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QUALITY CHARACTERISTICS AND GLUTENIN SUBUNIT COMPOSITION OF WHEAT LINES DERIVED FROM SYNTHETIC WHEAT (*Triticum turgidum x T. tauschii*) AND BREAD WHEAT (*T. aestivum*) CROSSES

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ABSTRACT

This study examined the quality characteristics and glutenin subunit composition of bread wheat lines derived from crosses between synthetic hexaploid (*Triticum turgidum* x *T. tauschii*) and bread (*T. aestivum*) wheats. Genotypes were field-grown at Ciudad Obregon, Sonora, Mexico. Test materials were evaluated for test weight, grain hardness, flour protein, SDS-sedimentation, Alveograph W and P/L, Mixograph mixing time and bread loaf volume. The advanced derivatives showed variations for most of the quality parameters evaluated. Lines carrying *Glu-D1* glutenins from *T. tauschii* had better dough extensibility than their bread wheat parent. Subunits 2.1+10 and 2.1+12 from *T. tauschii* showed negative and positive effects, respectively, on some bread making quality-related characteristics.

INTRODUCTION

The production of synthetic hexaploid wheats (synthetics), by hybridising *Triticum turgidum* and *T. tauschii*, has proven to be an excellent mechanism for the exploitation of desirable genetic variability present in the latter diploid species (Mujeeb-Kazi *et al.*, 1996). To take advantage of this mechanism, breeders at CIMMYT have been extensively crossing synthetics with bread wheat. At present there are several CIMMYTs advanced bread wheat lines that carry gene pools from *T. tauschii*. Field testing has revealed that several of these lines possess desirable disease resistance and agronomic traits (Villareal *et al.*, 1996).

Bread wheat lines carrying desirable disease and agronomic traits from *T. tauschii* may be considered for varietal release. However, bread making quality may be a determinant factor. In relation to quality, the D-genome of *T. tauschii* has a greater number of high molecular weight glutenin subunits (HMW-GS) than does the D-genome of bread wheat (Ciaffi *et al.*, 1992; Lagudah and Halloran 1988; William *et al.*, 1993). Since variations in the HMW-GS controlled at the *Glu-D1* locus are strongly associated with bread wheat's gluten strength and bread making quality, the same can be expected to occur for variations in HMW-GS of wheat lines carrying the 1DL chromosome of *T. tauschii*. In this study, we compared the quality characteristics of recombinant inbred lines (RILs), derived from three crosses between synthetics and bread wheat, in relation to their high- and low-molecular-weight glutenin subunit compositions.

MATERIALS AND METHODS

RILs from three crosses: Croc_1/*Ae. squarrosa* (205)//Kauz "s" (n = 17), Altar C84/*Ae. squarrosa* (221)//Borlaug M95 (n = 11), and Croc_1/*Ae. squarrosa* (205)//Borlaug M95 (n = 8) were grown in the field under irrigation at Ciudad Obregon, Sonora, Mexico, evaluated for test weight and then milled into flour using a Brabender Quadrumat Sr. mill. Grain hardness and flour protein were determined by Near-Infrared Reflectance, and flour SDS-sedimentation as described by Peña *et al.*, (1990). Alveographic dough strength parameters W

and P/L were obtained by testing 60-g flour samples following manufacturer's instructions. Mixograph mixing time and bread loaf volume were obtained using AACC methods 54-40A and 10-09, respectively (AACC 1983). Bread loaf volume per unit of flour protein (specific loaf volume) was calculated using the formula: bread loaf volume – 300 ÷ percent flour protein, where 300 was considered as the bread volume of a non-gluten flour. Glutenin subunit composition was determined by SDS-PAGE using unalkylated glutenin protein extracts prepared according to Singh *et al.*, (1991).

RESULTS AND DISCUSSION

The Croc_1/*Ae. squarrosa* (205)//Kauz "s" cross

Three distinct glutenin (*Glu-1/Glu-3)* subunit combinations were observed among RILs derived from the cross Croc_1/Ae. squarrosa (205)//Kauz "s" (Figure 1a). The one we called Kauz-type had the *Glu-1* (2*, 7+9, 5+10), *Glu-A3* and the *Glu-B3* glutenins of Kauz, and the *Glu-D3* glutenins of the synthetic parent. The intermediate-type carried 0, 7+9, 5+10 and the *Glu-3* glutenins of the synthetic parent. Lines in the synthetic-type group had the *Glu-1* (0, 7+8, 2.1+10) and *Glu-3* glutenins of the synthetic parent.

