Variation in HMW glutenin subunits of different species of wheat

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ABSTRACT

Method ISTA SDS-PAGE was used for separation, detection and evaluation of high molecular weight glutenin subunits (HMW) in the different wheat species. The relation has been studied between the HMW glutenin subunit alleles and the bread-making quality of 25 world wheat cultivars and 21 regional varieties common wheat varieties (*Triticum aestivum* L.), 17 winter spelt wheat (*Triticum spelta* L.), 3 durum wheat cultivars (*Triticum durum* DESF.), 9 cultivars of *Triticum turgidum* L. and 5 cultivars of *Triticum polonicum* L. The highest frequency of occurrence of HMW glutenin subunits 2*, 13 + 16 and 5 + 10 were found in world wheat cultivars. In Slovak wheat varieties were analysed subunits 0, 7 + 9 and 5 + 10, 2 + 12. The HMW subunits 0, 7 + 8 with Glu-score 4 were determined in *Triticum durum* DESF. Three electrophoretical profile groups of different HMW glutenin subunits were found in *Triticum turgidum* L. and *Triticum polonicum* L. and six electrophoretical profile groups were determined in *Triticum spelta* L. The verified correlations between bread-making quality and specific HMW subunits of glutenin can be utilised by wheat breeders using SDS-PAGE of proteins as a screening test for the prediction of bread-making quality of wheat.

Keywords: *Triticum aestivum* L.; *Triticum durum* DESF.; *Triticum turgidum* L.; *Triticum polonicum* L.; *Triticum spelta* L.; HMW glutenin subunits; electrophoresis SDS-PAGE; SDS sedimentation test

The glutenin proteins of wheat, particularly the highly aggregative glutenin fraction (HMW) strongly influence the bread-making properties of flours. The HMW glutenin subunits are encoded by genes at three genetically unlinked loci Glu-A1, Glu-B1, and Glu-D1, located close to the centromere on the long arm of the homoeologous chromosomes 1A, 1B, and 1D, respectively. There is the significant relationship between the presence and the absence of some specific HMW glutenin subunits and the bread-making quality of wheat varieties (Payne and Lawrence 1983, Payne et al. 1987, Vlasák 1995, Šašek and Černý 1997). The most important subunits are 5 + 10 and 2 + 12, which are expressed from Glu-D1 loci. Method of SDS-PAGE is possible to apply for separation, detection and evaluation of high molecular weight glutenin subunits in wheat.

The aim of our present contribution was to determine the type of the HMW glutenin subunits and to calculate the Glu-score in the grain of different species of wheat – *Triticum aestivum* L., *Triticum spelta* L., *Triticum durum* DESF., *Triticum turgidum* L. and *Triticum polonicum* L.

MATERIAL AND METHODS

The relationship between the HMW glutenin subunit alleles and the bread-making quality of different wheat species has been studied. The winter wheats included 25 world wheat cultivars and 21 regional varieties common wheat varieties (*Triticum aestivum* L.), 17 winter spelt wheat (*Triticum spelta* L.), 3 durum wheat cultivars (*Triticum durum* DESF.), 9 cultivars of *Triticum turgidum* L. and 5 cultivars of *Triticum polonicum* L. which were obtained from the Slovak Republic Genbank and from the Czech Republic Genbank. The cultivars Neepawa, Chinese spring, and Marquist were used as standards.

For identification and characterisation of wheat varieties the standard vertical discontinuous electrophoretic reference method by ISTA organisation was applied (Wrigley 1992). Glutenin wheat proteins were extracted from individually ground kernels and separated on 10% polyacrylamide gels in the presence of SDS. The gels were stained with Coomassie Brilliant Blue solution and destained with de-ionized distilled water. The stained bands were qualified by scanning densitometry (LD-01 Instrument). The HMW subunits of glutenin were designated according to the numbering system of Payne and Lawrence (1983). SDS sedimentation test was determined by seditester LS 03.

