Milling and Breadmaking Properties of Wheat–Triticale Grain Blends*

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Abstract: The milling and baking performances of wheat (*Triticum aestivum* L)/triticale (× *Triticosecale* Wittmack) grain blends (W/TCL-GB), with 25 or 50% triticale in the blend, were determined and compared with those of the two wheat and the two triticale composite samples included in the W/TCL-GB. The milling performance of the W/TCL-GB resembled the wheat more than the triticale samples; therefore, the wheat/triticale co-milling practice appears to be a good procedure to improve the milling performance of triticale. Bread loaf volume values for the W/TCL-GB flours were significantly higher (at 5% level) than those of the two triticales. When wheat of good breadmaking quality was used in the W/TCL-GB, up to 50% triticale could be substituted for wheat in the GB to produce flours with acceptable breadmaking quality.

Key words: wheat, triticale, wheat–triticale co-milling, milling properties, breadmaking quality.

INTRODUCTION

Although there are now some triticales (× *Triticosecale* Wittmack) that have considerably improved breadmaking properties (Amaya *et al* 1986) they are the exceptions. In comparison with bread wheat (*Triticum aestivum* L), triticale has low gluten content, deficient gluten viscoelasticity and, therefore, inferior breadmaking quality (Peña and Ballance 1987). The potential use of triticale flour in breadmaking could be more promising if it were used in blends with bread wheat flour; Rooney *et al* (1969) and Unrau and Jenkins (1964) have shown that adding up to 30% triticale flour to bread wheat flour will still result in satisfactory pan-type bread. Even higher proportions of triticale flour can be used for the production of speciality breads (Beaux and Martin 1985), as happens at present commercially in some parts of southern Brazil (Pfeiffer W, pers comm). However, because of triticale's inferior milling properties, millers do not like to produce triticale flour when bread wheat is available.

In general, triticale has lower flour yield than bread wheat because many cultivars have grains with morphological characteristics (long, shrivelled, with deep crease) less favourable than those of wheat for the production of flour (Weipert 1986). Additionally, many triticale cultivars have grains with soft endosperm, a characteristic responsible for the poor flour flow properties that affect negatively both flour sifting during milling and flour yield (MacRitchie 1980).

One possible approach to improve the milling performance of triticale could be milling this cereal blended with bread wheat. It could be expected that the coarse, hard wheat endosperm particles may help, by means of surface contact, to separate or 'scour' endosperm particles loosely attached to the bran pieces of triticale; furthermore, the presence of hard to semi-hard wheat flour particles in the mill streams may improve the flow properties of soft triticale flour particles. In addition, blending wheat and triticale grains could be more practical and economical than blending their flours. The present study has investigated the milling and breadmaking properties of wheat/triticale (W/TCL) grain blends (GB).

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MATERIALS AND METHODS

Grain samples

Wheat–triticale grain blends (W/TCL-GB) were prepared at two levels, ie 25 and 50% triticale, using wheat and triticale composite grain samples rather than single varieties because, in practice, commercial milling uses wheat blends composed of several cultivars, often of dissimilar hardness and baking quality type (Hook *et al* 1984). Wheat and triticale cultivars grown under irrigation at Sonora, Mexico in 1985–1986 were used in equal amounts to produce composite wheat and composite triticale grain samples representing various grain hardness types (Table 1). The Mexican wheat varieties used to produce W1 and W2 composite grain samples (Table 1) have satisfactory and good breadmaking quality, respectively. The triticale cultivars used to produce TCL1 and TCL2 (Table 1) were chosen based on their good agronomic and grain characteristics as well as on their grain hardness type. Two distinct hardness types within wheat and within triticale were included to examine if grain hardness influenced the milling properties of the W/TCL-GB.

Milling

All wheat, triticale, and W/TCL grain samples (1–1·5 kg) were tempered in duplicate to 150 g kg^{-1} moisture, for 24 h and milled in a Buhler pneumatic mill to obtain straight-grade flours. Shorts, bran, and flour yields were calculated based on clean, tempered grain sample weight.

Flour analysis

Moisture, protein (N × 5·7), and ash were determined in duplicate according to methods of the American Association of Cereal Chemists (AACC 1979). Dough viscoelastic properties were evaluated with a Chopin's Alveograph, following the manufacturer's instructions. Bread loaves were obtained in duplicate using the straight dough baking method 10–10 of the AACC (1979).

TABLE 1
Grain composite identification, cultivars included and grain hardness type

Grain composite identification	*Cultivar used*	*Grain hardness type*
Wheat 1 (W1)	Ures, Genaro, Seri, Pavon	Hard
Wheat 2 (W2)	Hermosillo, Ocoroni	Semi-hard
Triticale 1 (TCL1)	Eronga, Rhino, Mus/Bta, Gnu	Semi-hard
Triticale 2 (TCL2)	Alamos, Stier	Soft

W/TCL flour blends

To examine if the proportion of triticale used in the GB was maintained in the resulting flours, W/TCL flour blends (FB) were also prepared and compared with corresponding flours obtained from the W/TCL-GB with respect to ash, protein, and alveographic characteristics.