Significant differences were observed among the three groups in relation to most grain and flour parameters evaluated (Table 1). The intermediate-type in general resembled the parent Kauz more than the other two glutenin-type groups in test weight, grain hardness and SDS-sedimentation. Significant differences were also observed among the three glutenin-type groups in relation to most dough properties evaluated (Table 2). The synthetic-type group

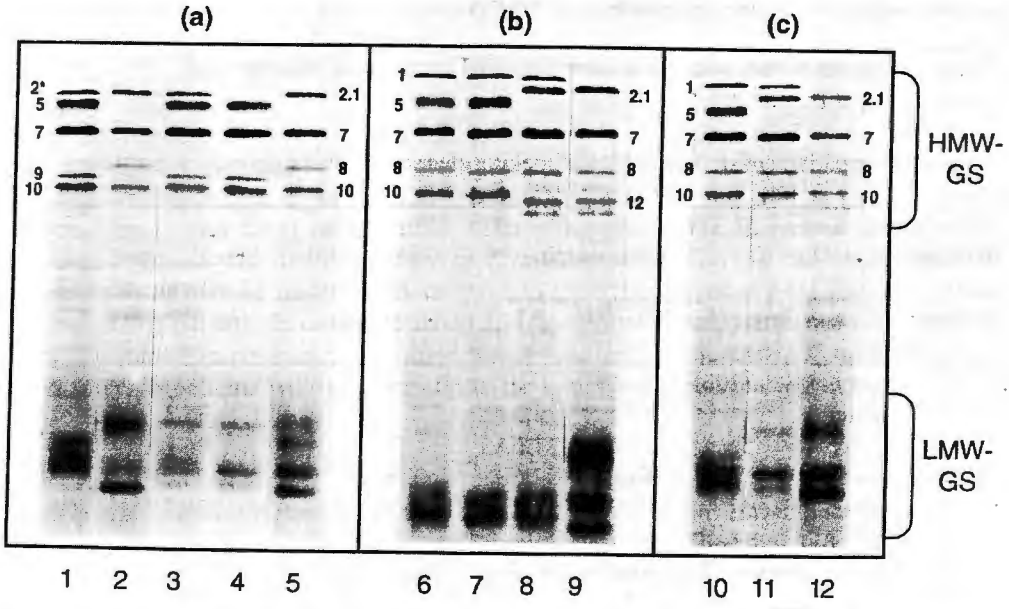

Figure 1. SDS-PAGE of glutenins from progeny of: (a) Croc_1/*Ae. squarrosa* (205)//Kauz "s"; (b) Altar C84/*Ae. squarrosa* (221)//Borlaug M95; and (c) Croc_1/*Ae. squarrosa* (205)//Borlaug M95. Bread wheat parents: 1, Kauz "s"; 6 and 10, Borlaug M95. Synthetic wheat parents: 2 and 12, Croc_1/ *Ae. squarrosa* (205); 9, Altar C84/*Ae. squarrosa* (221). Lines: 3, Kauz-type; 4, intermediate-type; 5, synthetic-type; 7, Borlaug-type; 8 synthetic-type; 11, synthetic-type.

showed better dough viscoelastic properties (larger W value and smaller P/L ratio) and longer mixing time than the other two groups and than the parent Kauz. Despite its weaker gluten character, the Kauz-type group showed larger specific bread loaf volume than the synthetic-type group. Some of the lines in the Kauz-type group had specific loaf volumes equal or better (36-38 ml per unit of protein) than that of the parent Kauz. The intermediate-type group had the poorest bread making quality.

Table 1. Comparison of grain and flour characteristics of glutenin-type groups

Cross and Glutenin-Type Group	n	Grain		Flour	
		Test wt (Kg/hl)[a]	Hardness (%)	Protein (%)	SDS-sediment (ml)
Croc_1/*Ae. squarrosa* (205)//Kauz "s"					
Kauz "s" (parent)	-	81.4	42.5	10.4	9.5
Kauz-type	5	78.4 A	49.5 A	10.3 A	10.9 A
Intermediate-type	7	80.2 B	42.0 B	11.5 B	9.5 B
Synthetic-type	5	76.1 C	43.6 B	11.2 C	13.1 C
Altar C84/*Ae. squarrosa* (221)//Borlaug M95					
Borlaug (parent)	-	80.8	41.5	10.9	13.2
Borlaug-type	5	80.5 A	39.5 A	11.1 A	13.3 A
Synthetic-type	6	80.0 A	40.4 A	11.5 B	13.8 A

[a]: For each cross, values within a column followed by the same letter are not significantly different ($\alpha = 0.05$).

