Breadmaking Properties of Triticale Flour with Wheat Flour and Relationship to Amylase Activity

M. Seguchi, C. Ishihara, Y. Yoshino, K. Nakatsuka and T. Yoshihira

ABSTRACT

Wheat flour was blended with triticale flour and baking tests were performed. When 18.3% of triticale flour was blended with wheat flour, the greatest bread height (mm) and specific volume (cm^3/g) were obtained. Triticale flour was fractionated into water solubles, gluten, prime starch, and tailings by acetic acid (pH 3.5) fractionation. Baking results indicated that only the water solubles fraction produced the same baking performance as the original triticale flour. Several types of triticale flour were blended with wheat flours, and the breadmaking tests and measurement of amylase activities were compared. Baking results appeared to be related to α-amylase activity of triticale flour.

Key Words: triticale, breadmaking, water solubles, α-amylase

INTRODUCTION

TRITICALE IS THE FIRST MAN-MADE CEREAL PRODUCED BY cross-breeding wheat (Triticum) and rye (Secale). If a tetraploid wheat (*T. turgidum* L., 2n = 4× = 28) or a hexaploid wheat (*T. aestivum* L. em Thell., 2n = 6× = 42) is used, then a hexaploid or an octoploid triticale (2n = 8× = 56) is produced, respectively. The use of colchicine, which can double the chromosome number, and the use of embryo culturing could make viable crosses of incompatible parental combinations and produce new fertile hybrids. Crossbreeding efforts to improve hexaploid triticale through interbreeding and selection using primarily triticales have been applied in Europe, Canada, Australia, and Mexico (Varughese et al., 1996). Triticale has superior nutritional qualities over wheat and baking qualities over rye. Under certain agricultural conditions its yield outperforms wheat or rye. The baking quality of triticale flour is inferior to wheat flour, as demonstrated by rheological properties of triticale-water dough (Tsen 1974). Mixing properties depend on flour protein (particularly gluten) quantity and quality. Madl and Tsen (1973) reported relatively high proteolytic activity in triticale flour, which could weaken dough structure through protein hydrolysis. The sulfhydryl contents of triticale flour were higher than wheat flour, which could cause weak dough structure (Tsen, 1970). Hexaploid triticales are made from durum wheats and lack the D-genome chromosomes responsible for breadmaking quality (National Research Concil 1989). Tsen et al. (1973) reported that prolonged or rapid fermentation could degrade the triticale dough structure and reduce the amount of reactants for browning reactions during baking, which resulted in triticale bread with a broken top and pale crust. Unrau and Jenkins (1964) had reported that triticale flour dough developed much faster, with lower absorption and less stability during mixing than wheat flour dough. Therefore, absorption, fermentation, and mixing procedures had to be modified from those used with wheat flour. Triticale malts have been recommended as a supplement to provide α-amylase for hydrolyzing starch in dough (Finney et al., 1972). They also compared the effects of malts from barley, wheat, rye, and triticale on loaf volume of a formulation without added sugar, and triticale malts were most effective in increasing loaf volume.

Triticale has not been commercially cultivated in Japan but test cultures were produced in Hokkaido. Glutinous wheat bread is popular in Japan and triticale bread is considered glutinous. Our objective was to make clear the possibility of using triticale flour in breadmaking.

Author Seguchi and Ishihara are affiliated with Kobe Women's Univ., Suma-Ku, Kobe City 654, Japan. Author Yoshino is affiliated with Kyoto Women's Univ., Higashiyama-ku, Kyoto City, 605, Japan. Author Nakatsuka is affiliated with the Hokkaido National Agricultural Experiment Station, KAFF, Hokkaido, 082, Japan. Author Yoshihira is with Rakuno Gakuen Univ., Ebetsu, Hokkaido 069, Japan.

