NOTE

Pentosans in Flours of 1B/1R Translocation Wheats[1]

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In wheats with the 1B/1R translocation, the short arm of chromosome 1B of wheat has been replaced by that of 1R of rye. This translocation offers some agronomic advantages, including enhanced resistance to several wheat diseases (e.g., stem, leaf, and stripe rust), and consequently is being used increasingly in wheat breeding programs around the world (Zeller 1973, Zeller et al 1982, Martin and Stewart 1986, Dhaliwal et al 1987, Pena et al 1990). Despite the high yielding potential of translocated wheats, a number of undesirable dough properties have been reported that restrict the release of the 1B/1R lines as bread wheats (Martin and Stewart 1986, Dhaliwal et al 1987). Doughs derived from such wheats frequently exhibit stickiness (especially when subjected to high-speed mixing), reduced strength, and intolerance to overmixing. Zeller and coworkers (1982) were the first to suggest that increased water absorption by the flours from such wheats leads to formation of sticky doughs. In this context, dough stickiness of translocation lines has been related to water-soluble proteins and pentosans (Bolling and Meyer 1981, Zeller et al 1982). However, recent studies have indicated that the underlying biochemical causes of the changes in the physical properties of doughs are far from clear (Dhaliwal et al 1988, Henry et al 1989, Dhaliwal and MacRitchie 1990, Dhaliwal et al 1990). Interestingly, some of the Australian cultivars that were previously reported to have these defects (Martin and Stewart 1986, Dhaliwal et al 1987) did not show dough stickiness when grown in northwestern Mexico (Pena et al 1990).

Since inferior breadmaking quality does seem to be associated with the presence of the short arm of the 1R chromosome of rye, it is important to examine the quality characteristics and composition of rye-derived wheat lines cultivated under various agronomic environments to provide further insights into the relationships between their composition and the physical properties of their flours. This article reports on the pentosan content and the nature of water-soluble pentosans of 1B/1R translocation wheat lines grown in western Canada.

MATERIALS AND METHODS

Sister lines of the bread wheat cultivar Thatcher and the 1B/1R translocation derived from Thatcher were used for analysis of pentosans and breadmaking quality. Two 1B/1R translocation wheats were used to obtain purified pentosans. RL6078 and W466 are translocation lines of the cultivars Thatcher (Canada Western Red Spring) and Biggar (Canada Prairie Spring), respectively, in which the short arm of the wheat chromosome 1B has been replaced by the short arm of chromosome 1R of Petkus cultivar rye. The 1B/1R translocation wheats were identified electrophoretically by the presence of rye secalins (Dyck et al 1987) and/or by a monoclonal antibody assay (Howes et al 1989). The translocation lines had similar flour yields (71.5 and 71.8% for RL6078 and W466, respectively). The protein and ash contents were 14.5 and 0.42%, respectively, for RL6078 and 12.4 and 0.47%, respectively, for W466.

Flours were milled on a Buhler pneumatic laboratory mill after wheat samples were tempered to 16.5% moisture. Flour protein content, ash content, mixograms, and the remix loaf volume were determined as previously described (Lukow et al 1990, Lukow and McVetty 1991).

The flours from RL6078 and W466 wheats were blended with three volumes of distilled water at 25°C for 5 min. After centrifugation (10,000 × *g*, 20 min), the supernatants were immediately heated (95°C, 5 min) to inactivate endogenous enzymes and to coagulate water-soluble proteins. After filtration, the aqueous extracts were treated with Vega Clay (Pembina Mountain Clay, Winnipeg, MB) to remove the residual proteins (20 g of clay per liter of extract, stirred for 30 min, and then centrifuged at 10,000 × *g* for 20 min). Salivary α-amylase (type IXA, EC 3.2.1.1, Sigma Chemical Co, St. Louis, MO) was used to digest starch contaminants in the extract. After incubation with the enzyme (48 hr, 37°C), the solutions were dialyzed; the enzyme was inactivated by heat (95°C, 15 min) and removed by centrifugation (10,000 × *g*, 20 min). Incubation with α-amylase and all subsequent steps were repeated to fully hydrolyze all residual α-D-glucans.

The content of total and water-soluble pentosans in the flours was determined by the phloroglucinol method of Douglas (1981). The content of water-insoluble pentosans was obtained by subtracting water-soluble pentosans from total pentosans. The relative amounts of component monosaccharides in pentosans were determined by high-performance liquid chromatography (Aminex HPX-87 column, 85°C, flow rate 0.6 ml/min using deionized and degassed water as eluant) after hydrolysis with 1*M* H_2SO_4 for 2 hr at 100°C and neutralization with $BaCO_3$ (Izydorczyk et al 1991a). Phenolic acids were liberated by treatment of pentosans with alkali and analyzed by high-performance liquid chromatography as described previously (Izydorczyk et al 1991a). Gel filtration chromatography of pentosans was performed on a Sepharose CL-4B column (2.5 × 80 cm). Elution was achieved with degassed 0.3% NaCl containing 0.05% NaN_3 at a flow rate of 25 ml/hr at 25°C. Total (V_t) and void (V_o) volumes were determined with xylose and Blue Dextran, respectively. Other molecular weight markers used were linear dextrans T_{500} and T_{150} (mol wt 466,000 and 143,000, respectively) (Pharmacia Ltd, Montreal, PQ). Eluant fractions were analyzed for total carbohydrates by the phenol-sulphuric method (Dubois et al 1956).

