EFFECT OF 1B/1R TRANSLOCATION ON PROTEIN COMPLEX AND RELATIVE VISCOSITY OF WHEAT GRAIN WITH EMPHASIS ON FEEDING VALUE*

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The research was aimed at a 1B/1R translocation effect on selected grain parameters of wheat double haploid (DH) lines. A set of DH wheat lines selected according to the presence (8 lines) or absence (10 lines) of 1B/1R translocation was grown for 3 years. There were tested following parameters of grain: content of crude protein, content of 9 selected essential amino acids, calculated essential amino acid index (EAAI), protein fractions content (albumins + globulins and their proportion in crude protein; gliadins and sum of glutenins) and relative viscosity. There were found out higher genotypic dependence of albumins+globulins content and relative viscosity in comparison with content of crude protein, gliadins, glutenins and amino acids. There was also confirmed high positive correlation among most of essential amino acids, crude- and storage proteins (gliadins and glutenins) and their negative correlation to proportion of albumins+globulins in crude protein. The parameter EAAI did not confirm significant dependence on higher variable storage proteins. Mutual relations between relative viscosity and content of albumins+globulins as well as their correlations to other tested parameters were low or indifferent. The presence of 1B/1R translocation significantly increased content of crude protein, albumins + globulins, gliadins and values of relative viscosity. Its significant influence was found out in the content increasing of isoleucine and arginine.

wheat; 1B/1R translocation; protein composition; essential amino acids; relative viscosity

INTRODUCTION

Kasarda et al. (1976) classified wheat soluble proteins in dilute salt solutions (albumins and globulins) as cytoplasmatic proteins. These "soluble" proteins differ distinctly in their amino acid (AA) composition from the gluten storage proteins (gliadins and glutenins) and are nutritionally important because about 45% of total AAs are created by essential AAs. Gluten and its fractions (gliadins and glutenins) are nutritionally inferior to soluble proteins, primarily because of extremely low lysine scores (Chung, Pomeranz, 1985).

From this point of view, the breeding of feed cereals is mainly focused on modification of low-quality protein fractions (gliadins and glutenins), increasing of limited essential amino acids and total digestibility of fodder (Čermák, 2002).

The short arm of rye (*Secale cereale* L.) chromosome 1R is one of the most widely utilized sources of alien chromatin in wheat breeding (Baum, Appels, 1991). Several hundred wheat (*Triticum aestivum* L.) cultivars are known to possess a 1BL/1RS translocated chromosome and many others will carry it unrecognized (Rabinovich, 1998). According to Garnsworthy and Wiseman (2000), the presence of 1B/1R translocation is characteristic for most feed wheat cultivars.

The effect of the chromosome arm 1RS on agronomic traits (higher yield and disease resistances) and the technological parameters of wheat have been the subject of numerous investigations, concerning its unfavorable effect on bread making quality (Bartoš, 1993; Graybosch, 2001). The main cause is probably the loss of the Glu-B3 encoded low molecular weight (LMW) glutenins and the Gli-B1 encoded gliadins with the exchange of the short arm of wheat chromosome 1B against the short arm of rye chromosome 1R. The primary result is a reduction in size and quality of the glutenin macropolymer. Moreover, the Sec-1locus on 1RS produces a massive amount of secalins with a high water binding capacity, which is probably one cause of the so-called 'sticky dough syndrome' of many 1RS-bearing wheat cultivars (Martin, Stewart, 1990; Zeller et al., 1982). On the other hand, the effect of the 1B/1R translocation on nutritional implications for animals or its influence on amino acids and protein fractions content have been still seldom published.

Genetic factors affecting nutritional value cannot be evaluated by simply comparing named varieties. This is because any two named varieties may be distantly or closely related in a generally unpredictable way and name alone would give no indication of the genetic relationship. Thus, programmes based on varietal names are of little value in assessing reasons for variability in nutritional value of wheat. The emergence of near-isogenic lines, developed through conventional plant breeding techniques, represents a major development as nutritional implications of specific characteristics may now be investigated against a comparatively uniform genetic background (Garnsworthy, Wiseman, 2000). In our case, the specific

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effect of translocation on nitrogen complex of common wheat can be examined without possible confounding effects of other factors.