MATERIALS & METHODS

Materials

Five common triticale lines (Presto, Almo, Banjo, SL3MR6, and Wapiti) were studied. All seeds were sown, and plants harvested and threshed to give seeds in Hokkaido, Japan, in 1996. They were ground just before the study. Presto I, II, III, IV, V, VI, VII, and VIII were grown in different places. Presto I was mainly used throughout this study as Presto triticale flour. The wheat flours we used were commercial brands 1-Red Knight (Nitto Flour Milling Co. LTD., Japan), 2-Super King, 3-Million, and 4-Number One (Nisshin Flour Milling Co. LTD., Japan) from Hard Red Spring wheat flour. The protein contents were 14.1, 16.5, 14.7, and 15.6%, and the ash contents were 0.37, 0.43, 0.41, and 0.38%, respectively, with 14.0% moisture content.

Brabender amylograph and α-amylase activity

Brabender amylograph tests were performed according to the AACC (1983) approved method 22-10. Presto triticale and Red Knight wheat flours were blended at various ratios, and the blended flours (65 g at 14% m.b.) were mixed with 460 mL of water, and subjected to the B. amylograph test across a temperature range of 20–96°C. All slurries for different flours had the same percent solids. The moisture content of the slurries was 89.4%. Each triticale flour (0.2%) was added to the Red Knight wheat flour, and maximum viscosity (BU) was also measured for each blended flour. The maximum viscosity (BU) was proportionally decreased with an increase in triticale α-amylase activity.

Brabender farinograph tests

A brabender farinograph was performed on 300 g of flour at 14% m.b. (AACC approved method 54-21). The baking absorption was determined from the farinograph absorption at 500 BU.

Breadmaking method

Breadmaking was performed according to Seguchi et al. (1997). Flour 100%, compressed yeast 2.9%, sugar 5.0%, salt 1.0%, and water according to the baking absorption estimated from the farinograph absorption at 500 BU were mixed, and put into a computer controlled National Automatic Bread Maker (SD-BT 6, Matsushita Electric Ind. Co. Ltd., Japan), until the 1st proof step after 2 h 20 min. The total time of the process was 2 h 20 min comprised of 15 min for the first mixing, 50 min rest, 5 min for the second mixing and a 70 min fermentation. The dough was divided into 120-g pieces, followed by rounding and molding, and placed in a baking pan (AACC approved method No. 10-10A). The AACC method was slightly modified since the dough was divided into 120-g pieces. The dough was subjected to a second proof for 22 min at 38°C, and the baking was performed at constant temperature (210°C)(oven Model DN-63 YAMATO Science Co. LTD., Japan) for 30 min. After baking, the bread was removed from the pan and left for 1 h in a room at constant temperature (26°C) and humidity (43%), and then the bread height (mm), weight (g), and volume (cm^3) were measured and crumb was evaluated visually.

Presto triticale and Red Knight wheat flours were blended at various ratios and subjected to the breadmaking test. Presto triticale (18.3%)/various wheat (81.7%) blended flour, and various triticale (18.3%)/Red Knight wheat (81.7%) blended flour were also subjected to breadmaking tests.

Fractionation of triticale flour by acetic acid (pH 3.5)

Fractionation of Presto triticale flour was performed by the method of Sollars (1958) with a modification. Flour (50g) was mixed with water (150 mL) and homogenized for 20 min using a Waring Blendor (Excel Auto Homogenizer Tokyo Nihon Seiki Seisakusho Co. LTD., Japan) on ice. The mixture was centrifuged at 1700 × *g* for 20 min at room temperature separating the supernatant (water solubles fraction) from the pellet. The water solubles fraction was freeze dried. The pellet was homogenized with 125 mL of 0.8% acetic acid (pH 3.5) for 20 min and centrifuged. The supernatant was the gluten fraction and the pellet was separated. This step was repeated with 75 mL of 0.2% acetic acid. The supernatant was then combined with the previous gluten fraction and freeze dried. The pellet was homogenized with 150 mL of water for 20 min and centrifuged. The supernatant was discarded, and the two layers evident in the pellet were separated by a spatula. The upper layer was considered to be the tailings fraction, and bottom layer was the prime starch fraction. Both were freeze dried. Protein content was determined by N×6.25. Starch, ash, and lipid were determined by the AACC approved methods No. 08-01 and 30-26, respectively (AACC, 1983).