Statistical analyses

The results were assessed with the SAS computer package (SAS 1985) using analysis of variance and least significance difference as appropriate.

RESULTS AND DISCUSSION

Milling performance of wheat and triticale samples

Shorts, bran and flour yields of the wheat and triticale samples are presented in Table 2. The wheat samples produced fewer shorts, less bran and higher flour yields than the triticales. The hard wheat sample showed better milling performance than the semi-hard one while the soft triticale sample showed better milling properties than the semi-hard one (Table 2). It is well known that, in general, soft wheat is somewhat more difficult to mill than hard wheat; soft grains produce bran pieces with endosperm particles adhered to them, as well as small flour particles which tend to pack loosely, complicating the flour sifting operation (MacRitchie 1980). This grain texture effect on the milling performance of wheat was not clearly observed to occur with the triticales used in this study; both the semi-hard and the soft triticale

TABLE 2
Milling results of wheats, triticales, and W/TCL-GB[a]

Sample	*Shorts*		*Bran*		*Flour*	
	%	*SD*	*%*	*SD*	*%*	*SD*
W1	8.64	0·41	12·72	0·10	74·55	0·16
W2	10·02	0·48	14·33	0·06	71·69	0·75
TCL1	13·90	0·10	17·07	0·54	64·70	0·76
TCL2	11·92	0·04	16·42	0·13	67·53	0·67
W1/TCL1-25[b]	8·15	0·35	13·32	0·52	74·06	0·45
W1/TCL1-50	12.52	0·44	14·80	0·42	69·02	0·76
W1/TCL2-25	8·21	0·14	15·29	0·25	72·26	1·18
W1/TCL2-50	10·76	0·04	13·97	0·11	71·88	0·75
W2/TCL1-25	9·83	0·00	13·74	0·27	71·94	0·54
W2/TCL1-50	10·98	0·18	13·96	0·11	70·21	0·95
W2/TCL2-25	8·12	0·40	13·94	0·67	74·88	0·14
W2/TCL2-50	10·83	0·31	16·08	0·11	69·74	1·15
LSD at 5%	0·94		0·74		1·65	

[a] Values are mean ± SD of two samples.
[b] Proportion (%) of triticale in the blend.

TABLE 3
Difference between observed and predicted shorts, bran, and flour yields for the W/TCL-GB

Grain blend	*Shorts O–P*[a]	*Bran O–P*	*Flour O–P*
W1/TCL1-25[b]	−1.81	−0.49	+1.97
W1/TCL1-50	+1.25	−0.10	−0.60
W1/TCL2-25	−1.25	+1.65	−0.54
W1/TCL2-50	+0.48	−0.60	+0.84
W2/TCL1-25	−1.16	−1.28	+2.00
W2/TCL1-50	−0.98	−1.74	+2.01
W2/TCL2-25	−2.38	−0.91	+4.23
W2/TCL2-50	−0.14	+0.70	+0.13

[a] Observed minus predicted values. Predicted yields were calculated from the data in Table 2, adding proportionally the amounts of flour of the two components in the blend.
[b] Proportion (%) of triticale in the blend.

samples produced bran and shorts similarly rich in endosperm particles. It appears, then, that the grain morphology defects of triticale predominate over grain hardness on defining the milling performance of this cereal.

Milling performance of the W/TCL grain blends

Shorts, bran and flour yields for the W/TCL-GB samples are presented in Table 2. All but two (W1/TCL1-50 and W2/TCL1-50) of the W/TCL-GB samples showed significantly lower shorts yields than the triticale samples and similar to those shown by the two wheat samples. Bran yields of the W/TCL-GB samples were, in general, lower than those of the triticale samples; two W/TCL-GB samples (W1/TCL2-25 and W2/TCL2-50) showed bran yields significantly larger than those of the bread wheat samples and one of these, W2/TCL2-50, was similar to that shown by TCL2. The rest of the W/TCL-GB samples showed bran yields falling within the range observed for the two wheat samples. Flour yields of the W/TCL-GB samples were in all cases larger than those observed for triticale. Sample W/TCL1-50 was significantly lower than W2, while the rest of the W/TCL-GB samples showed flour yields not significantly different from that of W2.