The apparent viscosities of aqueous solutions of pentosans were measured with Ubbelohde capillary viscometers (International Research Glassware, Kenilworth, NJ) at 25°C. The limiting viscosities were calculated from the Huggins equation (Huggins 1942). Pentosan gels were obtained by adding horseradish peroxidase (0.22 purpurogallin units per milliliter) and H_2O_2 (1.5 ppm) to aqueous solutions of pentosans (2% w/w). The development of gel structure was monitored by small-deformation oscillatory measurements using a Bohlin VOR rheometer (Bohlin Reology, Edison, NJ). All measurements were conducted at 15.0±0.1°C at a frequency of 1 Hz and a maximum input strain of 4% for up to 4 hr.

All statistical analyses were performed using the Statistical Analysis System package (SAS Institute 1985).

RESULTS AND DISCUSSION

The water-soluble and total pentosan contents in flours of 35 1B/1R translocation and 36 normal wheat lines are presented

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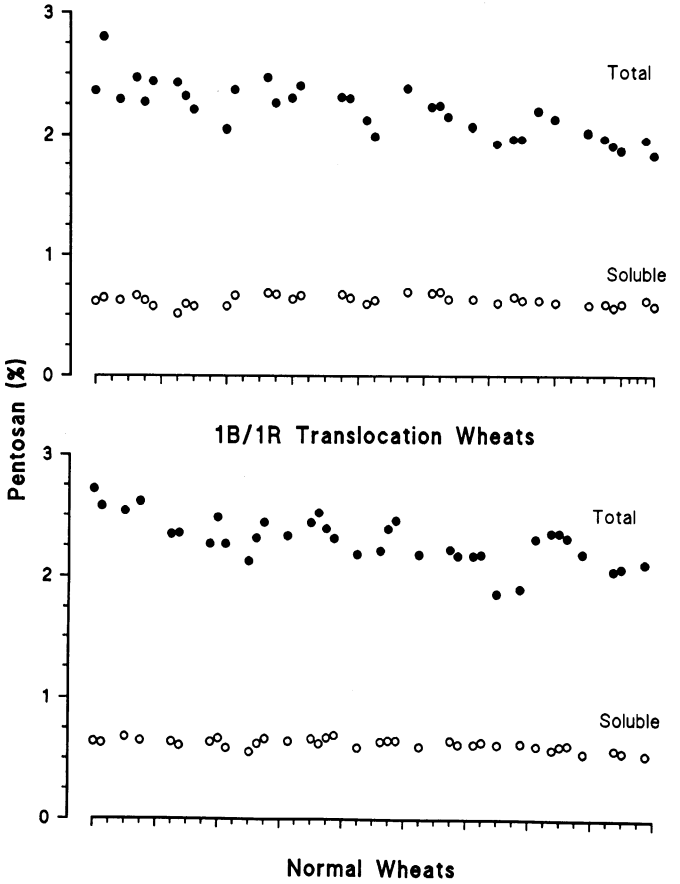

Fig. 1. Water-soluble and total pentosan content of flours from normal and 1B/1R translocation wheats.

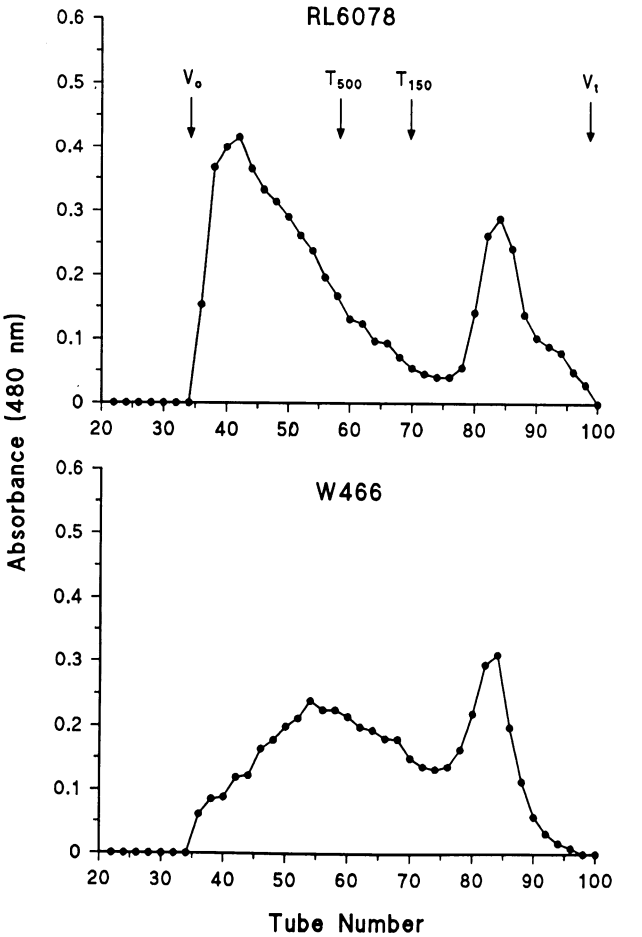

Fig. 2. Chromatography of water-soluble pentosans on Sepharose CL-4B column (2.5 × 80 cm, 0.3% NaCl containing 0.05% NaN_3 elution buffer, flow rate 25 ml/hr, 25°C). T_{500} and T_{150} represent elution volumes of linear dextrans used as molecular weight markers.