Statistical analysis

Data were analyzed using an analysis of variance (ANOVA). The calculated mean values were compared using Duncan's multiple range test with significance defined at $p \leq 0.05$.

RESULTS & DISCUSSION

Farinograph tests of wheat, triticale and blended flours

Farinograms of #1 wheat flour, Presto triticale, and blended dough were compared (Fig. 1). Wheat flour dough showed a stable profile after arriving at 500 BU (Fig. 1A), but triticale flour dough continued to decrease after 500 BU (Fig. 1B), which indicated the lower stability of the triticale. The width of the tail section (right side of farinograph) of triticale flour was narrower than that of wheat flour, which indicated the weakness of triticale flour compared to wheat flour. The weakness of triticale flour had been reported by Tsen et al. (1970). The farinogram of the blended flour (Fig. 1C), which was composed of 18.3% triticale and 81.7% wheat, showed a pattern as the intermediate of A and B. Madl and Tsen (1973) reported proteolytic activity in triticale flour, which weakened the dough structure.

Breadmaking test of wheat/triticale blended flour

The triticale breadmaking test was performed according to previous wheat baking methods (Seguchi et al., 1997). Presto triticale flour was blended with #1 wheat flour, and the blended percentages of triticale flour were 0.0, 3.0, 6.2, 12.5, 18.3, 25.0, 50.0 and 100.0%, when breadmaking tests were performed. We studied the many different blended percentages, which gave a maximum bread height and specific volume. Baking absorption was determined from farinograph absorption at 500 BU, and it increased markedly with the increase of wheat flour (Table 1). Although bread baked with triticale flour only had a lower bread height (47.6 mm), and specific volume (1.8 cm^3/g) (Table 1), the height and specific volume were increased by an increase in wheat flour. The maximum bread height (104.9 mm) and specific volume (4.5 cm^3/g) were obtained in the blend of 18.3% triticale and 81.7% wheat flour. The bread height and specific volume decreased at other ratios, which suggests that any improving effects on breadmaking would be due to the triticale enzyme reactions. The color of the crust of the 18.3% triticale/81.7% wheat flour, and 100% triticale breads (Fig. 2B and 2C) were brownish, probably because of Maillard reactions between carbohydrate and protein. The other kinds of wheat flours (81.7%) #2, 3, 4 were blended with the Presto triticale flour (18.3%) respectively, and the same baking results (improved bread height and specific volume) were obtained when they were blended with 18.3% Presto triticale (Table 2).

