Gluten composition, gluten quality, and dough mixing properties (National-Mixograph; Chopin-Mixolab) of high yielding wheats derived from crosses between common (T. aestivum) and synthetic (Triticum dicoccon x Aegilops tauschii) wheats

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SUMMARY – *Triticum dicoccum* and *Aegilops tauschii* carry genes/alleles influencing favorably yield, resistance to diseases, and tolerance to abiotic stresses. Hybrids made by crossing these two species, are referred to as synthetic wheats. Synthetic wheat has been crossed to modern wheat genotypes to combine desirable traits from the first into agronomically-acceptable wheat hybrids. A set of 14 synthetic-derived, agronomically-acceptable, wheat lines and 8 common wheat cultivars, were examined in relation to *Glu-1*/*Glu-3* glutenin subunit composition, gluten quality-related parameters (protein and SDS-Sedimentation), and dough viscoelastic properties (using the National-Mixograph and the Chopin-Mixolab dough mixers and the Alveograph). Nine lines possessed the *Glu-1*/*Glu-3* glutenin composition of the common wheat parent (Cv. Pastor, *Glu-1*: 1, 17+18, 5+10, *Glu-3*c, and *Glu-3*g); other two showed the *Glu-D1*^{t} subunit, 1.5+T2, from *Ae. tauschii*, and other five genotypes possessed the *Glu-A3*b' allele, from *T. dicoccum*. The wide differences in the gluten quality-related parameters observed among the synthetic-derived lines could not be clearly associated to their differences in *Glu-1/Glu-3* allelic composition. However, the *Glu-D1*^{t} subunit 1.5+T2 was present in the lines showing the best gluten extensibility but the weakest gluten type. The Chopin-Mixolab proved to be a potential instrument to screen breeder's lines for gluten quality; when testing whole grain flour, the dough development time stability, and breakdown parameters of the Mixolab showed high correlation with the dough strength parameter W of the Alveograph.

Introduction

Triticum dicoccum Schrank and *Aegilops tauschii* (Coss.) Schmal, ancestors of modern wheat, carry genes/alleles influencing favorably yield, resistance to diseases, and tolerance to abiotic stresses. Hybrids made by crossing *T. turgidum* L. and *Ae. tauschii*, are known as synthetic wheats (Mujeeb-Kazi *et al*., 1996). Synthetic wheats have proven a useful means of introducing new genetic diversity into bread wheat. Synthetic wheat generally carries undesirable agronomic traits but when it is crossed to conventional modern wheat genotypes, agronomically-acceptable synthetic-derived wheat cultivars combining desirable biotic and abiotic traits are obtained (Villareal *et al*., 1996; Trethowan *et al*., 2005). This study examined the grain quality attributes of a set of wheat lines derived from crosses between common wheat (*T. aestivum*) and one synthetic wheat produced from crossing *T. dicoccum* and *Ae. tauschii*. Concomitantly, the newly developed Chopin-Mixolab dough-mixing instrument was evaluated as a potential quality screening tool in wheat quality improvement.

Materials and methods

Twelve wheat lines derived from the cross *T. dicoccon* PI94625/*Ae.squarrosa* (372)//3*'Pastor' (Cross A), two lines derived from the cross *T. dicoccon* PI94625/*Ae.squarrosa* (372)//Tui/Clms/3/2*'Pastor' (Cross B), and eight bread wheat cultivars possessing contrasting quality, cultivated under irrigation in Cd. Obregon, Sonora, Mexico in 2004-05, were examined in relation to *Glu-1*/*Glu-A3/Glu-B3* glutenin subunit composition according to Peña *et al*. (2004). Flour milling was performed in a Brabender Quadrumat Sr. mill. Grain hardness and protein concentration were estimated by NIR spectroscopy, and flour SDS-sedimentation as described by Peña *et al*. (1990). Whole-meal (UDY grinder, 8 mm sieve) dough mixing parameters: development time (DT), stability

(S), and breakdown at 1.5min (Brk-1.5) and 3min (Brk-3) after DT, were determined in the Mixograph (AACC 1995) and in the Mixolab (manufacturer's protocol). Dough strength parameters W and P/L were obtained testing 60 g flour samples in the Alveograph, following manufacturer's instructions.

Results and discussion

Glutenin composition

In the case of cross A, nine of the twelve lines possessed the *Glu-1*/*Glu-3* glutenin composition of the common wheat parent (cv. 'Pastor', *Glu-1*: 1, 17+18, 5+10, *Glu-A3*c, *Glu-B3g*); one showed *Glu-1*/*Glu-B3* of Pastor and the *Glu-A3*b' allele, assumed to belong to *T. dicoccum*; other two showed the *Glu-A1*, *Glu-B1*, and *Glu-B3* subunits of 'Pastor', the *Glu-D1*^{t} subunit 1.5+T2 of *Ae. Tauschii*, and *Glu-A3*b' of *T. dicoccum*. The two lines from cross B showed the *Glu-1/Glu-B3* composition of 'Pastor' and *Glu-A3*b' of *T. dicoccum*. These results show that this interspecific hybridization allows ample chromosome recombination among the three gene pools involved, and permits widening the gluten protein-related genetic diversity of agronomically-acceptable common wheat.

Quality characteristics

All the synthetic-derived lines showed medium hard grain, similar to that of the bread wheat parent, Pastor. The quality characteristics of the lines were examined in relation to glutenin subunit composition and therefore were grouped accordingly (Table 1).