Our research was aimed at a 1B/1R translocation effect on selected grain parameters of wheat DH (double haploid) lines. The emphasis was put on variability of essential amino acids, protein fractions and relative viscosity as potential criteria of feeding value and characterizing their mutual relations. This activity represents part of wider study focused on specification of characters as possible criteria of wheat feeding value that will continue by final feeding tests.

MATERIAL AND METHODS

A set of 80 doubled haploid (DH) wheat lines was developed by Ladislav Kučera, from the F_1 generation after crossing of wheat cultivar Šárka with advanced line UH 410 (donor of 1B/1R translocation) in the Department of Molecular Biology of CRI Prague. Our previous three-year average evaluation of three important technological parameters (crude protein content, wet gluten and Zeleny sedimentation test) showed close similarity between both parental genotypes UH 410 and cultivar Šárka (Dvořáček et al., 2006). UH 410 with low agronomic characters was only used for introduction of 1B/1R translocation into DH lines.

A set of selected 18 DH wheat lines with a higher agronomical potential and according to the presence or absence of allele Gli 1B3 characterising 1B/1R translocation was subsequently divided into two numerically comparable sub-sets (8 lines with 1B/1R translocation and 10 lines without 1B/1R translocation).

Each selected DH line was genetically evaluated by means of gliadin alleles for confirmation of lines with/without 1B/1R translocation. Gliadin blocks were identified according to Metakovsky (1991) and Šašek, Černý (2000) in conditions of Acid-PAGE (ČSN 46 1085-2, 1998).

The lines and two check cultivars Šárka and Nela (with expected contrast results in final feeding tests) have been multiplied in large plot experiments with rates from 0.3 ha (2004) to 0.7 ha (2006) in the locality Kralovice for 3 years (2004–2006). Fertilization was applied according to soil analysis in the nitrogen range of 120–135 kg of and 50–60 kg of P_2O_5.

The following grain parameters were tested: content of crude protein – Kjeldahl method (ČSN 56 0512-12); content of selected 9 essential amino acids and calculation of EAAI (essential amino acid index) by Oser (1951), protein fractions content (albumins + globulins and their proportion in crude protein; gliadins) – modified Osborne's method according to Dvořáček et al. (2001). Content of sum glutenins was calculated as a difference between the content of crude protein and sum of albumins + globulins and gliadins. Relative viscosity was measured with a micro-viscosimeter Antón Paar according to Saulnier et al. (1994).

The software "Statistica 7.0 CZ" was used to test significant differences by ANOVA/MANOVA, Tukey HSD test, correlation matrix and PCA classified analysis.

RESULTS AND DISCUSSION

Three years average contents of essential amino acids, total essential amino acids index (EAAI), nitrogen content and composition of protein fractions are described in Tables 1 and 2. According to our presumption, differences of tested parameters among DH lines were not too high and wider spectra of statistical significant differences was only found in content of albumins + globulins fraction and its proportion in crude protein (Table 2). It corresponds with the tested set of DH lines which have closer genetic relation than e.g. set of commercial varieties. In spite of lower differences among average values of parameters there were identified more extreme results in certain lines. Such case was line 119 in 2004, which showed significantly higher content of crude protein (14.15%), content of gliadins (4.72%) and with the exception of methionine content, higher content of all tested amino acids (e.g. THR – 5.48 $g.kg^{-1}$, Val – 8,32 $g.kg^{-1}$ and ILEU – 6,61 $g.kg^{-1}$). Significantly higher content (Table 1) of several amino acids (e.g. THR – 4.55 $g.kg^{-1}$, Val – 7.08 $g.kg^{-1}$ and AGR – 9.26 $g.kg^{-1}$) was detected in DH line 163 in 2005 as well. Although these both lines did not confirm these characteristics in other tested years, their average values of the above mentioned parameters were higher in comparison with other DH lines. Values of EAAI were not significantly different among varieties because of their high variability among tested years and corresponded with average values published for wheat (Sarwar, McLaughlan, 1981).

In spite of this fact, higher values EAAI were found in 2 lines with 1B/1R translocation 119 and 139 and line 136 without 1B/1R translocation. In case of both translocated lines, there was not confirmed often mentioned deteriorate effect of higher storage proteins content (gliadins and glutenins) on chemical scores of essential amino acids (mainly lysine) (Chung, Pomeranz. 1985). It is probable that 1B/1R translocation (producing massive amount of secalins) positively influenced contents of essential amino acids in storage protein fractions (especially lysine). Significant higher lysine content in rye grain in comparison with wheat was confirmed by Eggum (1985).

