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Variation in Quality Characteristics Associated with Some Spring 1B/1R Translocation Wheats

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Advanced lines (295) from CIMMYT's International Bread Wheat Screening Nursery, a large proportion of which carry the 1B/1R translocation, were examined in terms of their sodium dodecyl sulfate (SDS)-sedimentation volumes and Alveograph characteristics, as well as their dough mixing and bread-making properties. A significant quality trait variability was observed for all parameters evaluated. Comparison of sister lines with and without the 1B/1R translocation showed that variations in SDS-sedimentation volume. Alveograph characteristics, dough mixing and baking properties cannot be attributed exclusively to the presence of the 1B/1R translocation. Finally, the poor breadmaking properties, particularly dough stickiness, associated with one Mexican (Glennson 81) and two Australian (QT-2870 and SUN-89D) cultivars could not be confirmed when doughs were mixed under medium-speed mixing conditions. Therefore, the dough stickiness problem seems to be an attribute restricted mainly to high-speed mixing conditions characteristic of some modern breadmaking processes.

Introduction

The 1B/1R translocation has been used to introduce disease resistance associated with the 1R chromosome of *Secale cereale* into *Triticum aestivum*[1]. In wheats with the 1B/1R translocation, the short arm of chromosome 1B of wheat is replaced by the short arm of the 1R chromosome of rye, presumably as a natural consequence of a centric-break-fusion event between chromosomes 1B of wheat and 1R of rye.

Two important wheats with the 1B/1R translocation (1B/1R) are the European cultivars Kavkaz and Aurora[1]. Unfortunately, these, and various other 1B/1R wheat cultivars, have inferior breadmaking quality, mainly due to dough stickiness and poor mixing tolerance[2–5]. Kavkaz has been extensively used in CIMMYT's program to improve spring bread wheats. It has resulted in the development of the Veery family wheats, which, in general, show a high genetic yield potential across a wide range of environments and which possess the 1B/1R translocation[6–10]. As a consequence of this high yield potential, the Veerys have been extensively used as progenitors in various national breeding programs, or have been released directly as varieties in several countries[6], being presently grown on more than 5 million hectares worldwide.

Since inferior breadmaking quality has been associated with the presence of the 1R chromosome of rye in 1B/1R wheats[3,4,11], and a large proportion of CIMMYT's

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advanced lines possess the 1B/1R translocation, some of these translocation lines were examined with respect to breadmaking quality characteristics. The study was based upon analysis of quality characteristics within the 1B/1R wheat population and between sister lines with and without the 1B/1R translocation that were identified earlier by isozyme[12] or chromosome banding analyses[13].

Experimental

Material

CIMMYT's 22nd International Bread Wheat Screening Nursery (IBWSN), comprising 295 homozygous advanced lines, was grown during the 1986/1987 season in Ciudad Obregon, Sonora, Mexico. Three Mexican (Genaro 81, Glennson 81, Seri 82) and two Australian (QT-2870, SUN-89D) cultivars grown in Sonora, Mexico in 1985/1986 were also used.

Identification of 1B/1R translocation wheat

The 1B/1R wheats were identified by glucose phosphate isomerase isozyme isoelectrofocusing[12] and/or C- and N-banding chromosome analyses[13].

Chemical analysis

Wheat flour samples were produced with a Brabender Quadrumat Senior mill (C. W. Brabender OHG, Germany). Flour moisture was determined with the Brabender moisture tester (130 °C for 1 h in an oven) and flour protein ($N \times 5{\cdot}7$) was estimated with a Technicon InfraAlyzer 350 (Technicon, Tarrytown, N.Y.) previously calibrated against protein contents determined using the Kjeldahl procedure (AACC, Kjeldahl method 46-11)[14].

SDS-sedimentation test

A modification of the sodium dodecyl sulfate (SDS)-sedimentation test of Axford *et al.*[15] was used. The procedure was as follows: Flour (1 g) was placed in a 25-ml glass cylinder with stopper (0·1 ml graduation and approximately 15 mm internal diameter). Aqueous 0·001 % (w/v) bromophenol blue solution (6 ml) was added and the contents thoroughly mixed (4–6 s) using a vortex-mixer. The cylinder was allowed to stand for 5 min, with intermediate vortex-mixing after 2·75 and 4·75 min. After the 5-min standing period, a freshly prepared working solution of lactic acid and SDS (19 ml; working solution consisted of 1·7 parts of lactic acid-water (1:8, v/v) and 48 parts of 2 %, w/v, SDS) was added and the cylinder shaken for 1 min on a mechanical shaker oscillating horizontally at a rate of 35 to 45 cycles/min. The cylinders were then allowed to stand for 14 min before the volume of the sediment was recorded. The test was conducted at 20–22 °C. Linear regression analysis ($y = 321{\cdot}76 + 28{\cdot}67\,x$) showed a highly significant correlation coefficient $r = 0{\cdot}75$ ($n = 118$) between SDS-sedimentation volume and bread loaf volume.