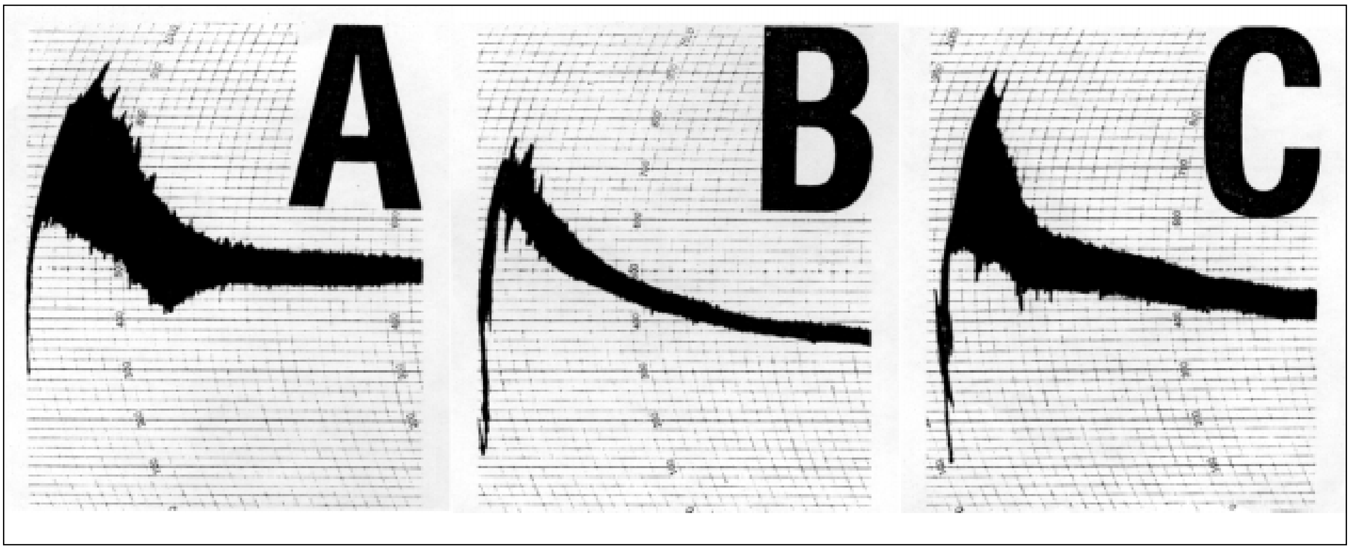

Fig. 1—Farinograms of Red Knight wheat flour dough (A), Presto triticale flour dough (B) and blended dough of triticale 18.3% and wheat 81.7% (C).

Table 1—Baking data on triticale/wheat flour blends[a]

Blend			Bread	
Triticale(%)	Wheat(%)	Abs(%)	Height (mm)	SV(cm3/g)
0.0	100.0	73.7	82.4^{d}	3.4^{ce}
3.0	97.0	63.0	92.1^{c}	4.1^{bd}
6.2	93.8	60.5	100.7^{b}	$4.4^{a\text{-}d}$
12.5	87.5	55.7	98.2^{b}	$4.5^{a\text{-}c}$
18.3	81.7	57.0	104.9^{a}	4.5^{a}
25.0	75.0	49.7	93.8^{bc}	4.2^{c}
50.0	50.0	46.7	68.3^{e}	2.8^{f}
100.0	0.0	39.0	47.6^{f}	1.8^{g}

[a]Means of 4 replicates. Means followed by different letters in columns are different ($P \leq 0.05$).

Table 2—Baking data on triticalevarious wheat flour blends[a]

Blend			Bread		
Wheat	Triticale (%)	Wheat (%)	Abs (%)	Ht (mm)	SV (cm3/g)
1	0.0	100.0	71.6	82.4_{f}	3.4_{g}
	18.3	81.7	60.6	104.9_{b}	4.5_{c}
2	0.0	100.0	68.5	93.0_{d}	4.1_{d}
	18.3	81.7	62.4	115.0_{a}	5.7_{a}
3	0.0	100.0	68.7	85.8_{ef}	3.8_{e}
	18.3	81.7	64.0	104.0_{c}	5.0_{b}
4	0.0	100.0	69.2	88.2_{e}	3.6_{f}
	18.3	81.7	64.3	101.0_{bc}	4.3_{c}

[a]Means of 4 replicates. Means followed by different letters in columns are different ($P \leq 0.05$).

The other kinds of triticale flour (18.3%) such as Almo, Banjo, SL3MR6, and Wapiti, whose moisture, protein, and ash contents were different (Table 3), were blended with #1 wheat flour (81.7%), and breadmaking tests were performed. The various triticale flours increased the bread height and specific volume, although the increase varied (Table 4). The flour components of triticale affected wheat breadmaking by increasing bread height and specific volume.

Fractionation of triticale flour by acetic acid, and effects of fractions on breadmaking

The effect of triticale flour (18.3%) on breadmaking was notable; however, the mechanism of improvement was not clear. The Presto triticale flour was fractionated into water solubles, gluten, tailings, and prime starch fractions using acetic acid (pH 3.5) fractionation. The analysis of the fractions (Table 5) were similar to those of soft wheat flour (Seguchi et al. 1998). Breadmaking tests were performed with a blend of #1 wheat flour and each fraction. Amounts of the fractions were equivalent to 18.3% of the Presto triticale flour as calculated (Table 5). The results of breadmaking with the blended flours showed that the water solubles fraction increased bread height and specific volume to the same level as the original Presto triticale flour, but the other fractions did not (Fig. 3 and Table 6). The water solubles fraction contained many components, such as water-soluble proteins, polysaccharides, peptides, and sugars, and the component that caused the improvement is unknown. When the water-solubles fraction was boiled for 5 min and subjected to the breadmaking test, the improvement did not occur, which suggests that enzymes in water solubles fraction caused the improvement (Table 7).