RESULTS AND DISCUSSION

The storage proteins of hexaploid wheat are important nutritionally but, above all, because of the unique cohesive-elastic properties they bestow on doughs made from wheat flours. The HMW subunits of glutenin are considered to be the most important components with the respect to the baking quality. Correlations have been established between particular HMW glutenin subunits and bread-making quality of wheat (Payne et al. 1987, Černý and Šašek 1996, Kraic et al. 1997).

From the electrophoretic spectra the individual HMW glutenin subunits were determined and the so-called Glu-

Table 1. Variation in the individual HMW glutenin subunit alleles in world wheat cultivars

Cultivar	Country of origin	HMW subunit of loci			Glu-score	HMW: LMW	SDS-test (cm^3)
		Glu-A1	Glu-B1	Glu-D1			
Kosava	Yugoslavia	0	7 + 8	2 + 12	6	0.1	50
Turda	Rumania	2*	7 + 8	5 + 10	9	0.109	33
Fundulea	Rumania	0	7 + 8	2 + 12	6	0.110	43
Bezostaja	Russia	2*	7 + 9	5 + 10	9	0.226	52
F-122	China	2*	13 + 16	5 + 10	8	0.137	44
MV-14	Hungary	2*	13 + 16	4 + 12	5	0.123	39
MV-15	Hungary	2*	7 + 9	5 + 10	9	0.104	32
Recitál	France	2*	7 + 9	5 + 10	9	0.124	53
Delta	Poland	0	13 + 16	2 + 12	4	0.138	32
TAM-200	USA	2*	7 + 9	5 + 10	9	0.154	55
Madsen	USA	2*	13 + 16	5 + 10	8	0.113	36
Laurel	China	2*	7 + 8	5 + 10	10	0.110	56
SK-26	Yugoslavia	0	13 + 16	2 + 12	4	0.151	44
Jasen	Bulgaria	2*	7 + 9	5 + 10	9	0.139	50
Super X	Mexico	2*	17 + 18	5 + 10	10	0.148	58
MV-16-85	Hungary	2*	13 + 16	5 + 10	8	0.091	38
MV-08-85	Hungary	2*	7	5 + 10	8	0.102	30
NS-62-38	Yugoslavia	2*	13 + 16	5 + 10	8	0.166	69
NS-65-84	Yugoslavia	0	13 + 16	2 + 12	4	0.226	52
Utud G-12	Turkey	2*	17 + 18	5 + 10	10	0.134	69
Utud G-21	Turkey	2*	7 + 9	5 + 10	9	0.073	48
BAU-402	China	2*	13 + 16	5 + 10	8	0.120	45
Pobeda	Bulgaria	2*	7 + 8	5 + 10	10	0.208	69
Zlatostrul	Bulgaria	2*	13 + 16	5 + 10	8	0.116	53
Alba	Poland	2*	7 + 9	5 + 10	9	0.072	52
Average					7.6	0.130	47.7

score was calculated. The results of 25 world wheat cultivars showed in Table 1. the high frequency of occurence of HMW glutenin subunits with composition of 2* (80%), 13 + 16 (40%) and 5 + 10 (76%). The highest value of Glu-score (10) was achieved by the cultivars Laurel, Super X, Utud G-12 and Pobeda what indicates good bread-making cultivars. On the other hand three another cultivars (Delta, SK-26, NS-62-38) can be judged as weak quality genotypes because 0, 13 + 16, 2 + 12 HMW glutenin subunits composition and 4 Glu-score value were determined. The couple of subunits 13 + 16 with good bread-making quality were found in world collection in a higher frequency than in comparative common Slovak wheat varieties. The average Glu-score of 25 world wheat cultivars was 7.6.