Alveograms

Alveograms were obtained with the Chopin Alveograph (Tripette and Renaud, Paris, France) using flour samples of 60 g and following the manufacturer's instructions. The water absorption used was 50·0 % for most flours, but 52·5 % absorption was used for flours having SDS-sedimentation values above 20·5 ml. The deformation energy (W), an indicator of gluten strength, and the overpressure (P) to swelling index (G) ratio (P/G), an indicator of tenacity/extensibility, were calculated from the Alveograms. Large W values (300×10^{-4} J and above) correspond to strong gluten, and large P/G values (6 and above) correspond to tenacious gluten types.

Mixograms

Mixograms were obtained with the Swanson and Working Mixograph (National Mfg Co. Lincoln, NE. U.S.A.) using a spring setting of 12, flour samples of 35 g and variable water absorption corresponding to flour protein, as suggested in AACC method 54–40[14]. A mixing tolerance score was established by considering the angle of breakdown, which consisted of the angle formed between a horizontal line centred at the peak position of the curve and a line drawn from the peak position through the center of the descending part of the curve. The mixing tolerance score ranged from 1 to 6, where 1 was considered very poor (angle larger than 35°); 2, poor (angle between 27–34·5°); 3, fair (angle between 20–26·5°); 4, good (angle between 13–19·5°); 5, very good (angle between 5–12·5°); and 6, excellent (angle smaller than 5°).

Breadmaking Procedure

The breadmaking procedure used was the straight-dough baking test 10-10 of the AACC[14], using the 100 g-flour formula. Bread loaf volume was determined by rapeseed volume displacement.

Dough stickiness assessment

Dough stickiness was assessed in the Mexican (Genaro 81, Glennson 81, Seri 82) and in the Australian (QT-2870, SUN-89D) cultivars as follows: The dough, which was prepared as described under 'Breadmaking Procedure', was placed in a covered aluminium bowl and allowed to rest for 5 min. The dough was then hand-kneaded, applying a slight pressure to see if it stuck to the hands when they were pulled apart. The kneading-pressing operation was repeated 12 times. In sticky doughs, stickiness appeared after 4 to 8 kneading-pressing operations, whereas non-sticky doughs could be kneaded and pressed 12 times without evidence of stickiness. After dough stickiness was assessed, the dough was shaped into a ball and placed to ferment for continuing the breadmaking operation.

Results and Discussion

Quality variability in the normal and in the 1B/1R wheat population

The isozyme-isoelectrofocusing and banding analysis showed that 40% of the lines in the 22nd IBWSN nursery had the 1B/1R translocation. Both, normal and 1B/1R wheat populations showed a large variability in all the parameters evaluated (Table I). The variability in SDS-sedimentation volume and in the Alveograph strength value W observed in both normal and 1B/1R wheat populations corresponded to weak to medium-strong gluten types; however, larger mean values for these two parameters in the normal than in the 1B/1R wheat population, indicated that the first population was slightly stronger than the latter one. The mean Alveograph P/G ratios were 6·3 in the normal and 6·6 in the 1B/1R wheats for gluten types that ranged mainly from tenacious to balanced; only two extensible gluten type lines were observed in the normal wheat group, while extensible gluten types were lacking in the 1B/1R wheat group (Table I).

A wide range of types exist among the normal and 1B/1R wheat groups in terms of Mixograph mixing tolerance (Table I). The mean mixing tolerance scores were 3·7 and 3·8 in these groups, which corresponded with fair to good mixing tolerance. Dhaliwal *et al.*[2] observed smaller height and width in the descending tail of Mixograms of 1B/1R derivatives than in Mixograms of their respective normal parents. These authors suggested that factors responsible for rapid dough breakdown during mixing may also

TABLE I. Means and ranges of values for the quality parameters of normal and 1B/1R wheats (*Triticum aestivum* L.) in the 22nd International Bread Wheat Screening Nursery (IBWSN) bread-wheat population

	SDS-sedimentation (ml)	Alveograph		Mixograph tolerance score	Breadmaking	
		$W \times 10^{-4}$ J	P/G		Mixing time (min)	Loaf volume (ml)
Normal						
Mean	16·1	231	6·3	3·7	2·0	690
Range	10·0–24·0	59–466	2·4–11·2	1–5	0·8–5·0	530–905
IB/IR						
Mean	14·0	211	6·6	3·8	1·8	690
Range	9·5–19·5	97–378	3·0–12·2	1–6	0·8–3·2	510–830

influence some of the other rheological problems associated with the translocation derivatives. Martin and Stewart[4], however, could not relate Mixograph mixing properties with dough stickiness for 1B/1R wheats. The fact that some 1B/1R wheats of this study had good mixing tolerance indicates that rapid dough breakdown during mixing cannot be generally associated with the 1B/1R translocation.