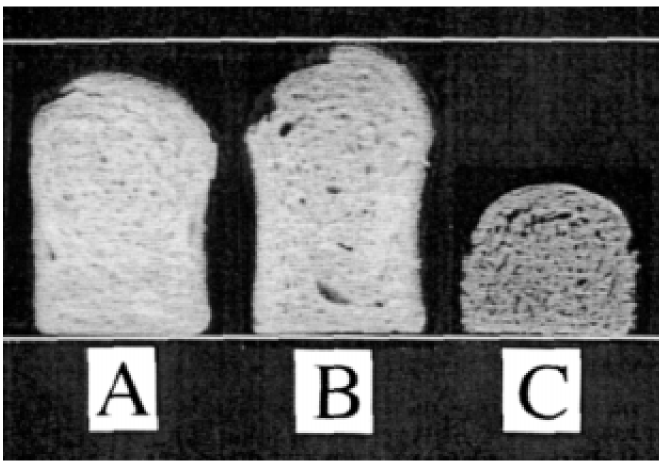

Fig. 2—Breadmaking results with triticale/wheat flour blends: A—0%/100%; B—18.3%/81.7%; and C—100%/0%.

Table 3—Protein and ash in triticale flours[a]

Triticale	Moisture content (%)	Protein (%)[b]	Ash (%)[b]
Presto I	11.5	9.55	0.69
Presto II	10.3	9.64	0.66
Presto III	10.1	11.1	0.76
Presto IV	10.4	10.7	0.74
Presto V	13.7	12.6	0.78
Presto VI	13.8	15.6	0.82
Presto VII	4.9	12.2	1.12
Presto VIII	10.6	10.1	0.84
Almo	4.3	12.6	1.18
Banjo	4.1	17.4	1.45
SL3MR6	3.1	17.0	1.67
Wapiti	3.9	16.3	1.33

[a]Three replicates.
[b]On dry basis.

Table 4—Baking data on triticale (18.3%)/wheat flour (81.7%) blends[a]

Blend		Bread	
+Triticale	Abs (%)	Ht (mm)	SV (cm3/g)
Wheat	73.70	84.2	3.4_{k}
+Presto I	59.30	104.9_{a}	4.5_{a}
+Presto II	64.10	92.4_{fghij}	$3.7_{cdefghi}$
+Presto III	63.70	$94.3_{cdefghi}$	$3.7_{cdefghij}$
+Presto IV	63.50	97.7_{c}	3.8_{cdefgh}
+Presto V	63.60	92.5_{fghij}	$3.7_{cdefghij}$
+Presto VI	64.20	97.4_{cd}	3.8_{cdefg}
+Presto VII	62.60	100.1_{bcd}	4.2_{b}
+Presto VIII	64.40	94.4_{cdefgh}	3.9_{c}
+Almo	69.00	95.8_{cdef}	3.8_{cde}
+Banjo	65.60	96.3_{cde}	3.9_{cd}
+SL3MR6	65.75	94.9_{cdefg}	3.8_{cdef}
+Wapiti	64.20	101.7_{ab}	4.2_{b}

[a]Means of 4 replicates. Means followed by different subscript letters in columns are different ($P \leq 0.05$).

Table 5—Acetic acid fractionation of Presto triticale flour[a]

Fractions	Yield (%)	Protein (%)	Lipid (%)	Starch (%)	Ash (%)
Triticale flour	100	9.55	0.92	84.2	0.69
Water-solubles	8.0	29.9	0.34	16.6	5.78
Gluten	9.2	59.4	1.84	5.46	2.90
Prime starch	53.7	0.28	0.31	96.7	0.11
Tailings	19.3	3.15	0.16	84.6	0.15
Recovery	90.2				

[a]Average of 3 determinations, water-free basis.

