NOTE

GRAIN QUALITY

Effect on Flour Quality from Inclusion of the *Hordeum chilense* Genome into the Genetic Background of Wheat[1]

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Cereal Chem. 71(5):517–519

ABSTRACT

Hordeum chilense Roem. et Schulz. is a South American wild barley that has been used for the attainment of amphiploids with durum and bread wheats. These amphiploids, called tritordeums (×*Tritordeum* Ascherson et Graebner), have shown unique agronomic characteristics and potential breadmaking quality. The *H. chilense* genome in durum and bread wheats was studied in six durum and six bread wheats and in the hexa- and octoploid tritordeum lines derived from them. In general, the grain quality characteristics of tritordeums were inferior to those of the wheat parents. However, both hexa- and octoploid tritordeums exhibited flour quality characteristics that were similar to those of bread wheat but not to those of durum wheat. The effects of the H^{ch} genome were greater in the absence of the D genome.

Tritordeum (×*Tritordeum* Ascherson et Graebner) is the amphiploid derived from the cross between a South American wild barley (*Hordeum chilense* Roem. et Schulz.) and wheat. This amphiploid was obtained in the hexaploid form (*H. chilense* × *Triticum turgidum* conv. *durum* Desf. em. M.K.) for the first time in 1979 (Martin and Sánchez-Monge Laguna 1982). Before the production of hexaploid tritordeum, a partially fertile octoploid form had been obtained from the cross involving *H. chilense* and bread wheat (*T. aestivum* L. em. Thell, cv. Chinese Spring) (Martin and Chapman 1977). Later, new octoploid fertile amphiploids were obtained with other bread wheat cultivars, resulting in better agronomic characteristics (Martin 1988). Cubero et al (1986) and Martin (1988) determined that both tritordeum forms could be used as protein source crops. Subsequent studies have shown that the protein contents of tritordeum and wheat are not significantly different when their grain yields are similar (Ballesteros 1993).

Alvarez et al (1992) suggested that hexaploid tritordeum has some potential for breadmaking. The breadmaking characteristics of the amphiploid are associated with the variations in the endosperm storage proteins from *H. chilense* present in the amphiploid (Alvarez 1993, Alvarez et al 1993).

[1]Presented at the AACC 78th Annual Meeting, Miami Beach, FL, October 1993.
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The principal objective of the current work has been to study the effect of the *H. chilense* genome (H^{ch}) on quality characteristics of both durum and bread wheat genomes in tritordeum.

MATERIALS AND METHODS

Grain Samples

Twelve lines of primary tritordeum (six hexaploid and six octoploid) were analyzed, along with their respective wheat parents. These lines were obtained with different accessions of *H. chilense*. These materials were grown in the Guadalquivir River Valley, Córdoba, Spain, during 1989–90 in 6-m^2 plots distributed in a completely randomized design with two replicates.

Mean kernel weight was determined on 20 g of clear sample. Test weight (kg/hl) was measured using a 250-ml chondrometer.

Carotene, Protein, and Sodium Dodecyl Sulfate Sedimentation

Whole meal flour was analyzed for all traits. Pigment content of flour (expressed as parts per million of carotene) was determined according to Williams et al (1988). Protein content of the flour was determined by the Kjeldahl method (%N × 5.7, db). Sodium dodecyl sulfate (SDS) sedimentation tests were performed as described by Peña et al (1990), using a solution of 2% SDS. A quality index was determined from the relationship between the SDS-sedimentation volume and protein content (Halverson and Zeleny 1988).

Statistical Analysis

Data were statistically analyzed by an analysis of variance. The least significant difference among species and within species were determined according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Differences between species and within species for the six quality traits were highly significant (Table I). The coefficient of variation was low for all traits except carotene content.

Kernel weight and test weight data are presented in Table II. As expected, the typically flat and oblong kernels of the tritordeums weighed considerably less than those of bread and durum wheats. These results are similar to the findings of Cubero et al (1986). Test weights of tritordeums were also lower than those of the wheats. The differences between the hexaploid tritordeums (mean = 74.9 kg/hl) and their parents (mean = 85.5 kg/hl) were higher than the differences between the octoploid tritordeums (mean = 73.7 kg/hl) and their parents (mean = 80.5 kg/hl).