Yields for the milling products of the W/TCL-GB samples were calculated to examine if it was possible to predict yields for W/TCL-GB, as has been done in the case of flour yield for GB including hard and soft wheats (Hook *et al* 1984). Table 3 shows that, in general, the observed shorts and bran yields of the W/TCL-GB samples were lower than calculated, as well as that the observed flour yields of the grain blends were in general higher than the calculated ones. These results show that the milling performance of the W/TCL-GB was equal to or slightly better than calculated. The ash content of the W/TCL-GB flours was 5 ± 0.5 g kg^{-1}, intermediate between the average ash content of the wheat flour samples (4.5 g kg^{-1}) and of the triticale flour samples (5.4 g kg^{-1}), and acceptable for a breadmaking flour.

Comparison between quality characteristics of flours from W/TCL-GB and W/TCL-FB

Flours originated from the W/TCL-GB samples were compared with their respective flours obtained from W/TCL-FB samples to examine if the proportions of the components in the grain blends were maintained in the resulting flour. Ash and protein contents of flours from W/TCL-GB and W/TCL-FB samples are shown in Table 4. Only in two cases (W2/TCL1-25) and W2/TCL1-50) was the difference in ash content between W/TCL-GB flours and W/TCL-FB flours statistically

TABLE 4
Ash and protein content of flours from W/TCL-GB and W/TCL-FB

Flour	*Ash (g kg^{-1})*[a]			*Protein (g kg^{-1})*[a]		
	Grain blend	*Flour blend*	*Difference*	*Grain blend*	*Flour blend*	*Difference*
W1/TCL1-25[b]	0.47	0.48	−0.01	10.5	10.5	0.0
W1/TCL1-50	0.51	0.54	−0.03	9.9	9.7	+0.2
W1/TCL2-25	0.51	0.49	+0.02	10.5	10.2	+0.3[c]
W1/TCL2-50	0.56	0.52	+0.04	10.2	10.2	0.0
W2/TCL1-25	0.46	0.49	−0.03[c]	11.0	10.7	+0.3
W2/TCL1-50	0.51	0.49	+0.02[c]	10.2	10.2	0.0
W2/TCL2-25	0.48	0.48	0.00	10.9	11.1	−0.2
W2/TCL2-50	0.50	0.52	+0.03	10.1	10.3	−0.2

[a] 140 g kg^{-1} moisture basis
[b] Proportion (%) of triticale in the blend.
[c] Significantly different ($P < 0.05$).

TABLE 5
Alveographic characteristics of flours from W/TCL-GB and W/TCL FB

Flour	*W* (×10⁴*J*)			*P/G*		
	Grain blend	*Flour blend*	*Difference*	*Grain blend*	*Flour blend*	*Difference*
W1/TCL1-25[a]	207	173	+34	7·4	6·8	+0·6
W1/TCL1-50	132	133	−1	6·1	5·3	+0·8
W1/TCL2-25	209	181	+28	5·1	5·3	−0·2
W1/TCL2-50	117	119	−2	4·7	4·3	+0·8
W2/TCL1-25	232	227	+5	2·5	2·7	−0·2
W2/TCL1-50	172	206	−34	3·6	4·2	−0·6[b]
W2/TCL2-25	195	221	−26	2·0	2·4	−0·4
W2/TCL2-50	172	144	+28	4·0	3·6	+0·4

[a] Proportion (%) of triticale in the blend.
[b] Significantly different ($P < 0{\cdot}05$).

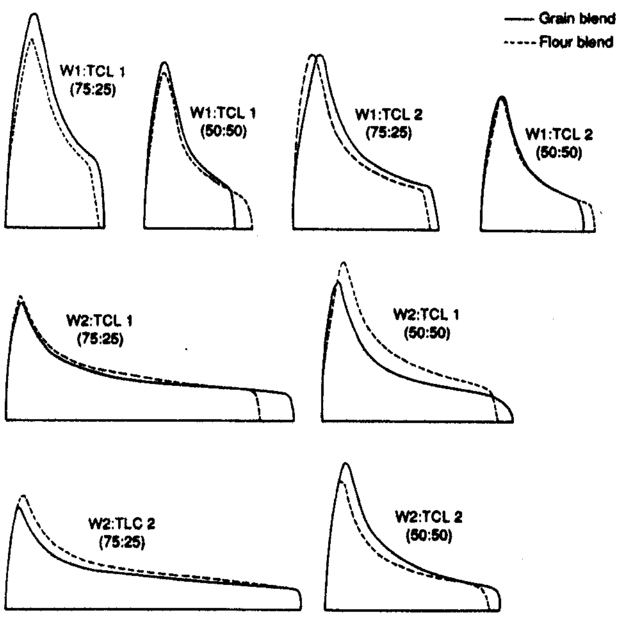

Fig 1. Alveograms of flours from (——) wheat–triticale grain blends, and (– – –) flours from wheat–triticale flour blends.