Amylograph tests of triticale/wheat flour and α-amylase activity

Peña (1982) reported that triticale had a higher α-amylase activity than wheat or rye. The improved breadmaking may have been caused by the increased α-amylase activity. All tested triticale flours were not viscous throughout the temperature range 20–96°C, which indicated the presence of higher α-amylase activity in triticale flour than in wheat flour. Presto triticale flour was diluted with #1 wheat flour and changes of the BU values were compared. Because a linear relationship between 0.02-2.0% of Presto triticale flour was obtained

Table 6—Baking data on Presto triticale flour fraction/wheat flour blends[a]

Blend	Bread		
+Fraction	Abs (%)	Bread Ht (mm)	SV (cm³/g)
Wheat	73.7	82.7_{cd}	3.3_{bc}
+Triticale flour(18.3%)	57.0	104.9_{a}	4.5_{a}
+Water solubles	64.9	101.7_{a}	4.7_{a}
+Gluten	67.8	83.6_{cd}	3.5_{b}
+Tailings	66.2	89.8_{b}	3.2_{bcd}
+Prime starch	65.9	84.6_{c}	3.0_{cd}

[a]Means of 4 replicates. Means followed by different letters in columns are different (P≤0.05).

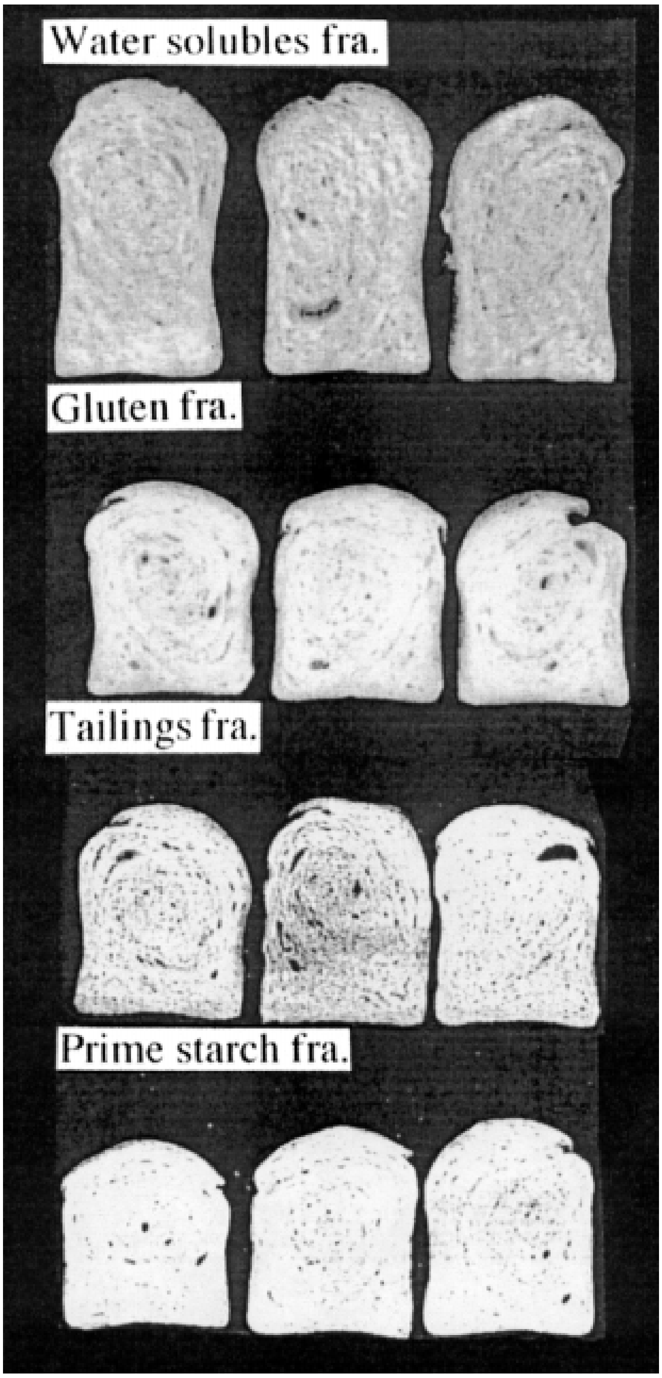

Fig. 3—Breadmaking results with various triticale flour fraction/ wheat flour blends (from top to bottom; triticale flour water solubles fraction, gluten fraction, tailings fraction, and prime starch fraction plus wheat flour, respectively).