Table 2. Comparison of dough and bread making characteristics of glutenin-type groups

Cross and Glutenin-Type Group	n	Alveograph		Mixograph Mix time (min)	Specific bread Loaf volume (ml / % prot)
		$Wx10^{-4}$ J [a]	P/L		
Croc_1/*Ae. squarrosa* (205)//Kauz "s"					
Kauz "s" (parent)	-	162	2.5	1.5	35.3
Kauz-type	5	168A	1.6A	1.1A	34.1A
Intermediate-type	7	198B	2.6B	1.4B	24.9B
Synthetic-type	5	247C	1.8A	1.6C	29.7C
Altar C84/*Ae. squarrosa* (221)//Borlaug M95					
Borlaug (parent)	-	265	1.5	2.0	46.7
Borlaug-type	5	240A	1.6A	2.1A	43.6A
Synthetic-type	6	252A	0.8B	1.5B	42.0B

[a]: For each cross, values within a column followed by the same letter are not significantly different ($\alpha = 0.05$).

The Altar C84/*Ae. squarrosa* (221)//Borlaug M95 cross

Two distinct HMW-GS combinations were found among RILs derived from the cross Altar C84/*Ae. squarrosa* (221)//Borlaug M95 (Figure 1b). The Borlaug-type had the *Glu-1* glutenins of Borlaug (1, 7+8, 5+10), and the synthetic-type carried the *Glu-D1* glutenins of the synthetic parent (1, 7+8, 2.1+12). Both groups carried the *Glu-3* glutenins of Borlaug.

Except for slightly higher protein content in the synthetic-type group than in the Borlaug-type group, no significant differences were observed in the grain and flour characteristics evaluated between the two glutenin-type groups, and between each of the two groups and the bread wheat parent (Table 1). The dough-strength parameter W was similar in both groups, and practically the same as that of Borlaug (Table 2). The synthetic-type group showed better dough extensibility (smaller P/L ratio) but shorter mixing time than the Borlaug-type group, and than the parent Borlaug. Specific loaf volumes of both groups were similarly lower than that of Borlaug. The largest specific volume for a line within the synthetic-type group was 43.5 ml per unit of protein, slightly lower than that of the bread wheat parent.

The Croc_1/*Ae. squarrosa* (205)//Borlaug M95 cross

All RILs derived from the cross Croc_1/*Ae. squarrosa* (205)//Borlaug M95 showed the same glutenin subunit composition: *Glu-A1* glutenin 1 of Borlaug, *Glu-B1* subunit 7+8, common to both parents, and the *Glu-D1* subunit 2.1+10 of the synthetic parent. The *Glu-3* glutenin composition was that of the synthetic parent (Figure 1c). These lines showed lower test weight, softer grain type, and overall weaker gluten type than their bread wheat parent (data not shown). Mean and range specific loaf volumes for the RILs were 26.0 and 23.4 to 33.0 ml per unit of protein, respectively, inferior to that of the parent Borlaug, which had a specific loaf volume of 46.7 ml per unit protein.

CONCLUSIONS

Two important bread-making quality-related characteristics of the bread wheat derivatives were consistently associated with the presence of HMW-GS of *T. tauschii*. One was dough extensibility, which was better (smaller P/L ratio) in lines carrying *Glu-D1* glutenins of *T. tauschii* than in their bread wheat parent. The other one was the differential quality effect associated with *Glu-D1* allelic variations of *T. tauschii*; subunit 2.1+10 had negative quality effects on RILs derived from crosses involving a poor (Kauz) and a good (Borlaug) bread making quality parent. In contrast, subunit 2.1+12 showed a quality effect similar to that of 5+10. Therefore, in addition to desirable disease and agronomic traits, *T. tauschii* carries novel glutenin proteins with positive effects for improving bread making quality of bread wheat.

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