significant ($P < 0{\cdot}05$), but these differences were too small to be considered of practical importance. In the case of protein content, only in one case (W1/TCL 2-25) were the flours from W/TCL-GB and W/TCL-FB significantly different ($P < 0{\cdot}05$). Table 5 shows the alveographic characteristics *W* and *P/G* for the flours of W/TCL-GB and W/TCL-FB samples. None of the differences in *W* value between flours from W/TCL-GB and W/TCL-FB were significant. Only in one case (W2/TCL1-50) was the difference in the *P/G* value between flours from W/TCL-GB and W/TCL-FB significant ($P < 0{\cdot}05$). Therefore, these results indicate that the alveographic characteristics of the compared flours were practically the same, as illustrated in Fig 1. Thus, the results obtained from comparing the flours indicate that, during wheat/triticale grain co-milling, the proportion of wheat and triticale in the grain blend is more or less maintained in the resulting flours.

TABLE 6
Breadmaking characteristics of flours from wheats, triticales, and their grain blends

Flour	*Loaf volume*		*Crumb*	
	ml	*Grouping*[a]	*Grain*[b]	*Texture*[b]
W2	952·5	A	c	e
W2/TCL1-25[c]	930·0	A	so	e
W2/TCL2-25	920·0	A	c	e
W2/TCL2-50	867·5	B	c	e
W2/TCL1-50	847·5	B	so	e
W1	795·0	C	c	e
W1/TCL1-25	785·0	CD	so	su
W1/TCL1-50	752·5	ED	so	su
W1/TCL2-25	745·0	E	so	su
W1/TCL2-50	672·5	F	so	u
TCL2	580·0	G	o	u
TCL1	500·0	H	o	u

[a] Loaf volume means with the same letter are not significantly different at 5%.
[b] c—closed; so—slightly open; o—open; e—even; su—slightly uneven; u—uneven.
[c] Proportion (%) of triticale in the blend.

Breadmaking quality characteristics of flours from W/TCL-GB

Breadmaking quality characteristics of the wheat, of the triticale and of their grain blend samples are presented in Table 6. Wheat W2 showed large loaf volume (952·5 ml), typical of good pan-type bread wheat, while W1 had a loaf volume of 795 ml, still satisfactory for pan-type bread production. Both wheats showed desirable crumb structure (closed grain and even distribution of gas cells).

In the case of the triticale samples, both TCL1 and TCL2 flours have very low loaf volumes (< 600 ml), as well as poor crumb structures (open grain and unevenly distributed gas cells), unacceptable for breadmaking. The bread loaf volumes of the W/TCL-GB flours varied with the source of wheat and triticale and with the level of triticale in the GB. However, the loaf volumes of all the W/TCL-GB flours were significantly larger than those of TCL1 and TCL2. When W2 was used, addition of 25% of TCL1 or TCL2 to the GB resulted in flours with loaf volumes not significantly different from that of W2. Increasing the level of TCL1 or TCL2 to 50% in the GB resulted in flours with loaf volumes lower than that of W2, but significantly larger than that of W1 (Table 6). When W1 was used, the GB flours including TCL1 gave larger loaf volumes than when TCL2 was included. The loaf volume of W1/TCL1-25 was not significantly different from that of W1, while W1/TCL1-50 had a loaf volume similar to that of W1/TCL2-25 (Table 6). Only W1/TCL2-50 gave a loaf volume that can be considered unacceptable for a pan-type bread flour, but still acceptable for the production of variety breads. Breads from W/TCL-GB flours including W2 and TCL2 showed crumb quality characteristics similar to those of the two wheat flour samples. All the other W/TCL-GB flours showed crumb structure characteristics inferior to those of the wheat flours but superior to those of the triticale ones (Table 6).

CONCLUSIONS

The inferior milling potential of the triticales studied was due to losses in both the shorts and the bran fractions. These milling losses may result mainly from the grain morphology defects, such as long grain, deep creases, and incomplete plumpness, which characterised the triticale samples used. The milling properties (shorts, bran, and flour yields) of the W/TCL-GB resembled wheat more than triticale. Therefore, the wheat/triticale grain co-milling practice seems to be a good alternative to improve the milling performance of triticale. Furthermore, the breadmaking results of this study indicate that, depending on the quality of the bread wheat used, triticale can substitute for up 50% of the wheat, to produce flours with satisfactory breadmaking quality. Most breads prepared with the W/TCL-GB flours showed slightly open crumb grain. This could be taken as undesirable considering that the size of the crumb cells influences the rate of moisture loss and, consequently, the rate of bread staling. However, this should not be taken as a major problem in using triticale in breadmaking since it has been shown that crumb structure of breads prepared from wheat–triticale flours can be improved by adding dough improvers in the baking formula (Tsen *et al* 1973), and since new triticales with better gluten and breadmaking properties than those of the triticale samples used in this study are now available (Peña *et al* 1991).

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