Table 7—Baking data on Presto triticale, boiled water solubles fraction/wheat flour blends[a]

Blend Bread			
+Fraction	Abs (%)	Bread ht (mm)	SV(cm³/g)
Wheat	73.7	84.2_{b}	3.4_{b}
+Triticale,18.3%	57.0	104.9_{a}	4.5_{a}
+Triticale water solubles fraction	64.9	104.5_{a}	4.7_{a}
+Boiled triticale water solubles fraction	66.7	85.6_{b}	3.7_{b}

[a]Means of 4 replicates. Means followed by different subscript letters in columns are different (P≤0.05).

Table 8—Results of amylograph measurements of various triticale (0.2%)/wheat flour blends

Blend	Maximum viscosity
+Triticale	(BU)
Wheat	545
+Presto I	210
+Presto II	515
+Presto III	480
+Presto IV	470
+Presto V	405
+Presto VI	355
+Presto VII	280
+Presto VIII	440
+Almo	315
+Banjo	460
+SL3MR6	355
+Wapiti	300

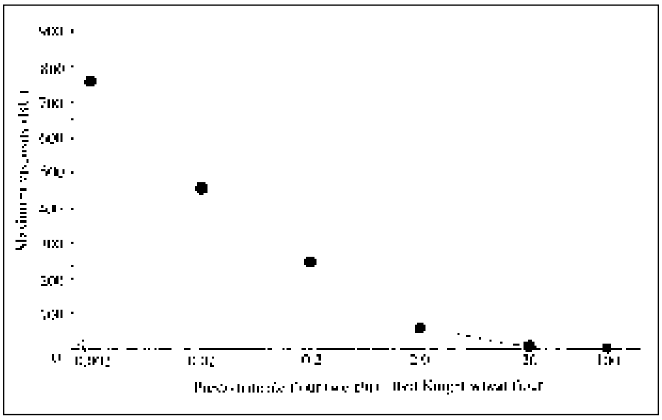

Fig. 4—Change of maximum viscosity (BU) in triticale/wheat flour blends at various ratios.

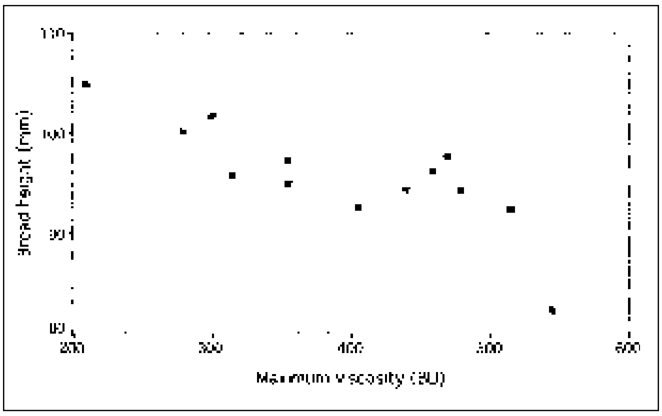

Fig. 5—Relationship between maximum viscosity (BU) and bread height (mm) baked with various triticale (18.3%)/wheat (81.7%) flour blends.

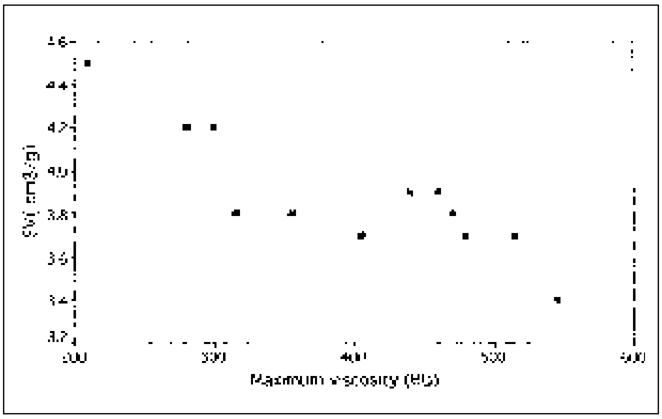

Fig. 6—Relationship between maximum viscosity (BU) and SV (cm3/g) of bread baked with various triticale (18.3%)/wheat (81.7%) flour blends.