The most common banding patterns in 21 Slovak wheat varieties (Table 2) were subunits „zero“ (86%) from the locus Glu-A1, subunits 7 + 9 (81%) from the locus Glu-B1 and subunits 5 + 10 (71%), 2 + 12 (29%) located on the locus Glu-D1. The highest Glu-score (9) was determined in the varieties Ilona with 2*, 7 + 9, 5 + 10 HMW glutenin subunits, Vlada and Regia with 1, 7 + 9, 5 + 10 HMW glutenin subunits composition. The lowest Glu-score (5) was calculated in the varieties Iris, Sana, Vala and Sk 3756-1-76 with 0, 7 + 9, 2 + 12 HMW glutenin subunits composition what can be judged as weak quality cultivars. The average Glu-score of 21 Slovak wheat varieties was 6.8. Positive correlations between SDS-sedimentation test and Glu-score were determined ($r = 0.633^{++}$).

Payne and Lawrence (1983) and Payne et al. (1987) proofread the assigned value for Glu-score by its decreasing in the case of the occurrence of gliadin (secaline) allelic GLD 1B3 block, which is characterised as the bad bread-making cultivar quality marker. As it is seen from Table 2 the secaline block GLD 1B3 (*), the marker of bad baking quality, but at the same time the marker of resistance to stem rust, was identified from the gliadin spectra of the five varieties – Fundulea 29, Iris, Lívia, Sana and Sk 3756-1-76.

Šašek and Černý (1997), who following the evaluation of the obtained electrophoretic gliadin spectra, did not find the GLD 1B3 marker in the analysed spelt wheat cultivars.

Bread-wheat (*Triticum aestivum* L.) is the most common cultivated species of *Triticum*. The production volume of durum or macaroni wheat (*Triticum durum* DESF.) is primarily used for the manufacturing of pasta's (macaroni, spaghetti etc.). *Triticum durum* DESF., *Triticum tur-*

Table 2. Variation in the individual HMW glutenin subunit alleles in Slovak wheat varieties

Cultivar	HMW glutenin subunits			Glu-score	SDS test (cm^3)
	Glu-A1	Glu-B1	Glu-D1		
Astella	0	7 + 9	5 + 10	7	57
Barbara	0	7 + 9	5 + 10	7	50
Blava	0	7 + 9	5 + 10	7	60
Fundulea 29*	0	7 + 9	5 + 10	7	43
Ilona	2*	7 + 9	5 + 10	9	61
Iris*	0	7 + 9	2 + 12	5	48
Košútka	0	7 + 9	5 + 10	7	64
Lívia*	0	7 + 9	5 + 10	7	35
Maris Marksman	0	7 + 8	2 + 12	6	40
Rada	0	7 + 9	5 + 10	7	47
Samanta	0	7 + 8	5 + 10	8	75
Sana*	0	7 + 9	2 + 12	5	32
SK3756-76*	0	6 + 8	2 + 12	5	46
Solara	0	7 + 9	5 + 10	7	71
Solida	0	7 + 9	5 + 10	7	52
Torysa	0	7 + 8	2 + 12	6	54
Vala	0	7 + 9	2 + 12	5	56
Viginta	0	7 + 9	5 + 10	7	70
Klea	0	7 + 9	5 + 10	7	68
Vlada	1	7 + 9	5 + 10	9	79
Regia	1	7 + 9	5 + 10	9	70
Average				6.8	53.6

* secaline block GLD 1B3

Table 3. Composition of HMW subunits of glutenin in durum wheat

Cultivar	HMW glutenin subunits			Glu-score
	Glu-A1	Glu-B1	Glu-D1	
Soldur	0	7 + 8	–	4
Istrodur	0	7 + 8	–	4
Vendur	0	7 + 8	–	4

Table 4. Composition of HMW subunits of glutenin in *Triticum turgidum* L.

