic and short, and incapable of the gas retention required to produce bread of good quality. An absorption of 68%, however, made a slightly soft and sticky dough which was elastic and capable of gas retention satisfactory for a good-quality bread.

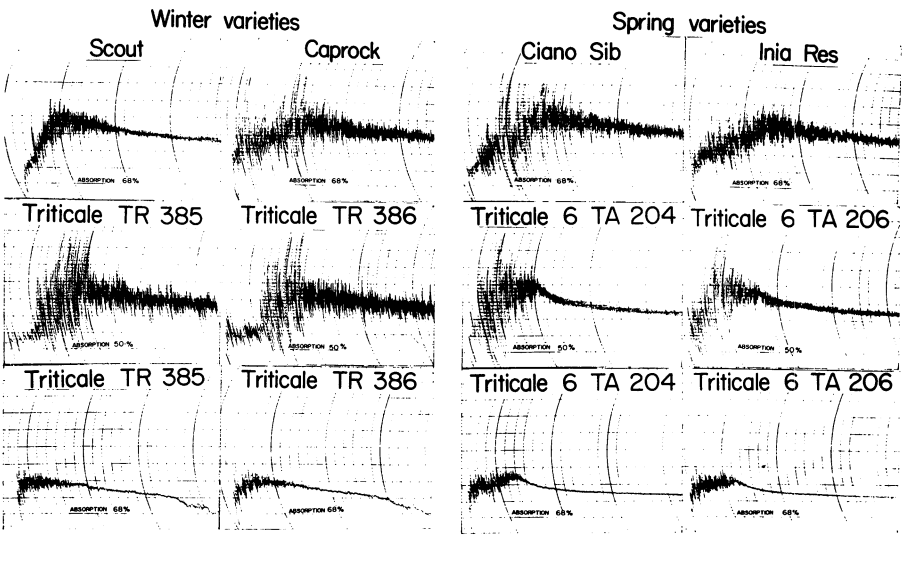

Fig. 1. Mixograph curves of flours milled from winter (left) and spring (right) varieties of wheat and triticale.

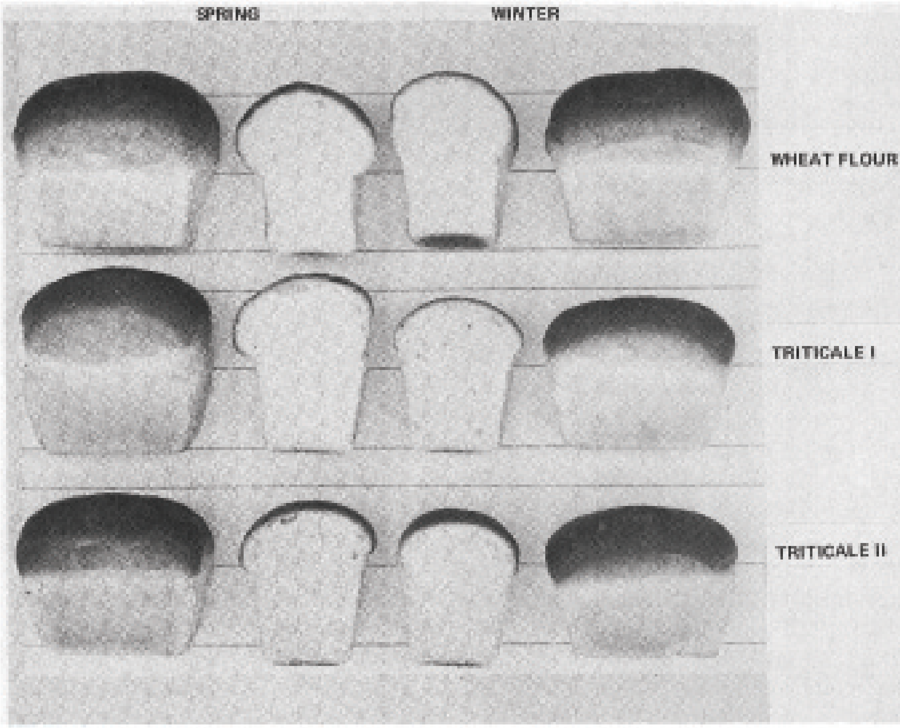

Fig. 2. Breads baked from wheat flours and triticale flours: Spring wheat, Inia Res.; winter wheat, Scout; spring triticale I, 6-TA-204; winter triticale I, TR-385; spring triticale II, 6-TA-206, and winter triticale II, TR-386.

The mixograph, therefore, while giving reliable information about the mixing and baking characteristics of wheat flours, does not seem to be capable of accurately predicting the baking qualities of triticale flours.

Baking Results

Triticale doughs required a higher absorption and a longer mixing time than indicated by the mixograph. An absorption of 68% was found to give very satisfactory results with all eight flours under investigation. The wheat-flour doughs were mixed with a dough hook and produced dry, smooth, and pliable doughs—as expected. Use of a dough hook for mixing triticale doughs was completely unsatisfactory. The doughs would not pick up, making constant scraping during mixing necessary. Use of a paddle instead of a dough hook completely eliminated the problem. The doughs could be mixed easily, but were slightly soft and sticky immediately after mixing. Following fermentation they became tighter and easy to handle.

The breads baked with wheat and triticale flours are illustrated in Fig. 2. The prooftimes, specific bread volumes, individual scores for external and internal bread characteristics, and total scores are compiled in Table III.

The winter triticale flours produced bread of slightly lower quality than the winter wheat flours. The specific volumes were lower, the grain more open, the texture slightly harsher, and the crumb color slightly darker. However, the quality of these triticale breads was considerably better than the quality of any triticale bread previously reported (2,9).

The spring triticale flours produced breads of very acceptable quality. Bread baked from triticale 6-TA-204 had the highest volume of all the breads baked. It also scored higher in overall appearance and flavor than any of the wheat-flour breads. The flavor of all triticale breads was characteristic of a very mild rye bread and was preferred over the flavor of the wheat breads. The total score of the bread baked from triticale 6-TA-204 was as high as the highest score of all the wheat-flour breads baked. The second spring triticale flour, 6-TA-206, produced a bread with a slightly lower bread volume than the 6-TA-204 and a slightly more open grain. However, the overall quality was still very acceptable, with a total score only slightly lower than that of the spring-wheat-flour bread.

CONCLUSIONS

Breads of very acceptable quality can be produced with certain varieties of triticale. Only minor adjustments are required in absorption and mixing time from those indicated by the mixograph. A change in mixing procedure from dough hook to paddle facilitated dough handling.

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