PERFORMANCE OF TRITICALE FLOURS IN TESTS FOR SOFT WHEAT QUALITY[1]

L. T. KISSELL[2], Soft Wheat Quality Laboratory, Ohio Agricultural Research and Development Center, Wooster, OH 44691, and K. LORENZ[3], Department of Food Science and Nutrition, Colorado State University, Ft. Collins, CO 80521

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ABSTRACT

Five cultivars of triticale were milled on a Quadrumat Senior mill to straight-grade flours for evaluation in the Wooster Sugar-Snap Cookie Test. Basic performance was poor and correlated inversely with hydration properties as measured by the alkaline water retention capacity (AWRC) test. Addition to the dough system of 1–2% (flour weight basis) of commercial soy lecithin improved both cookie spread and top-grain scores to equal soft red winter (SRW) wheat flour. Layer cake performance of triticale flour was determined by AACC Method 10-90. The effects of processing variables (rebolting, pin-milling, and chlorination) on flours were studied as they influence cake quality. Volumes from as-milled, chlorinated triticale were significantly below the level of cake from SRW patent flour. Both removal of large particles by rebolting on 165-mesh sieve and reduction of particle size by progressive pin-milling improved performance of triticale flours. Additional improvement was obtained by increasing emulsification of the batter system with commercial mono- and diglycerides. With 3% added emulsifier, blends of triticale-wheat flour, ranging from 20 to 50% triticale, produced layers equal to or significantly larger than SRW patent without added emulsifiers.

Triticale, the cereal grain hybridized from durum wheat and rye, has generally higher protein content and better amino acid balance than wheat for human nutrition (1). In feeding trials, triticale was equivalent or superior to wheat in protein efficiency ratios (PER) (2,3,4), with some cultivars comparing favorably with casein in this respect.

Flours from most triticale varieties have gluten-development properties that are weaker and less stable than those of wheat (5,6,7). Among suggested causes of inferior gluten properties of triticale are the low ratio of gluten to water- and salt-soluble proteins (8), high proteolytic activity (9), and/or the high sulfhydryl contents (7) with respect to bread flours from wheat. Nevertheless, it has been shown that triticale flour can be adapted to production of breads and rolls (5,6,10), pasta (11), and extruded products (12).

Physical characteristics of the parental species of triticale and the proximate analysis of triticale flours invite a prognosis of poor inherent quality with respect to soft wheat products. Tsen (7), in evaluating triticale flour in cookie-baking, noted that the weak gluten properties of triticale doughs bear a similarity to soft wheat flour doughs.

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[2]Research Chemist, U.S. Department of Agriculture, Agricultural Research Service, North Central Region.
[3]Associate Professor.

The present study, initiated by Colorado State University and conducted cooperatively with the USDA Soft Wheat Quality Laboratory, yielded data which confirm and extend those of Tsen (7) regarding the use of triticale flour in soft wheat test products. Some physicochemical and mechanical treatments for improving the inherent baking performance of triticales were also investigated.

MATERIALS AND METHODS

Five varieties of triticale were evaluated, including two spring cultivars, 6TA-204 and 6TA-206, two experimental winters, TR-385 and TR-386, all grown on irrigated sites in Colorado, and a commercial winter, WT-66. Three interrelated milling and baking studies were conducted:

Series A

Samples of the five varieties were tempered to 15% moisture for 18 hr and milled on Brabender Quadrumat Senior[4] equipment at Colorado State. At Wooster, a portion of each flour was retained "as-is" for cookie-baking, and the remainder was Alpine pin-milled[4] at 9000 rpm and chlorinated for cake-baking.

Series B

A 35-lb sample of commercial variety WT-66 was Quadrumat-milled after 18 hr temper to 14% moisture. At Wooster, portions of the flour were pin-milled at 9000, 12,000, and 18,000 rpm, respectively. In an attempt to reduce patent extraction, another lot was rebolted on 120- and 165-mesh sieves to remove coarse and intermediate size particles. The resultant throughput of rebolted straight-grade flour was chlorinated for cake-baking.

Series C

On the basis of results from series A and B, the five varieties were Quadrumat-milled and quantities of each flour were rebolted, pin-milled at 12,000 rpm, rehydrated to 14% moisture, and chlorinated at optimum levels.