The breadmaking dough mixing time in the normal wheats was from short (0·8 min) to long (5·0 min), while in the 1B/1R wheats it was from short (0·8 min) to medium-long (3·2 min); with both populations showing quite similar medium-long mixing times (Table I). Bread loaf volume data (Table I) show that the normal wheat population included advanced lines with larger loaf volume than those in the 1B/1R wheat population. The mean loaf volume for both populations was 690 ml, indicating that poor-to-fair breadmaking quality predominated among the genotypes included in the 22nd IBWSN.

Quality variability between normal and 1B/1R sister lines

Comparative studies have shown that some lines carrying the 1B/1R translocation have reduced quality compared with their normal recurrent parents[2,4]. This reduction in quality is thought to be associated with the presence of the 1RS chromosome in the wheat background. Consequently, we examined the quality characteristics of all the families (three) in the 22nd IBWSN consisting of normal and 1B/1R wheat sister lines (Table II). Quality variability occurred for all the parameters examined between sister lines in each family. The variation observed could not be attributed to differences in flour protein between sister lines. With respect to the SDS-sedimentation volume, in family A, 1B/1R lines had larger volumes than their normal sister lines. In contrast, families B and C showed the opposite with respect to this relationship (Table II). Thus, the reduction in SDS-sedimentation volume in 1B/1R derivatives, as observed earlier[2], does not occur in all cases, and therefore, in our opinion, cannot be exclusively attributable to the presence of the 1B/1R translocation.

TABLE II. Quality variation in normal and 1B/1R wheats (*Triticum aestivum* L.) from the same family

Cross name and pedigree	Flour protein (%)	SDS-sedimentation (ml)	Alveograph		Mixograph mixing tolerance score	Breadmaking	
			$W \times 10^{-4}$ J	P/G		Mixing time (min)	Loaf volume (ml)
		Family A					
BAU 'S'							
CM59123-3M-1Y-3M-1Y-2M-1Y-0M[a]	9·2	13·0	173	5·6	4	1·5	690
CM59123-3M-1Y-3M-1Y-3M-0Y[b]	9·3	15·0	215	4·9	3	1·8	705
CM59123-3M-1Y-3M-2Y-1M-0Y-29Y-0M[b]	9·8	19·5	268	4·5	4	1·5	775
		Family B					
DWL5023/SNB 'S'//SNB 'S'							
CM84986-H-1M-2Y-4B-0Y[a]	9·8	13·0	162	3·6	2	1·8	630
CM84986-H-1M-2Y-5B-0Y[a]	10·0	13·5	167	3·5	2	1·5	755
CM84986-H-4M-3Y-1B-0Y[a]	9·2	16·0	245	9·1	4	2·2	630
CM84986-H-1M-3Y-2B-0Y[b]	9·7	9·5	99	4·1	2	1·2	600
CM84986-H-1M-3Y-3B-0Y[b]	10·0	10·5	105	3·4	2	1·2	640
CM84986-I-1M-1Y-3B-0Y[b]	8·0	12·5	250	12·4	5	2·7	590
		Family C					
DWL5023/3/JUP/FURY//SIS 'S'/4/SERI							
CM84987-C-2M-3Y-1B-0Y[a]	9·5	14·0	197	9·4	5	2·7	630
CM84987-I-7M-1Y-5B-0Y[a]	9·4	12·0	156	5·6	3	1·4	680
CM84987-I-7M-1Y-1B-0Y[b]	7·6	10·5	181	8·8	4	1·7	640
CM84987-I-7M-1Y-3B-0Y[b]	9·2	11·0	100	6·2	3	1·4	625
CM84987-I-7M-1Y-10B-0Y[b]	9·3	10·5	129	5·9	2	1·5	670

[a] Normal.
[b] 1B/1R translocation.

In family A, the Alveograph *W* value for the normal line was smaller than that for its 1B/1R sister lines; in family B, one 1B/1R line showed a larger *W* value than its normal counterparts; in family C, one 1B/1R line had a larger *W* value than one of the normal sister lines (Table II). The *P/G* value is indicative of the degree of tenacity and extensibility of the doughs. In all families, the normal lines had a higher degree of tenacity than at least one of its 1B/1R sister lines (Table II). Dhaliwal *et al.*[2], using the Extensigraph, observed that resistance and extensibility were reduced in 1B/1R derivatives compared with their normal recurrent parents. A similar situation could not be observed in this work with respect to dough viscoelastic properties as measured with the Alveograph. Rather, it was found that variations in strength and tenacity/extensibility could not be associated with the presence or absence of the 1B/1R translocation.