The year comparison of all tested parameters reflected much higher influence than DH line effect. Generally significantly higher content of essential amino acids, content of albumins + globulins fraction (3.73%), value of EAAI and relatively lower ratio of sum of glutenins (5.59%) were obtained in 2005 opposite to the year 2006.

The lowest contents of protein and protein fractions were found out in 2004, although average content of essential amino acids was comparable with the year 2006. Significantly lower contents of crude protein and its fractions in 2004 were probably influenced by colder weather conditions in May and June, which slowed down protein

Table 1. Three years' average content of essential amino acids and values of EAAI (Essential Amino Acids Index) in grains of wheat DH lines (2004–2006)

Line / parametr	1B/1R transl.	EAAI (%)	THR ($g.kg^{-1}$)	VAL ($g.kg^{-1}$)	MET ($g.kg^{-1}$)	ILE ($g.kg^{-1}$)	LEU ($g.kg^{-1}$)	PHE ($g.kg^{-1}$)	LYS ($g.kg^{-1}$)	HIS ($g.kg^{-1}$)	ARG ($g.kg^{-1}$)
110	Y	49.20a	2.90a	4.00a	1.92a	3.63ab	7.07a	4.31a	2.91a	2.46a	5.15a
112	Y	50.48a	2.74a	4.12a	1.85a	3.44ab	6.87a	4.50a	2.87a	2.30a	4.96a
119	Y	58.50a	3.98a	6.20a	2.11a	5.09b	9.28a	6.53a	3.40a	3.15a	6.85a
121	N	53.11a	2.95a	4.86a	1.93a	3.68ab	7.66a	4.67a	2.97a	2.45a	5.18a
126	Y	55.33a	3.12a	5.18a	1.96a	3.83ab	7.68a	5.13a	3.20a	2.49a	6.49a
131	N	50.88a	2.54a	4.33a	1.72a	3.20a	6.59a	4.17a	2.90a	2.20a	4.71a
136	N	60.21a	3.24a	5.02a	2.07a	3.90ab	7.68a	5.16a	3.17a	2.85a	5.74a
139	Y	59.75a	3.36a	5.10a	2.13a	4.37ab	8.30a	5.50a	3.32a	2.96a	5.91a
144	N	51.31a	3.09a	4.64a	2.07a	3.73ab	7.35a	5.05a	2.98a	2.82a	5.68a
146	N	53.56a	3.28a	4.76a	2.04a	4.03ab	8.01a	5.44a	3.04a	2.78a	5.58a
157	Y	46.11a	2.54a	3.79a	1.77a	3.22a	6.28a	4.20a	2.57a	2.23a	4.62a
159	N	50.08a	2.71a	3.97a	1.66a	3.37ab	6.65a	4.63a	2.61a	2.21a	4.68a
163	N	52.55a	3.03a	4.74a	1.78a	3.86ab	7.59a	5.50a	2.85a	2.44a	5.35a
164	Y	55.18a	3.30a	5.45a	1.87a	4.49ab	9.01a	6.95a	3.21a	2.91a	6.73a
167	N	48.48a	2.69a	3.96a	1.76a	3.24a	6.44a	4.89a	2.47a	2.09a	4.73a
171	N	48.57a	3.12a	4.13a	1.62a	3.41ab	7.03a	4.74a	3.04a	2.54a	4.81a
174	Y	52.22a	3.15a	4.35a	1.77a	3.54ab	6.93a	4.62a	3.27a	2.66a	5.32a
176	N	53.37a	2.84a	4.14a	1.66a	3.31ab	6.77a	4.36a	2.94a	2.44a	4.96a
Nela	N	54.29a	2.95a	4.12a	1.79a	3.36ab	6.78a	4.51a	2.85a	2.49a	4.92a
Šárka	N	53.37a	2.86a	4.26a	1.73a	3.51ab	7.08a	4.78a	3.18a	2.50a	5.31a
Transl.	Y	53.35a	3.14a	4.77a	1.92a	3.95b	7.68a	5.22a	3.10a	2.65a	5.75b
Transl.	N	52.48a	2.94a	4.41a	1.82a	3.55a	7.14a	4.83a	2.92a	2.48a	5.14a
Year	2004	43.73a	2.85a	4.29a	1.71a	3.39a	6.54a	4.43a	2.67a	2.17a	4.29a
	2005	66.83b	3.56b	5.27b	2.28b	4.01b	8.48b	5.72b	3.50b	2.81b	6.92b
	2006	47.93a	2.65a	4.11a	1.60a	3.74ab	7.04a	4.80a	2.80a	2.67b	4.94a