Moisture, protein (Kjeldahl N × 5.7), ash, and pH of triticale flours were determined by standard methods (13). For series A, the effectiveness of particle-size reduction by Alpine pin-milling was measured by separating a 2-g sample of triticale flours at the 105 μ cut-point on a Sonic Sifter[4] for 2 min. Data were expressed as per cent of sample larger than stated size. Complete particle-size profiles were obtained for flours in series B and C, by the Coulter Counter method[4] (14).

Hydration properties of triticale flours were determined by the micro-alkaline water retention capacity (AWRC) test (15,16). Damaged starch levels were assessed by the rapid-enzymatic procedure of Donelson and Yamazaki (17).

Evaluation as Cookie Flour

Cookies of the sugar-snap type were baked with series A samples by the Wooster Cookie Test, known as Micro-Method III, of Finney *et al.* (18).

[4]Quadrumat is a trademark of Brabender Instruments Inc., South Hackensack, N.J.; Alpine is a trademark of Alpine Aktiengesellschaft, Augsburg, W. Germany; Sonic Sifter is a trademark of the Allen-Bradley Co., Milwaukee, Wis.; Coulter Counter is a trademark of Coulter Electronics, Hialeah, Fla.; Forma is the trademark of Forma Scientific, Inc., Marietta, Ohio.

Performance of the varieties was compared under the following conditions: a) as untreated Quadrumat-milled flour; b) as-milled in dough systems to which commercial soy lecithin was added at 1% level (flour weight basis); and c) the same, with 2% soy lecithin added (19,20).

Evaluation as Cake Flour

Moisture losses resulting from pin-milling ranged from 1 to 2%, and were restored by rehydration in a Forma conditioning chamber[4] to the 13–14% range prior to chlorination. Series A flours were treated in the Wooster Reactor (21) at four levels of chlorine: low (0.4 ml/g), medium (0.5 ml/g), mid-high (0.6 ml/g), and high (0.7 ml/g), based on nominal rates for soft red winter (SRW) flour. The medium rate (0.5 ml/g) was equivalent to 2.3 oz Cl_2/cwt flour. Series B and C flours were chlorinated at the levels found optimum in series A, 0.4–0.5 ml Cl_2/g.

Cakes were baked from all series using AACC Method 10-90 (13). Series C samples were tested alone, and as blends with commercial SRW cake patent flour ranging from 10 to 50% triticale, in batter systems modified by the addition of 3% (fat basis) of commercial mono- and diglyceride emulsifier. Layer volumes were measured by rapeseed displacement; contours and internal appearance of cakes were scored in comparison with those properties of SRW patent controls prepared each day. For the baking tests, least significant differences (LSD) for duplicate determinations at the 5% level of confidence were: Wooster cookie method—diameter = ±0.4 cm; top grain = ±2.5 units; AACC cake method—volume = ±35 cc; internal score = ±14%.

Two wheat flours unrelated to the triticale millings were used for comparison: for cookies, a laboratory-milled SRW straight-grade composite, and for cakes, a commercial SRW short patent.

RESULTS AND DISCUSSION

Farrell *et al.* (22) reported flour yields ranging from 55 to 63% for four triticales with the MIAG Multomat mill. Our yields were from 56.5 to 68.3% (Table I) with the Quadrumat equipment. These low yields (compared to a nominal 73% for SRW) were due primarily to the shriveled conditions of the triticale kernels, a shortcoming often noted for this cereal (5,23,24). Kernels in the sample of commercial variety WT-66 were extremely shriveled and gave the lowest extraction of the series.

Analytical data for series A triticale flours, compared with a SRW control, are also shown in Table I. Ash and protein values were high for all cultivars, and granulation was coarse before pin-milling. Hydration capacities of milled triticales were generally higher than those of SRW wheat flour, suggesting restricted cookie spread, if the high negative correlation of AWRC with cookie diameter found for wheat also holds for triticales. Low-speed (9000 rpm) pin-milling increased the water retention of each flour by 3–8%. Damaged starch contents of the flours paralleled the AWRC responses within treatments.

In Table II cookie-baking data from each flour treatment and cultivar are compared with data from SRW control flour. All Quadrumat-milled triticale flours gave significantly smaller diameters and lower top-grain scores than SRW products. Based on previous use of wheat-lipid extracts, soy lecithins, and other surfactants to improve cookie-baking performance of wheat flours and fortified blends (19,20), additions of 1.0 and 2.0% (flour weight basis) of a commercial natural-soy lecithin, containing 60% phosphatides in soybean oil, were made to the fat phase of the dough system during mixing. With 1% added lecithin, WT-66 was about equal in spread to the SRW control without surfactant, and top grain was superior. At the 2% level, cultivars 204 and 206 were also improved to the point of acceptability on soft wheat criteria, although at no point did they approach the performance of SRW flour plus lecithin. Although both spread and top grain of cultivars 385 and 386 were markedly improved by the increased emulsification, they did not equal the spread of the SRW standard.