(Fig. 4), 0.2% of various triticale flours was added to the #1 wheat flour, and the α-amylase activity was measured (Table 8). Red Knight wheat flour had a maximum viscosity of 545 BU, but values from 210 to 515 BU were obtained for various triticale/Red Knight wheat blended flours, which indicated the amounts of α-amylase activity in the triticale flours were variable.

Relationship between maximum viscosity (BU) of various triticale/ #1 wheat flour blends (Table 8), and bread height (mm) (Fig. 5) and SV (cm^3/g) (Fig. 4) (Table 4). Correlation coefficients were –0.8008 and –0.8355 respectively. These values suggest that α-amylase in the triticale flour caused a significant improvement of bread height and specific volume during breadmaking.

CONCLUSIONS

A BREADMAKING TEST WITH BLENDED TRITICALE (18.3%) and wheat (81.7%) flours demonstrated a marked increase in bread height and specific volume. Triticale flour was fractionated by acetic acid (pH 3.5) into water solubles, gluten, tailings, and prime starch fractions, the water solubles fraction improved breadmaking. When the water solubles fraction was boiled, it did not improve breadmaking. Triticale flour had a higher α-amylase activity than wheat flour, which may have been responsible for the improved breadmaking.

REFERENCES

AACC. 1983. *Approved Methods of the AACC*, Method 08-01, 10-10A, 22-10, 30-26, and 54-21 approved May 1960. American Association of Cereal Chemists, St. Paul, MN, USA (1983).

Finney, K.F., Shogren, M.D., Pomeranz, Y., Bolte, L. 1972. Cereal malts in breadmaking. Baker's Dig. 46(1): 36-55.

Madl, R.L., and Tsen, C.C. 1973. Proteolytic activity of triticale. Cereal Chem. 50: 215-219.

National Research Concil. 1989. In *Triticale—A Promising Addition to the World's Cereal Grains.* National Academy Press, Washington, DC.

Peña, R.J. 1982. Grain shrivelling in secondary hexaploid triticale. I. α-amylase activity and carbohydrate content of moisture and developing grains. Cereal Chem. 59: 455-458.

Seguchi, M., Hayashi, M., and Matsumoto, H. 1997. Effect of gaseous acetic acid on dough rheological and breadmaking properties. Cereal Chem. 74: 129-134.

Seguchi, M., Hayashi, M., Kanenaga, K., Ishihara, C., and Noguchi, S. 1998. Springiness of pancake and its relation to binding of prime starch to tailings in stored wheat flour. Cereal Chem. 75: 37-42.

Sollars, W.F. 1958. Fractionation and reconstitution procedures for cake flours. Cereal Chem. 35: 85-99.

Tsen, C.C. Chemical dough development. 1970. Baker's Dig. 44(4): 28-35.

Tsen, C.C., Hoover, W.J., and Farrell, E.P. 1973. Baking quality of triticale flour. Cereal Chem. 50: 16-26.

Tsen, C.C. 1974. Bakery products from triticale flour. In *Triticale—First Man-made Cereal*, C.C.Tsen (Ed.). Am. Assoc. Cereal Chemists, St. Paul, MN.

Unrau, A.M. and Jenkins, B.C. 1964. Investigations on synthetic cereal species. Milling, baking, and some compositional characteristics of some triticale and parental species. Cereal Chem. 41: 365-375.

Varughese, G., Pfeiffer, W.H., and Pena, R.J. 1996. Triticale: A successful alternative crop (part 1). Cereal Foods World. 41: 474-482.

MS 2838; received 6/29/98; revised 11/6/98; accepted 2/13/99.