Values of parameters marked by the same letters are not significantly different at $P \leq 0.05$

synthesis in grain. Generally known fact of positive influence of dry and worm weather on biosynthesis of grain storage protein mentioned e.g. Prugar and Hraška (1986).

Variability of protein composition is pronounced in content of albumins + globulins and glutenins between 2005 and 2006. It does not seem probable that differences in weather conditions that were only found out in the beginning of vegetation would be the main course of the protein variability between the years.

Relative viscosity showed the highest stability among tested years and significant differences among DH lines also confirmed closer genetic relation of this parameter. The statistically lowest value of relative viscosity was found in wheat line 159 (1.72), on the contrary lines 110, 164 and 171 showed significantly highest values (2.37, 2.35 and 2.31, respectively). These results indicated strong genotypic relationship of relative viscosity in common wheat and they are in coincidence with Martinant et al. (1998). Closer genetic relations are evident in the above mentioned albumins + globulins fraction. The significantly highest content and proportion of albumins + globulins was found in wheat line 174 (4.00% and 30.81%, respectively) and the lowest value was detected in line 163 (3.03% and 22.40%, respectively). Stehno et al. (2006) described exceptionally high significant dependency of albumins + globulins content on wheat genotypes as well.

Our attention was especially focused on the effect of 1B/1R translocation and on mutual relations among tested parameters. The presence of 1B/1R translocation in DH lines significantly increased content of crude protein, content and proportion of albumins + globulins as well as content of gliadins and values of relative viscosity. DH lines with 1B/1R translocation generally showed higher content of all tested essential amino acids and two of which (isoleucine and arginine) confirmed significantly higher content in dry matter. The 1B/1R translocation effect on a significantly higher content of crude protein and no significant differences in relative viscosity were confirmed by Amiour et al. (2002). Subda et al. (1997) obtained a higher content of albumin fractions in lines with 1B/1R translocation as well.

Correlation analyses of tested parameters showed in the set of evaluated lines positive middle strong relationships among crude protein and essential amino acids except lysine (r = 0.25) and arginine (r = 0.31) (Table 3). Similar correlation coefficient was found among content

Table 2. Three years' average values of protein composition and relative viscosity in grains of wheat DH lines (2004–2006)

Line /parametr	1B/1R translocation	Crude protein (%)	Alb. + glob. (%)	Gliadins (%)	Sum of Glutenins (%)	Rel. Viscosity	Proportion of Alb. + glob. in crude protein (%)
110	Y	13.36ab	3.87cd	4.22bc	5.26ab	2.37c	29.18cde
112	Y	12.39ab	3.77bcd	3.68abc	4.94a	2.16ab	30.44e
119	Y	14.30b	3.66bcd	4.69c	5.96abc	2.14ab	25.57abcd
121	N	12.89ab	3.25ab	3.67abc	5.97abc	2.10ab	25.37abcd
126	Y	13.15ab	3.87cd	3.72abc	5.55abc	2.24c	29.44de
131	N	11.69a	3.19ab	2.96a	5.54abc	2.17ab	27.34bcde
136	N	12.36ab	3.24ab	3.61abc	5.51abc	2.15ab	26.19abcde
139	Y	13.59ab	3.60abcd	4.10ab	5.88abc	2.08ab	26.63abcde
144	N	13.61ab	3.36abc	4.00abc	6.24abc	2.06ab	24.60abc
146	N	13.32ab	3.24ab	4.07abc	6.02abc	2.18ab	24.33ab
157	Y	12.66ab	3.32abc	3.85abc	5.50abc	2.30c	26.36abcde
159	N	12.92ab	3.20ab	3.84abc	5.88abc	1.72a	24.99abcd
163	N	13.60ab	3.03a	4.11bc	6.46bc	1.97ab	22.40a
164	Y	14.54b	3.61abcd	4.30bc	6.63c	2.35c	24.87abcd
167	N	12.74ab	3.52abcd	3.62abc	5.60abc	2.18ab	27.60bcde
171	N	13.40ab	3.25ab	4.16bc	5.99abc	2.31c	24.24ab
174	Y	13.06ab	4.00d	3.60abc	5.46abc	2.16ab	30.81e
176	N	12.41ab	3.26ab	3.65abc	5.49abc	2.15ab	26.34abcde
Nela-check var.	N	12.87ab	3.17ab	3.93abc	5.77abc	2.22a	24.79abc
Šárka-check var.	N	12.82ab	3.54abcd	3.54ab	5.74abc	2.19ab	27.89bcde
Translocation Y	Y	13.38b	3.71b	4.02b	5.65a	2.23b	27.91b
Translocation N	N	12.89a	3.27a	3.76a	5.85a	2.12a	25.51a
Year	2004	11.93a	3.22a	3.39a	5.32a	2.06a	27.05a
	2005	13.44b	3.73b	4.12b	5.59a	1.94a	27.86a
	2006	13.88b	3.40c	4.09b	6.39b	2.49b	24.49b