The relationship of hydration capacity (AWRC) to cookie diameters of triticale flours (as-milled) is shown in Fig. 1. The inverse response of cookie spread to increasing AWRC is similar to that found for wheat flours differing in cookie potential (15,16). Both hydration capacity and inherent damaged-starch content reflect quality differences among the cultivars studied. Cookie-baking performance of flour from certain triticale cultivars may be improved, by

TABLE I
Straight-Grade Flour Yield and Analytical Data for Quadrumat-Senior Triticale Flours: Series A Milling

		Triticale Cultivar Number					Straight-
		Spring		Winter			Grade
	Milling						SRW
Test[a]	Treatment	204	206	385	386	66	Control
Flour yield—%	As-milled	61.0	62.8	62.9	68.3	56.5	73.0
Ash—%	As-milled	0.49	0.54	0.46	0.48	0.51	0.39
Protein—%	As-milled	11.3	12.1	11.0	11.2	12.3	10.4
Particle size—%>105 μ	As-milled	12.5	19.5	24.5	22.6	18.4	7.3
Particle size—%>105 μ	+9K Alpine	0.5	2.4	4.9	1.6	1.5	...
AWRC—%	As-milled	58.2	59.7	64.0	64.0	54.5	48.3
AWRC—%	+9K Alpine	64.8	65.4	67.0	68.2	62.0	...
Damaged starch—%	As-milled	3.5	4.1	5.4	6.1	2.3	2.6
Damaged starch—%	+9K Alpine	4.3	4.3	6.0	6.4	2.9	...

[a]Analytical data on a 14% moisture basis.

TABLE II
Performance of Triticale Flours in the Wooster (Micro III) Cookie Method: Series A Milling[a]

	Triticale Cultivar Number										SRW	
	204		206		385		386		66		Control	
Treatment	Diam cm	TG	Diam cm	TG	Diam cm	TG	Diam cm	TG	Diam cm	TG	Diam cm	TG
Flour as-milled	15.8	3	15.4	2	14.9	1	14.7	1	16.3	1	17.9	7
+ 1% Soy lecithin	17.4	9	17.3	8	16.6	8	16.5	8	17.8	9	18.9	8
+ 2% Soy lecithin	17.7	9	17.5	9	17.0	9	17.0	9	18.2	9	19.1	9

[a]Diam = Mean diameter of two cookies in centimeters. TG = Top grain score: range from 0 for no grain to 9 for maximum surface break-up.

increasing emulsification in dough systems, to equal or exceed SRW standards without additives.

Adaptation of triticale flour for layer cake production was more complex than for cookies since cake quality depends, in part, on fine granulation, and optimizations of chlorination, batter-liquid level, and fat/surfactant ratios in the system.

Table III contains performance data (AACC Method) for pin-milled triticale flours at five levels of chlorination and at optimum batter-liquid content. At a given chlorine rate, the pH response of all cultivars was lower than that normally found for SRW patent flour, and maximum baking performance was found at higher pH levels than expected with wheat flours. Liquid requirements for optimum performance of triticale batters were 20–30% higher (flour weight basis) than normal for a soft wheat cake patent. For all cultivars, volumes were maximum at low to medium chlorine rates (0.4–0.5 ml Cl_2/g flour) with respect to soft wheat chlorination. With increased chlorination, there were general losses in volume, contour, and internal score. All cultivars responded to chlorination but maximum performance of each was significantly below that of the SRW control.

Series B milling was undertaken to study the effects of mechanical treatments as possible cake-baking improvers on a single cultivar, WT-66. Analytical, particle-size, and chlorination data from each treatment are listed in Table IV. Increasing levels of pin-milling reduced particle size mass median diameter (MMD) from 58 to 17 μ and narrowed the size range containing 80% of particles in each treatment. Under the uniform chlorination treatment, finer flour reached a lower pH than the as-milled control. Rebolting the as-milled WT-66 flour

