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Relationships between bread-making quality and starch viscosity parameters in bread wheat partial-waxy

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Introduction

The influence of the high molecular weight glutenin subunits (HMW) on bread wheat quality in bread wheat (*Triticum aestivum* L.) is well known. However, the role of low molecular weight glutenin subunits (LMW) is not so well known. The puroindolines (controlled by the *Ha* locus) are the principal determinants of the endosperm texture of the grain.

Starch, a predominant component of wheat grain, plays an important role in the appearance, structure and quality of food products. The amylose content of starch, controlled by the *Waxy* genes located on 7A, 7D and 4A chromosomes, is related to the viscosity of the starch and the partial-waxy mutants have a lower amylose content than the normal wheat.

The aim of this work is to understand the influence of prolamins and puroindolines on bread quality and starch viscosity in partial, single or double waxy bread wheat mutants.

Material and methods

Fifty five single or double waxy mutant F_5 lines derived from the 'Ablaca' x 'Waxy Line' (0% amylose) cross were analysed for their composition of HMW and LMW glutenins, waxy proteins and puroindolines. The compositions of HMW and LMW glutenins and waxy proteins were determined by SDS-PAGE. Analysis of the expression of HMW subunit 1Bx7 and puroindolines were made by PCR with specific primers.

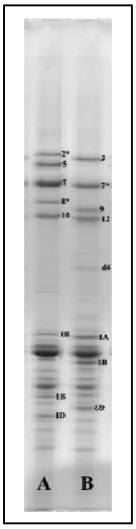
The following quality characteristics were measured: protein content (by NIR), SDS-sedimentation volume (SDSS), peak resistance (PR), and mixing time (MT) of Mixograph, amylose content (by colorimetric determination with spectrophotometer), and the peak viscosity (PV), trough viscosity (TV) and final viscosity (FV) by Rapid Visco Analyser (RVA). Statistical analysis of variance, *t*-test and Pearson correlation, were made by SAS.

Results and discussion

The HMW and LMW compositions of the parents 'Ablaca' and 'Waxy Line' are shown in Fig. 1. The *Glu-B1* in Ablaca results in over-expression of HMW subunit 1Bx7 (band 7 in Fig. 2). Figure 3 shows the puroindoline compositions of the parents: 'Ablaca' is a hard wheat and 'Waxy' is soft.

These results indicated the influence of some HMW glutenin subunits, puroindolines and waxy genes on dough strength parameters (Table 1). Statistical analysis using the *t*-student showed that the SDSS Mixograph MT were higher in lines showing over-expression of subunit 1Bx7 or the presence of subunits 1Dx5+1Dy10 encoded by *Glu-B1* and *Glu-D1* loci, respectively. Also, Mixograph PR was higher when the subunit 1Bx7 was present.

Grain texture also influenced PR, with hard lines having greater values for PR than soft lines.



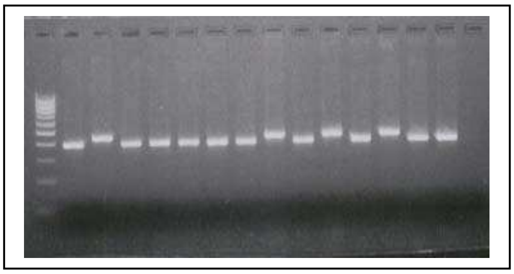


Fig. 1. HMW and LMW glutenin subunit compositions of 'Ablaca' (lane A) and 'Waxy Line' (lane B).

Fig. 2. Over-expression of HMW subunit 1Bx7 in partial-waxy (lanes 4-15) and the parents 'Waxy Line' (1Bx7-) and 'Ablaca' (1Bx7 +) (lanes 2 and 3, respectively).

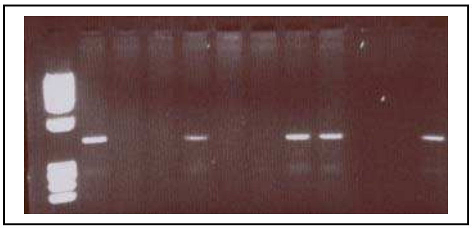


Fig. 3. Composition in puroindoline A of some partial-waxy (lanes 4-12) and the parents 'Waxy Line' (soft) and 'Ablaca' (hard) (lanes 2 and 3, respectively).

The amylose content of starch was influenced by the waxy protein composition, the order being Wx-B1>Wx-A1>Wx-D1. The waxy loci also influenced the final viscosity but did not have significant effects on the peak viscosity and trough viscosity.

The correlation (Table 2) between protein content and peak resistance was significant and positive, while it was significant and negative with starch viscosity parameters (PV, TV and FV). The sedimentation volume was significantly and positively correlated with MT. The correlation between starch viscosity and Mixograph parameters indicated a positive relationship between viscosity and MT and a negative relationship with PR. Starch viscosity was correlated positively with amylose content but not with protein content or sedimentation volume.

Table 1. Analysis of variance (mean squares) for quality traits of F_5 lines from 'Ablaca' x 'Waxy Line' cross grouped for HMW and LMW glutenin subunits, waxy alleles and puroindoline genotypes

Source	df	Protein	SDSS	PR	MT	Amylose	PV	TV	FV
Glu-A1	1	n.s.	n.s.	n.s.	n.s.	n.s.	2226.0*	318.2*	n.s.
Glu-B1	1	n.s.	997.6**	669.0**	13460.2**	n.s.	n.s.	n.s.	n.s.
Glu-D1	1	n.s.	552.5**	n.s.	11372.4**	n.s.	n.s.	n.s.	n.s.
Glu-A3	1	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Glu-B3	2	n.s.	352.1*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Glu-D3	2	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Wx-A1	2	n.s.	n.s.	94.4*	n.s.	140.9**	n.s.	n.s.	1238.1**
Wx-D1	2	n.s.	n.s.	n.s.	n.s.	83.0**	n.s.	n.s.	1072.8*
Wx-B1	2	n.s.	n.s.	84.1**	n.s.	145.2**	n.s.	n.s.	1207.4*
PinA	2	n.s.	n.s.	184.7**	n.s.	n.s.	n.s.	n.s.	n.s.
Error	38	0.8	67.8	19.2	485.7	6.5	383.1	59.4	236.7

** and * significant at 1% and 5% , respectively; n.s., no significant.

Table 2. Pearson Correlations between parameters analysed

	Protein	SDSS	PR	MT	Amylose	PV	TV
SDSS	n.s.	-	-	-	-	-	
PR	0.51**	n.s.	-	-	-	-	
MT	n.s.	0.74**	n.s.	-	-	-	
Amylose	n.s.	n.s.	n.s.	n.s.	-	-	
PV	-0.52**	n.s.	-0.44**	0.31**	0.46**	-	
Trough	-0.38**	n.s.	-0.32*	0.28*	0.47**	0.78**	-
Final V.	-0.39**	n.s.	-0.32*	0.34*	0.68**	0.81**	0.93**

** and n.s.: significant at 1% , and no significant, respectively.

Conclusions

The results of this study indicated that the over-expression of subunit 1Bx7 had the most important effect on dough strength in the partial-waxy lines but that grain texture was also important.

In addition, correlation of the various parameters that were determined indicated that MT measured by the Mixograph, correlated positively and significantly with SDSS and starch viscosity parameters.