Values of parameters marked by the same letters are not significantly different at $P \leq 0.05$

of amino acids and both storage protein fraction of gluten (gliadins and sum of glutenins) including lower correlations in case of arginine and lysine.

Relative viscosity showed indifferent relations to other parameters except its significant correlation value to content of arginine (0.4). Higher mutual correlation coefficients among storage proteins and logically among amino acids result from their mutual common composition, because main part of grain crude protein is incorporated into wheat gluten in the form of both storage protein fractions – gliadins and glutenins (Pomeranz et al., 1988).

Content of albumins + globulins fraction indicated only lower positive correlations to tested amino acids and their content changes did not play important role for increasing or decreasing essential amino acids and EAAI in this set of DH lines (Tables 1 and 2). On the contrary, proportion of albumins + globulins in crude protein was in middle-strong negative correlation to content of amino acids, once again with exception of lysine and arginine, which had indifferent relations too. The higher effect of crude and storage protein on content increasing of essential amino acids was caused by lower variability of albumins + globulins complex and antagonistic relations among albumins + globulins and storage protein fractions evoked by their time-different synthesis (Prugar, Hraška, 1986).

In spite of increasing of AA contents with increasing of crude protein and gluten fractions and decreasing of their contents with the growing of albumins + globulins proportion, the calculated EAAI did not confirm significant dependence on changes of these characteristics. Nevertheless, it is not possible to ignore consequence among significantly higher content of albumins + globulins fraction and significantly higher value of EAAI and content of the most limited AAs in 2005. This fraction is characterized as the most biological value part of wheat protein (Mittag et al., 2004) and will play important role from point of nutritive and feeding value respectively. Generally lower enzymatic digestibility of prolamins, their low biological value (Steenson, Sathe, 1995; Eggum, 1985) and their confirmed high positive relations to crude protein should lead in wheat breeding for higher feeding value to materials selection with lower content of crude protein and prolamins.

Potential effect of 1B/1R translocation on final feeding value seems to be controversial. Increasing of albumins + globulins including their proportion in crude protein is

Table 3. Correlation coefficients among tested parameters of DH lines (2004–2006)