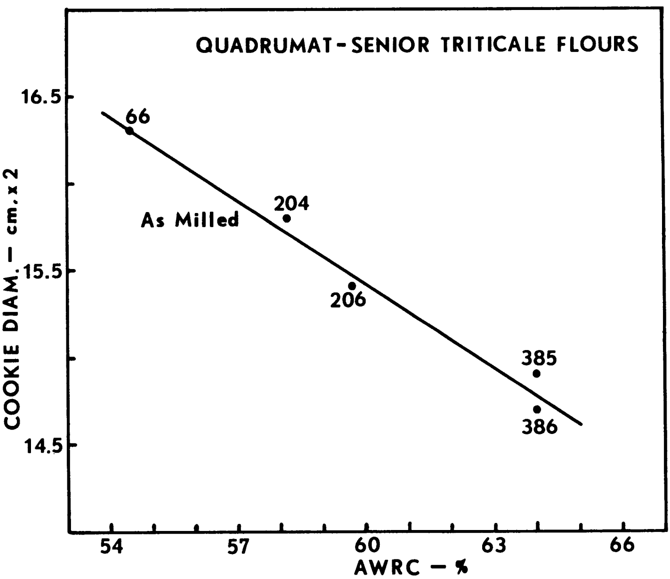

Fig. 1. Relationship of alkaline water retention capacity (AWRC) to the cookie spread of straight-grade triticale flours (n = 5; r = −0.9903**; Y = −0.1599X + 25.0239).

removed 29% by weight as coarse particles, with a corresponding reduction in protein level and a shift of MMD from 55 to 36 μ. The volume response of as-milled triticale flour to chlorination was significant and was accompanied by marked improvement in internal appearance score. Pin-milling at 9K, 12K, and 18K rpm, respectively, prior to bleaching further improved volume and score; the advantage was greatest at the medium level. Finally, rebolting Quadrumat flour through the 165-mesh sieve, without pin-milling, also increased volume over the as-milled, chlorinated triticale control. Nevertheless, at the maximum level of pin-milling (18K rpm), volume of triticale cake was still significantly smaller than that of the SRW control.

Based on positive responses in the foregoing work, series C flours were given a combination of treatments to maximize performance in the cake test. Each flour was rebolted on 165 mesh with throughput receiving 12,000 rpm pin-milling, rehydration to 14%, and chlorination at 0.5 ml Cl_2/g. Results of these treatments (data not shown) paralleled those in series B. Yields of rebolted flour ranged from 66 to 78%, with WT-66 showing the highest yield of fine fraction. Removal of

TABLE III
Optimum Performance of Pin-Milled, Chlorinated Triticale Flours in AACC Method 10-90: Series A Milling

Triticale Cultivar	Chlorine Rate ml/g	Flour pH	pH Response ΔpH/ml/g	Optimum Liquid[a] %	Layer Volume cc	Contour	Internal Score[b] %
6TA-204	0.0	6.2	...	175	820	Flat	54
	0.4	5.3	2.2	175	959	Rounded	72
	0.5	5.2	2.1	175	948	Rounded	75
	0.6	5.0	2.0	175	905	Rounded	74
	0.7	4.8	2.0	175	911	Sl. flat	75
6TA-206	0.0	6.2	...	175	814	Flat	57
	0.4	5.3	2.2	175	961	Rounded	68
	0.5	5.1	2.1	175	932	Sl. flat	73
	0.6	5.0	2.1	175	900	Rounded	73
	0.7	4.7	2.1	175	890	Sl. flat	73
TR-385	0.0	6.2	...	175	800	Flat	59
	0.4	5.4	1.8	185	881	Sl. flat	73
	0.5	5.3	1.6	185	883	Sl. flat	75
	0.6	5.1	1.8	175	814	Flat	70
	0.7	4.8	2.0	175	846	Sl. flat	69
TR-386	0.0	6.3	...	175	801	Flat	56
	0.4	5.6	1.7	185	888	Rounded	75
	0.5	5.3	1.8	175	892	Sl. flat	77
	0.6	5.2	1.7	175	860	Sl. flat	68
	0.7	4.9	2.0	175	850	Flat	69
WT-66	0.0	6.2	...	175	771	Flat	45
	0.4	5.4	2.0	185	955	Rounded	74
	0.5	5.2	2.0	185	944	Rounded	72
	0.6	5.0	2.0	185	900	Rounded	68
	0.7	4.8	1.9	175	902	Sl. flat	74
Patent SRW	0.0	5.8	...	155	924	Flat	54
(Control)	0.5	4.6	2.5	155	1032	Rounded	83

[a]Flour weight basis.
[b]Crumb scores adjusted to 100 possible-point basis.

coarse material moderately reduced flour ash and protein contents. Application of pin-milling at 12K rpm reduced the range of MMD from 56–100 μ to 25–32 μ, with corresponding decreases in the 80% size range.