With regard to Mixograph mixing tolerance, only in family C did one of the normal lines have a mixing tolerance score greater than any of its sister lines; all three families had at least one 1B/1R line with a mixing tolerance score equal to or greater than that of one of their corresponding normal sister lines (Table II), suggesting that the presence of the 1B/1R chromosome did not affect mixing properties for the samples studied. A similar conclusion was reached by Martin and Stewart[4], who examined the mixing properties of an Australian variety and its 1B/1R derivative.

The breadmaking mixing time of the normal line in family A was equal or shorter (1·5 min) than those of its 1B/1R sister lines (1·5, 1·8 min); in family B, all the normal lines had shorter mixing times (1·5–2·2 min) than one of its 1B/1R sister lines (2·7 min); and in family C, one of the normal lines had equal or shorter mixing time than any of its 1B/1R sister lines (Table II). Dhaliwal *et al.*[2] found that 1B/1R wheat derivatives had shorter Mixograph mixing times than their normal recurrent parents, while Martin and Stewart[4], comparing one 1B/1R line with its normal parent, found that, in the Mixograph, the 1B/1R derivative had a shorter mixing time than the normal parent, whereas in the Farinograph the mixing times were the same. This variation in the influence of the 1B/1R translocation on mixing time could be due to the differences in dough mixing action and mixing speed that exist between the Mixograph and Farinograph. In general, however, our results indicate that variation in dough mixing time was not associated with the 1B/1R translocation. Variation in bread loaf volume between normal and 1B/1R sister lines observed in all families (Table II) also could not be attributed to the presence of the 1B/1R translocation, as concluded previously[2,4].

Dough stickiness in 1B/1R wheats

Dough stickiness has been one of the principal defects associated with 1B/1R wheats. Two Australian 1B/1R wheats (QT-2870 and SUN-89D) show excessive dough stickiness[2,4]. These cultivars, as well as three commercial 1B/1R Mexican wheats, were compared with respect to their baking quality characteristics, giving special attention to dough properties after mixing. The doughs of Genaro 81 and Seri 82 were very sticky and slightly sticky, respectively, while the others did not show this dough defect (Table III). The wheat varieties Seri 82, Genaro 81 and SUN-89D were good, while the cultivars Glennson 81 and QT-2870 were very good, for bread loaf volume (Table III).

TABLE III. Quality characteristics of Mexican and Australian 1B/1R translocation wheat *Triticum aestivum* L. cultivars

Cultivar	Flour protein (%)[a]	Mixograph mixing tolerance score	Breadmaking: Mixing time (min)	Breadmaking: Dough character[b]	Breadmaking: Loaf volume (ml)
Mexican					
Seri 82	10·2	3	1·8	SS	820
Genaro 81	10·8	3	1·7	S	750
Glennson 81	11·3	4	2·5	NS	905
Australian					
QT-2870	12·2	2	1·9	NS	905
SUN-89D	11·5	2	1·7	NS	855

[a] 14% (m.b.).
[b] SS, slightly sticky; S, sticky; NS, non-sticky.

Conclusion

The results of this study indicate that 1B/1R wheats with good quality traits can be obtained. Additionally, we could not associate the presence of the 1RS rye chromosome in the bread wheat background with the variations in dough viscoelasticity, mixing and baking properties. Therefore, to demonstrate whether or not the 1B/1R translocation is a major factor responsible for reduced quality properties and dough stickiness, it is nec sary to analyse near-isogenic lines with and without the 1B/1R translocation. Weak to medium-strong gluten types predominated in the population evaluated. The explanation for this is that there is generally an inverse relationship between grain yield and grain protein quantity, and consequently breadmaking quality[11]. The lines included here were selected primarily for high yield and other agronomic traits and not for breadmaking quality. Crosses involving high yielding 1B/1R wheats and good breakmaking wheats should result in new lines carrying the translocation as well as improved breadmaking character, given that selection for quality is integrated with the breeding activities.

Dough stickiness could not be detected in the Australian cultivars QT-2870 and SUN-89D that were reported[2,4] to have this defect, a difference presumably attributable to the fact that assessment of dough stickiness is rather complex under medium-speed dough mixing conditions, or that QT-2870 and SUN-89D do not show stickiness under the growing conditions of northwestern Mexico. The dough stickiness problem observed for some 1B/1R wheats seems to be an attribute restricted mainly to the high-speed mixing conditions characteristic of some modern breadmaking processes. Although our 1B/1R wheats are not characterized by having the type of quality required for the production of bread under modern high-speed, intense dough mixing processes, many of these wheats fulfill the baking requirements for bread types and breadmaking procedures that predominate in a majority of the countries utilizing CIMMYT bread wheat germplasm.

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