	EAAI	THR	VAL	MET	ILE	LEU	PHE	LYS	HIS	ARG	Crude protein	Alb. + glo.	Gli.	Sum of Glu.	Rel. Viskosity	Proportion of alb. + glob.
EAAI	1.00															
THR	**0.68**	1.00														
VAL	**0.70**	**0.87**	1.00													
MET	**0.41**	**0.47**	**0.60**	1.00												
ILE	**0.57**	**0.89**	**0.94**	**0.61**	1.00											
LEU	**0.52**	**0.88**	**0.92**	**0.54**	**0.97**	1.00										
PHE	**0.55**	**0.85**	**0.90**	**0.49**	**0.93**	**0.92**	1.00									
LYS	**0.67**	**0.78**	**0.67**	**0.35**	**0.63**	**0.67**	**0.55**	1.00								
HIS	**0.59**	**0.90**	**0.84**	**0.63**	**0.90**	**0.89**	**0.82**	**0.76**	1.00							
ARG	**0.83**	**0.74**	**0.79**	**0.45**	**0.66**	**0.60**	**0.68**	**0.67**	**0.62**	1.00						
Crude protein	0.21	**0.56**	**0.60**	**0.62**	**0.72**	**0.68**	**0.71**	0.25	**0.66**	0.31	1.00					
Alb. + glob.	0.08	0.21	0.18	0.25	0.23	0.21	0.19	0.23	0.19	0.15	0.33	1.00				
Gli	0.14	**0.57**	**0.53**	**0.54**	**0.69**	**0.66**	**0.66**	0.23	**0.65**	0.21	**0.91**	0.30	1.00			
Sum of Glu.	0.24	**0.45**	**0.56**	**0.52**	**0.61**	**0.57**	**0.64**	0.16	**0.55**	0.33	**0.86**	–0.10	**0.66**	1.00		
Rel. Viskosity	0.32	0.12	0.08	–0.01	–0.01	–0.04	0.05	0.20	0.03	**0.40**	–0.05	0.09	–0.11	–0.04	1.00	
Proportion of alb. + glob.	–0.09	–0.29	**–0.35**	–0.33	**–0.42**	**–0.40**	**–0.44**	–0.01	**–0.40**	–0.12	**–0.59**	**0.56**	**–0.55**	**–0.83**	0.14	1.00

Statistical significant correlations at $P \leq 0.05$ are boldly emphasized

nutritive favorable. On the other hand, its influence on higher content of prolamins and value of relative viscosity can deteriorate potential feeding value for certain farm animals. Rose (2003) also mentioned that comparisons of the nutritive value of cultivars with and without the translocated chromosome have given variable results for poultry feeding test and there is still no general evidence that presence of the 1B/1R chromosome is associated with nutrient availability.

CONCLUSIONS

There were found out higher genotypic dependence of albumins + globulins content and relative viscosity in comparison with content of crude protein, gliadins, glutenins and amino acids. There was also confirmed high positive correlation among most of essential amino acids, crude- and storage proteins (gliadins and glutenins) and their negative correlation to proportion of albumins + globulins in crude protein. Calculated parameter EAAI did not confirm significant dependence on higher variable gluten fractions.

Mutual relations between relative viscosity and content of albumins + globulins as well as their correlations to other tested parameters were low or indifferent. The presence of 1B/1R translocation significantly increased content of crude protein, albumins + globulins, gliadins and values of relative viscosity. Its significant influence was found out in content increasing of isoleucine and arginine as well.

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Vliv 1B/1R translokace na bílkovinný komplex pšeničného zrna a relativní viskozitu s ohledem na krmnou kvalitu.

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Výzkum byl zaměřen na vliv 1B/1R translokace na vybrané parametry zrna u dihaploidních (DH) linií pšenice. Soubor DH linií členěných podle přítomnosti (8 linií) či absence (10 linií) 1B/1R byl pěstován po tři roky. Byly u něho hodnoceny následující charakteristiky zrna: obsah hrubých bílkovin, obsah devíti vybraných esenciálních aminokyselin, vypočtený index esenciálních aminokyselin (EAAI), obsah bílkovinných frakcí (albumino-globulinové frakce a její podíl v hrubých bílkovinách; gliadiny a suma gluteninů) a relativní viskozita. Byly zjištěny větší rozdíly mezi genotypy v obsahu albumino-globulinové frakce a v relativní viskozitě ve srovnání s obsahem hrubých bílkovin, gliadinů, gluteninů a aminokyselin. Byla potvrzena silná pozitivní korelace mezi obsahem většiny esenciálních aminokyselin a obsahem hrubých a zásobních bílkovin (gliadinů a gluteninů) a jejich negativní korelace k podílu albuminů a globulinů v hrubých bílkovinách. U EAAI nebyla zjištěna průkazná závislost na více variabilních zásobních bílkovinách. Vzájemné vztahy mezi relativní viskozitou a obsahem albuminů + globulinů i jejich korelace k dalším hodnoceným parametrům byly nízké nebo indiferentní. Přítomnost 1B/1R translokace průkazně zvyšovala obsah hrubých bílkovin, albuminů + globulinů, gliadinů a hodnotu relativní viskozity. Její průkazný vliv byl zaznamenán i v průkazném nárůstu obsahu izoleucinu a argininu.

pšenice; 1B/1R translokace; složení bílkovin; esenciální aminokyseliny; relativní viskozita

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