Cultivar	HMW glutenin subunits			Glu-score
	Glu-A1	Glu-B1	Glu-D1	
Turgidum di Maliani	0	13 + 16	–	2
Schottischer Winter Ranker	1	6 + 8	–	4
Ble. Geabt de Sainte Hellene	1	6 + 8	–	4
Wohltmanns Schwarzer Barico	1	6 + 8	–	4
Mettes Rauhweizen	1	6 + 8	–	4
Schwarzer Wunderweizen	1	6 + 8	–	4
Požehnaná	2*	6 + 8	–	4
Asturie 46	1	6 + 8	–	4
Helen Rauhweizen	1	6 + 8	–	4
Average				3.77

gidum L. and *Triticum polonicum* L. have the genome constitution AB.

Three cultivars of *Triticum durum* DESF. (Table 3) were analysed and HMW subunits 0 at the Glu-A1 locus and 7 + 8 at the Glu-B1 locus with Glu-score 4 were determined in analysed genotypes. This evidence was also acknowledged by the more particular study written by Kraic et al. (1997), Gregová et al. (1995), Gálová et al. (1998).

Triticum turgidum L. and *Triticum polonicum* L. belong to the old-world crop. At the present time they are in the position of the source of important agricultural properties for wheat breeding and the preservation of genotype variability at a Genbanks.

Table 5. Composition of HMW subunits of glutenin in *Triticum polonicum* L.

Cultivar	HMW glutenin subunits			Glu-score
	Glu-A1	Glu-B1	Glu-D1	
Never polnischner Weizen	0	7	–	2
Mirabella	0	6 + 8	–	2
Mansholts White	1	7	–	4
Schliepkakes Riesen polonicum	1	7	–	4
Münchener	1	7	–	4
Average				3.2

Table 6. Composition of HMW subunits of glutenin in *Triticum spelta* L.

Cultivar	HMW glutenin subunits			Glu-score
	Glu-A1	Glu-B1	Glu-D1	
Weisser Kolbenspelz	1	6 + 8	2 + 12	6
Baetting Niederuill	1	6 + 8	2 + 12	6
Bauländer Spelz	1	13 + 16	2 + 12	8
Burgdorf 1	1	6 + 8	2 + 12	6
Roter Kolbendinkel	1	6 + 8	2 + 12	6
Spalda (Landrace 1–96)	1	7 + 9	5 + 10	9
Fuggers Babenhauser Zuchveesen D	1	6 + 8	2 + 12	6
Kipperhaus Weisser spelz	1	6 + 8	2 + 12	6
Weisser Winter Granendinkel Hohen.	1	6 + 8	2 + 12	6
Franckenkorn	1	6 + 8	5 + 10	8
Holstenkorn	1	7 + 8	2 + 12	8
Rouquin	1	6 + 8	2 + 12	6
Ostro	1	6 + 8	2 + 12	6
Schwabenkorn	1	6 + 8	2 + 12	6
Renval	1	20	2 + 12	6
Ardenne	1	6 + 8	5 + 10	8
Zugor Dinkel	1	6 + 8	2 + 12	6
Average				6.65

Three electrophoretical profile groups of different HMW glutenin subunits were determined in *Triticum turgidum* L. (Table 4). The first group is 0, 13 + 16, the second one (78%) is 1, 6 + 8 and the third one is 2*, 6 + 8. Average Glu-score was 3.8.

Also three electrophoretical profile groups of different HMW glutenin subunits were determined in *Triticum polonicum* L. (Table 5). The first group is 0, 7, the second one is 0, 6 + 8 and the third one is 1, 7 (60%) with average Glu-score 3.2.

Spelt (*Triticum spelta* L.) is an old-world crop which was one of the major feed and food cereals of ancient Europe. At the present time it is in the position of a minor crop, but it rightly attracts renewed interest in the field of its relationship to wheat, methods of production, final use characteristics and breeding methods (Campbell 1997). Determination of the spelt wheat HMW glutenin subunits composition was dealt with by Rodriguez-Quijano et al. (1990). They surveyed 118 Spanish landraces of spelt and found that the most common subunits composition was 1, 13 + 16, 2 + 12.