During the period in which this study was made, it was necessary to change to a new supply of shortening. There was an immediate change in batter appearance

TABLE IV
Analytical, Physicochemical, and Cake-Baking Data for Treatments Applied to WT-66 Triticale Flour: Series B Milling

Treatment	Analytical Data[a] Ash %	Analytical Data[a] Protein %	Particle Size MMD[c] μ	Particle Size 80% Range μ	Chlorine Treatment[b] Flour pH Unbleached	Chlorine Treatment[b] Flour pH Bleached	Cake Data AACC Method 10-90 Opt. Liquid %	Cake Data Volume cc	Cake Data Score %
As-milled—unbleached	0.48	12.2	55	15–120	6.1	...	175	810	57
As-milled—bleached	0.48	12.2	58	17–120	6.1	5.3	175	863	79
+ 9K Alpine	0.49	12.3	24	13–78	6.2	5.2	175	885	79
+12K Alpine	0.49	12.2	20	12–53	6.2	5.2	175	940	86
+18K Alpine	0.50	12.3	17	11–37	6.2	5.1	170	960	86
Rebolt thru *165* mesh	0.48	11.8	36	16–80	6.2	5.2	175	895	79
SRW Control patent	0.33	9.4	21	13–68	5.8	4.6	155	1032	83

[a]Data on 14% moisture basis.
[b]Chlorine applied at the rate of 0.5 ml Cl_2/g flour ≅ 2.3 oz/cwt.
[c]Mass-median diameter.

TABLE V
Volume Performance of SRW Cake Patent-Triticale Flour Blends in AACC Method 10-90, in the Presence of Added Emulsifier: Series C Milling

Triticale Cultivar	Level of Added Emulsifier[b] %	SRW Patent Control cc	Triticale in SRW Patent Blend 20% cc	30% cc	40% cc	50% cc	100% cc
WT-66	0	980	959	967	917	...	826
	3	1070	1038	1008	1000	950	881
6TA-204	0	980	972	985	914	...	852
	3	1070	1028	1000	990	954	966
6TA-206	0	980	998	975	941	939	824
	3	1070	1052	1032	1043	1014	1006
TR-385	0	980	991	987	925	934	785
	3	1070	1064	1036	1049	1017	961
TR-386	0	980	988	990	942	949	789
	3	1070	1048	1021	1014	1000	965

[a]All data are from layers with acceptable contour and internal appearance scores.
[b]Shortening-weight basis.

(curdled) and significant reduction in layer volumes of both control and experimental bakes, suggesting that the shortening was deficient in emulsifying power. Adjustments were made by blending 3% (fat weight basis) of commercial emulsifier (40% mono- and 60% diglyceride) into the deficient shortening prior to batter preparation.

As shown in Table V, this modification increased SRW (control) volumes from 980 to 1070 cc. Each whole-triticale flour (100%) was improved in performance by increasing the emulsification of batter systems, but products from all cultivars were significantly smaller than SRW cake with added emulsifier. Under conditions of this experiment, triticale flours were at a disadvantage in competition with patent soft wheat flour on a 100% replacement basis.

Blends of triticale and wheat flour ranging from 20 to 50% triticale were, therefore, tested using the 3% emulsifier-enhancement modification. Data for blends of chlorinated rebolted flour from all cultivars with patent SRW cake flour are also presented in Table V. Without added emulsifier (0%), up to 30% triticale flour in the blend was tolerated without significant reduction in volume below the appropriate SRW control. Addition of 3% emulsifier to the system gave significant volume increases at most ratios of triticale-SRW patent included in the experiment. With emulsifier (3%), cakes from all blends tested were equal statistically to the patent control without emulsifier enhancement. In all, 11 combinations with emulsifier were larger than the 980 cc control, with 6TA-206 and TR-385 cc performing well at 40–50% levels. With the exception of 6TA-204, blends containing 20% triticale plus added emulsifier were not significantly smaller than the corresponding SRW control. Internal scores were high (80–90%) for cakes from all blends with added emulsifier and the products were acceptable visually and organoleptically.

Under favorable circumstances, some triticale cultivars have potential for use in products traditionally produced from soft winter wheat. Practical usage, however, may depend upon factors which were not optimized in this study. Among the areas which should be investigated are 1) breeding for intended uses, 2) comprehensive triticale milling studies, and 3) reformulation of traditional ingredient systems to adapt the special properties of triticale flour.

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