in Figure 1. Although rye contains higher levels of cell wall polysaccharides—pentosans and (1→3)(1→4)-β-D-glucans—than wheat (Henry 1987), the mean values for total and water-insoluble pentosans in normal wheats (2.31 and 1.68%, respectively) were slightly higher than those in the rye-derived lines (2.20 and 1.58%, respectively, $P < 0.05$); no significant differences were observed for the water-soluble pentosan content between the two groups. Unpaired *t*-test analysis revealed significant differences between the means of the two groups for flour protein content (12.4%, normal vs. 13.3%, 1B/1R; $P < 0.001$), flour yield (61.5%, normal vs. 62.1%, 1B/1R; $P < 0.05$), mixograph development time (2.29 min, normal vs. 2.02 min, 1B/1R; $P < 0.05$), and remix loaf volume (792 cm^3, normal vs. 828 cm^3, 1B/1R; $P < 0.001$). These results clearly indicate that the chromosome translocated wheat lines were not inferior to their normal counterparts with respect to the remix loaf volume.

The composition and properties of the isolated pentosans from the two 1B/1R translocation wheats, RL6078 and W466, are given in Table I. The two major polymeric constituents of wheat pentosans are arabinoxylan and arabinogalactan (Neukom 1973). The former has a high water binding capacity and thereby affects the rheological properties of dough and bread (Jelaca and Hlynka 1972, McCleary 1986). Moreover, the water holding capacity of arabinoxylan can be greatly enhanced via covalent cross-linking involving feruloyl groups present in this polymer (Izydorczyk et al 1990). The ferulic acid contents and the molar ratios of component monosaccharides of both pentosan preparations were similar to those of pentosans from the normal wheats previously reported by Izydorczyk et al (1991a). Unlike rye pentosans, which consist primarily of arabinoxylans (Antoniou et al 1981, Girhammar et al 1986), the 1B/1R translocation lines showed substantial amounts of galactose, most likely originating from the arabinogalactan component. This is further supported by the gel filtration profiles of the water-soluble pentosans shown in Figure 2. The carbohydrates eluting at a low molecular size ($<1.5 \times 10^5$) correspond to arabinogalactan-peptide, as previously reported by Izydorczyk et al (1991a); indeed, monosaccharide analysis of carbohydrates eluting in fractions 77–95 showed mainly arabinose and galactose. These results showed that the transfer of a large number of rye genes into 1B/1R wheats does not cause any modification in the polymeric composition of their water-soluble pentosans. Interestingly, the molecular weight distributions of the arabinoxylan components of the pentosan preparations differed substantially. Arabinoxylan from the RL6078 sample eluted in large portion in the vicinity of the void volume, indicating a polymer of relatively high molecular weight. The corresponding profile of the W466 showed a greater proportion of species eluting at low molecular weight. These chromatographic data concur with the limiting viscosity values ([η]) for these materials (Table I). Similarly, significant differences in the rigidity of pentosan gel networks was evident following oxidative treatment of pentosan solutions with H_2O_2 and peroxidase; the elastic modulus (G′) of RL6078

TABLE I
Composition and Properties of Pentosans from 1B/1R Translocation Wheats

Sample (Wheat Parent)	Relative Molar Ratio			Ferullic Acid (μg/g)	Limiting Viscosity (dl/g)	G′[a] (Pa)
	Ara	Xyl	Gal			
RL6078	1.00	1.15	0.54	0.76 ± 0.05	3.18	31.85 ± 0.21
W466	1.00	1.07	0.58	0.92 ± 0.06	1.69	4.04 ± 0.50

[a] Pentosan solutions (2% w/v) were treated with horseradish peroxidase (0.22 purpurogallin units per milliliter) and H_2O_2 (1.5 ppm); G′ values were obtained after 4 hr of reaction.

pentosan was much greater than that of W466 pentosans. These findings are in agreement with the observations of Izydorczyk et al (1991b) on pentosans from a number of flours of normal wheats, where G′ and [η] were found to be positively correlated. Although the data on purified pentosans from 1B/1R translocation wheats are limited to only two lines, it is evident that considerable variation in molecular size and physical properties of these polymers exists in these wheats, as has been found for normal wheat varieties (Izydorczyk et al 1991a,b). This in turn would have direct functional implications on the mixing, dough development, baking, and shelf life of baked products derived from such flours.

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