Cubero et al (1986) reported high protein content in the grain of the first hexaploid tritordeums. In this study, only one line of hexaploid tritordeum ([H-13/T-54]) had a high value (18.3%), although some lines of hexaploid ([H-57/T-61] and [H-12/T-103]) and octoploid ([H-11/T-26] and [H-46/T-90]) tritordeums had values higher than 14%. In general, the rest of tritordeum lines had values similar to those of the corresponding durum and bread wheat parents.

For SDS-sedimentation volume, the hexaploid tritordeums had values considerably higher (mean = 11.2 ml) than those of their durum wheat parents (mean = 5.3 ml). These differences were less marked in the case of the octoploid tritordeum (mean = 10.5 ml) than they were in the parents (mean = 8.5 ml). Because protein content had a great influence on SDS-sedimentation volume, the quality index obtained by dividing the value for SDS-sedimentation volume by protein content (Halverson and Zeleny 1988) was calculated for a better evaluation of protein quality. For this index, the octoploid tritordeums exhibited the highest values (mean = 0.79), followed by the bread wheat (mean = 0.75), hexaploid tritordeums (mean = 0.71), and durum wheat (mean = 0.47). Two lines of octoploid tritordeum had SDS-

TABLE I
Mean Squares from the Analysis of Variance for Six Traits

Source of Variation	df[a]	Test Weight	Kernel Weight	Protein Content	SDS-Sedimentation[b] Volume	Quality Index	Carotene Content
Species	3	719.69***[c]	2940.29***	43.89***	167.64***	0.48***	194.24***
Genotype (species)	20	39.61***	69.24**	5.10***	14.01***	0.06***	6.81***
Error	24	2.76	24.46	0.88	1.39	0.008	1.33
CV %[d]	...	1.17	2.41	0.31	3.15	3.05	10.08

[a]Degrees of freedom.
[b]Sodium dodecyl sulfate.
[c]**, *** = significant at the 99 and 99.9% levels, respectively.
[d]Coefficient of variation.

TABLE II
Quality Characteristics of the Durum and Bread Wheat Parent Lines and Corresponding Tritordeums

	Test Weight (kg/hl)	Kernel Weight (mg)	Protein Content (%)	SDS-Sedimentation[a] Volume (ml)	Quality Index Ratio	Carotene Content (ppm)
Durum wheat[b]						
T-54	83.6 c[c]	55.1 ab	12.5 a	5.4 a	0.43 b	5.1 ab
T-61	84.3 c	49.1 b	10.7 b	5.4 a	0.50 a	6.0 a
T-71	85.4 bc	49.2 b	11.6 ab	5.5 a	0.48 ab	5.1 ab
T-91	84.1 c	54.9 ab	10.5 b	5.4 a	0.51 a	3.8 cd
T-102	88.4 a	51.9 b	11.0 ab	5.0 b	0.45 ab	4.4 bc
T-103	87.2 ab	59.5 a	11.0 ab	5.0 b	0.45 ab	3.3 d
Mean (n = 6)	85.5 A	53.3 A	11.2 D	5.3 D	0.47 D	4.6 C
Hexaploid tritordeum						
[H-13/T-54]	72.0 c	33.0 a	18.3 a	13.8 b	0.75 b	10.6 ab
[H-61/T-102]	71.1 c	26.4 c	13.3 d	9.1 cd	0.68 c	8.8 bc
[H-57/T-61]	74.2 b	32.1 ab	15.7 b	15.9 a	1.01 a	8.6 bc
[H-12/T-103]	79.3 a	28.9 bc	15.8 b	10.0 c	0.63 cd	12.4 a
[H-8/T-71]	77.5 a	33.8 a	14.0 c	8.5 d	0.61 d	7.4 c
[H-74/T-71]	75.5 b	33.8 a	12.5 c	9.9 c	0.79 b	11.0 a
Mean (n = 6)	74.9 C	31.3 C	14.8 A	11.2 A	0.75 B	9.8 A
Bread wheat						
T-20	84.0 b	34.9 b	11.3 cb	8.8 b	0.77 a	3.2 ab
T-26	77.1 d	34.5 b	11.9 c	7.4 c	0.62 bc	3.9 ab
T-79	86.1 a	33.9 b	10.8 c	8.4 bc	0.77 a	3.4 ab
T-86	76.0 d	24.2 c	12.9 a	8.9 ab	0.68 b	4.1 ab
T-90	79.7 c	41.4 a	13.2 a	8.0 bc	0.61 c	4.3 a
T-92	82.4 b	39.9 a	12.6 a	9.9 a	0.78 a	3.1 b
Mean (n = 6)	80.5 B	34.8 B	12.1 C	8.5 C	0.71 C	3.9 D
Octoploid tritordeum						
[H-7/T-20]	74.8 b	28.5 bc	12.4 cd	8.8 c	0.70 c	7.6 b
[H-11/T-26]	69.0 c	27.2 a	14.8 a	7.1 d	0.48 d	5.6 c
[H-17/T-79]	76.2 ab	31.6 ab	11.7 d	10.4 b	0.88 ab	8.8 a
[H-56/T-92]	70.5 c	26.3 c	13.2 b	12.4 a	0.94 a	9.9 a
[H-46/T-90]	76.9 a	33.0 a	14.9 a	11.8 ab	0.79 bc	7.5 b
[H-17/T-86]	74.8 b	27.0 c	13.1 bc	12.4 a	0.95 a	7.2 b
Mean (n = 6)	73.7 D	28.9 D	13.3 B	10.5 B	0.79 A	7.8 B

