Effects of Glutenin Subunit Variation and 1AL.1RS Translocation on Dough Properties of Wheat Grown in Colorado Environments

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Introduction

Wheat (Triticum aestivum L.) flour is unique because it has the ability to form a dough that can be used to produce leavened bread and other food. This ability is largely determined by its gluten proteins. Research has shown that allelic variation at the Glu-1 and Glu-3 loci plays an important role in determining wheat dough properties and bread-making quality (Gras et al., 2001). The 1AL.1RS translocation from rye (Secale cereale L.) to wheat confers disease and insect resistance and increased grain yield, biomass and grain weight, and is used extensively in North America. On the other hand, 1AL.1RS has been associated with a decrease in hard winter wheat quality (Espitia-Rangel et al., 1999; Graybosch, 2001). The effects of glutenins and rye translocations on quality are known to vary across environments. However, their effects on dough mixing properties in irrigated and dryland environments has not been reported by evaluating a segregating population of recombinant inbred lines (RILs).

Objectives

➢ To evaluate the effects of glutenin subunit variation and 1AL.1RS translocation on wheat flour mixing properties.
➢ To determine the consistency of those effects on wheat flour mixing properties in two Colorado environments, irrigated and dryland field conditions.

Materials and Methods

➢ 190 F7 RILs were developed from a cross between the hard winter wheat TAM 107-R7 and Arlin. This population segregates for the presence of 1AL.1RS and for several glutenin subunits.
➢ Plants were grown in two replications in an alpha-lattice incomplete block design at Ft Collins (irrigated with a sprinkler system) and Akron (dryland), Colorado in 2004-05.
➢ The high molecular weight (HMW) glutenin subunits were extracted and analyzed by SDS-PAGE according to the protocols of Graybosch and Morris (1990), and scored using the nomenclature of Payne and Lawrence (1983). The low molecular weight (LMW) glutenin subunits were extracted and resolved on SDS-PAGE according to Singh (1991) and Gupta and MacRitchie (1991). The nomenclature follows Gupta and Shepherd (1990).
➢ 1AL.1RS was identified with the PCR method developed by Katto et al. (2004).
➢ Milling followed the AACC method 26-50 using a Brabender Quadrumat Jr experimental mill.
➢ Dough mixing properties were evaluated with a 10g Mixograph connected to a computer (National Manufacturing, Lincoln, NE, USA) according to the AACC method 54-40A. Data were analyzed with the Mixsmart®, V. 3.8. Selected mixograph parameters are shown in the following mixograph.

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Results

➢ Light frost damage at heading stage and drought stress during grain filling stage occurred at Akron. No visible stress symptoms were observed at Ft Collins (Fig. 1).
➢ Although kernel weight was lower in Akron, protein content and mixograph traits were more favorable in the dryland environment (Table 1).
➢ Mixograph parameters were all highly influenced by the environment (Env), genotype (Entry) and their interaction (Env*Entry). Environmental variances were the major source of the variation of all the mixograph parameters (Table 2).
➢ RILs segregated of most of the glutenin loci, except for Glu-B1 (subunit 7) (Fig 2).
➢ Presence of 1AL.1RS reduced most of the mixograph parameters, except MPT, indicating that it is detrimental to wheat flour quality (Table 3).
➢ Variation at the Glu-D1 locus had a significant influence on dough strength with the 5+10 subunits giving higher values, except for MPV at Akron (Table 3).
➢ Variation at Glu-B1 locus had a significant influence on MPT, MRW and MRV in both environments with the 7+8 subunits having higher values (Table 3).
➢ Variation at the Glu-A3 locus significantly affected MPW, MRW and MRV with allele e giving higher values than allele c (Table 3).
➢ In general, the effects of 1AL.1RS and glutenin subunit variation on mixograph parameters showed the same trend in both environments, but the effect sizes differed between environments (Table 3).

Summary

➢ To evaluate the effects of the Glu-1 and Glu-3 loci and the presence of 1AL.1RS on dough mixing properties of hard winter wheat, we evaluated the TAM107-R7/Arlin RIL population which segregates at several Glu-1 and Glu-3 loci and at 1RS.1AL. The 190 RILs were grown in two Colorado locations, Akron (dryland) and Fort Collins (irrigated) in 2004-05. Gluten strength and dough mixing properties were measured by 10 g Mixograph. The results indicated that:
➢ Wheat dough mixing properties were significantly effected by growing environments. Wheat from dryland location produced stronger dough than wheat from the irrigated location.
➢ Presence of 1AL.1RS was associated (P<0.01) with reduced dough strength.
➢ Better dough mixing properties were observed in both environment with Glu-D1 (5+10) vs. Glu-D1 (2+12), Glu-A1 (2*) vs. Glu-A1 (1), Glu-B1 (7+8) vs. Glu-B1 (7+9), and Glu-A3 e vs. Glu-A3 c.

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References