Table 1. Mean and range values of grain and flour quality parameters of wheat genotypic groups

Cross and glutenin-type groups	n	GP[a]	SDS-S[a]	SDS-SI[a]	Mixograph[a]	Alveograph[b]	P/L
		%	ml/1g		DT, min	W x 10^{-4} J	
'Pastor'		12.1	12.5	1.0	2.3	302	1.7
Cross A							
'Pastor' type	9	11.9	12.3	1.1	2.9	332	1.3
		11.5-12.9	*11.3-13.8*	*1.0-1.1*	*2.5-3.3*	*250-387*	*0.8-2.1*
'Pastor'/dicoccum-type	1	11.6	13.8	1.2	3.7	400	1.2
'Pastor'/tauschii/ dicoccum-type	2	12.2	11.5	0.9	1.6	161	0.7
		11.9-12.6	*11.3-11.8*	*0.9-1.0*	*1.5-1.8*	*156-166*	*0.6-0.9*
Cross B							
'Pastor'/dicoccum-type	2	12.9	13.8	1.1	2.5	330	1.1
		12.3-13.4	–	*1.0-1.1*	*2.5-2.6*	*312-348*	*0.9-1.3*

[a]: whole meal; [b]: flour. GP: grain protein; SDS-S: SDS-sedimentation volume; SDS-SI: SDS-S Index (SDS-S/GP); DT: development time; W: strength value; P/L: tenacity/extensibility ratio.

The *Pastor/dicoccum-type* group of cross B was the only one showing average protein content larger than in 'Pastor'. The '*Pastor'-type* and the *Pastor/dicoccum-type* of Cross A, and the *Pastor/dicoccum-type* of Cross B, showed average gluten quality values superior to those of 'Pastor'. With the exception of the '*Pastor'/tauschii/dicoccum-type* group, which showed lower values than 'Pastor', all the glutenin-type groups had lines showing gluten quality-related values lower and higher than those shown by 'Pastor'. Although there were lines in all the glutenin-type groups showing better extensibility (lower P/L value) than 'Pastor', the best extensibility character corresponded to the lines of the '*Pastor'/tauschii/dicoccum-type* group, (Table 1).

Even though the gluten quality-related differences observed among the glutenin-type groups could not be clearly associated to their glutenin-related allelic differences, it was consistent that the

presence of the *Glu-D1*^{t} allele 1.5+T2 corresponded to the lines showing weak and extensible gluten type. Therefore the role of this *Glu-D1*^{t} allele on dough viscoelastic properties should be further examined. The results also showed that among this newly developed wheat Germplasm, there are lines possessing gluten quality-related properties, specially gluten extensibility, superior to those of their high-quality bread wheat parent.

The Mixolab as a breeding tool

Dough development time and stability in both, the Chopin-Mixolab and the National-Mixograph, and dough breakdown in the Mixolab showed highly significant correlations (R between 0.66 and 0.88, p>0.05) with the Alveograph's strength value W. It was also observed that performing the dough mixing test at constant water absorption results in highly significant R^2 values, which are slightly lower than when water absorption is adjusted to achieve constant dough consistency (Fig. 1). None of the dough mixing parameters in both the Mixolab and the Mixograph showed significant correlation coefficients with the Alveograph's extensibility index, P/L. Completing one full test in the Mixolab takes a long time (approx 1h), but the instrument's software allows programming to operate only in the dough mixing mode, reducing considerably the testing time. Therefore, the Chopin-Mixolab appeared to be a reliable instrument to screen for gluten strength in wheat quality improvement.

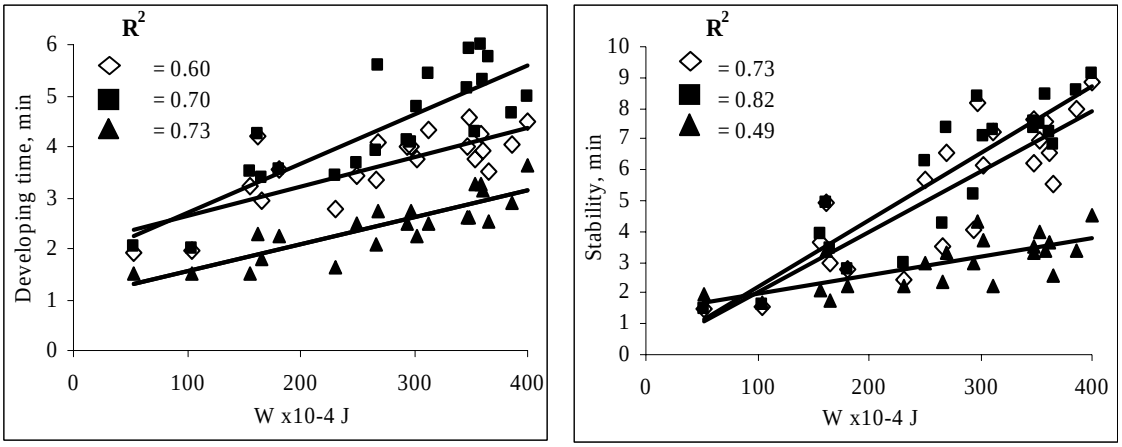

Fig. 1. Relationship between dough mixing parameters (Mixolab and Mixograph) and strength value W of the Alveograph. ◊: Mixolab constant absorption; ■: variable absorption; ▲: Mixograph.

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