Results obtained by studying the HMW glutenin subunits composition and Glu-score calculation are given in Table 6. Six electrophoretical profile groups were determined in 17 winter spelt wheat cultivars. The first electrophoretical profile, with 1, 6 + 8, 2 + 12 HMW glutenin subunits composition and 6 Glu-score value, was very frequent and was found in 11 varieties (65%). On the basis of the value obtained for Glu-score these cultivars can be classified as tools for enhancement of low bread-making quality and they seem to be useful for additions to common meals for increase their nutritive and sensorial parameters. The others profiles were of low frequency of occurrence. They are 1, 6 + 8, 5 + 10 (Ardenne, Franckenkorn), 1, 13 + 16, 2 + 12 (Bauländer spelz), 1, 20, 2 + 12 (Renval), 1, 7 + 8, 2 + 12 (Holstenkorn) and 1, 7 + 9, 5 + 10 (Landrace 1–96). Average Glu-score was 6.65.

The dough made from the spelt wheat flours is characterised with the lower stability and elasticity and with the higher extensibility and dissolubility. The similar electrophoretic characterisation of spelt seed gliadins was studied by several authors (Abdel-Aal et al. 1996, Harsch et al. 1997, Šašek and Černý 1997).

HMW glutenin subunits may be used as a molecular marker of bread-making quality of wheat. The verified correlations between bread-making quality and specific HMW subunits of glutenin can be utilised by wheat breeders using SDS-PAGE of proteins as a screening test for the prediction of bread-making quality of wheat.

Acknowledgement

Authors thank the Research Institute of Crop Production Genebank, Praha-Ruzyně, Czech Republic and Research Institute of Plant Production Genebank, Piešťany, Slovak Republic for supplying the wheat cultivars. This work was supported by the VEGA grant No.1/7648/20.

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Received on May 21, 2001

ABSTRAKT

Variabilita HMW gluteninových podjednotek v různých druzích pšenice

Metoda ISTA SDS PAGE byla použita pro separaci, detekci a stanovení vysokomolekulárních gluteninových podjednotek (HMW) v různých druzích pšenice. Byl studován vztah mezi alelami HMW gluteninových podjednotek a technologickou kvalitou 25 odrůd světového sortimentu pšenic, 21 regionálních odrůd pšenice obecné (*Triticum aestivum* L.), 17 odrůd pšenice špaldy (*Triticum spelta* L.), tří odrůd pšenice tvrdé (*Triticum durum* DESF.), devíti odrůd pšenice naduřené *Triticum turgidum* L. a pěti odrůd pšenice polské (*Triticum polonicum* L.). Ve světovém sortimentu byla zjištěna nejvyšší frekvence výskytu HMW gluteninových podjednotek 2*, 13 + 16 a 5 + 10. V slovenském sortimentu odrůd byly analyzovány podjednotky 0, 7 + 9 a 5 + 10, 2 + 12. HMW podjednotky 0, 7 + 8 s Glu-hodnocením 4 byly determinovány v *Triticum durum* DESF. Tři skupiny elektroforetických profilů HMW gluteninových podjednotek byly zjištěny v *Triticum turgidum* L, *Triticum polonicum* L. a šest v *Triticum spelta* L. Prezentované vztahy mezi technologickou kvalitou a jednotlivými HMW gluteninovými podjednotkami jsou přínosem pro šlechtitele, kteří mohou používat metodu SDS-PAGE gluteninových bílkovin jako screeningový test pro určování technologické kvality pšenice.

Klíčová slova: *Triticum aestivum* L.; *Triticum durum* DESF.; *Triticum turgidum* L.; *Triticum polonicum* L.; *Triticum spelta* L.; HMW gluteninové podjednotky; SDS-PAGE elektroforéza; SDS sedimentační test

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