[a]Sodium dodecyl sulfate.
[b]T = wheat; H = *Hordeum chilense*; and [H- /T-] = tritordeum.
[c]Means with the same letter are not significantly different. Capital and lower letters were used for species and genotypes within species comparisons, respectively.

sedimentation volumes and quality index values that were lower than ([H-11/T-26]) or similar to ([H-7/T-20]) the parents. In the case of [H-11/T-26], the quality index (0.48) was the lowest value of all tritordeums and similar to those of the durum wheats (0.47). The line of *H. chilense* (H-11) used in the synthesis of this amphiploid was also used in the cross HTC-227, which was evaluated by Alvarez (1993). He indicated that the H-11 had detrimental effects on quality characteristics in the tritordeum that were similar to that observed in this study.

Carotene contents in tritordeum flours were about two times greater than those of the wheat parent flours. For this trait, the hexaploid tritordeums exhibited the highest values (mean = 9.8 ppm), followed by the octoploid tritordeums (mean = 7.8 ppm) and the durum (mean = 4.6 ppm) and bread (mean = 3.9 ppm) wheats. The high carotene content gave the flours a strong yellowish tinge, which is not favored by Western consumers. However, there are changes in consumption patterns, and tritordeums could be used in the production of novel cereal-based foods.

The present study demonstrates that the tritordeum quality characteristics are similar to those of bread wheat, but different from those of durum wheat. The differences between the wheat parent and its derived tritordeum were more important in hexaploid than in octoploid tritordeum. In octoploid tritordeum, the presence of the D genome appeared to moderate the effects of H^{ch} genome, suggesting the possibility of an interaction between the D and H^{ch} genomes. Undoubtedly, the genetic relationships between both genomes deserves to be investigated further. Because *H. chilense* has shown few detrimental effects on breadmaking quality, it could be useful in transferring some interesting characteristics to wheat (Pearson-Dedryver et al 1990; Rubiales et al 1992, 1993) and, at the same time, serve to widen the genetic background of cereals.

ACKNOWLEDGMENTS

This work was supported by grant AGR91-0844 of the Comisión Interministerial de Ciencia y Tecnología (CICYT) of Spain. The first author thanks the FPI programme of the Spanish MEC for a predoctoral fellowship. We want to thank to A. Martin from CSIC (Spain) for the seed materials.

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[Received February 22, 1994. Accepted June 1, 1994.]