Protein Structure Variability of *Aegilops* Species

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Abstract: A part of the *Aegilops* collection in the Gene Bank Prague was evaluated for its grain quality. The species selected were *Ae. triuncialis*, *Ae. biuncialis*, *Ae. neglecta* and *Ae. geniculata*. Crude protein content was measured from two year trials. SDS micro-sedimentation test and thousand grain weight (TGW) served as a criterion of grain technological quality. The average crude protein content varied between 187 and 339 mg/kg DM, with the average for 83 accessions being 239 mg/kg DM. These values greatly exceed those of commercial wheat cultivars. On the basis of previous evaluations, the top 10 tetraploid accessions were chosen for the evaluation of seed protein content and protein fractions using a modified Osborn method. The protein content varied between 290 and 330 mg/kg DM, which was three times higher than check wheat cultivar Samanta. All the individual protein fraction contents were higher as well. Evaluation of relative share of protein fractions in total crude protein showed a lower ratio of albumin and globulin fraction in *Aegilops* spp. than in check wheat cultivar. This suggests that *Aegilops* spp. have lower nutritional quality. The ratios between contents of gliadines and soluble glutenins were significantly wider in comparison with commercial wheat cultivars showing high baking quality. The tested *Aegilops* accessions can be divided into two groups: one with a higher ratio between both storage proteins (7105, 7115, 7125, and 8048) and the other with a lower ratio. This last group included the other *Aegilops* spp. plus the check wheat cultivar Samanta. The technologically more treatable (more solid and elastic) gluten was found within the latter group. Nevertheless, further conclusions of nutritional and technological quality will be possible after determination of amino acid composition and rheological analyses.

Keywords: *Aegilops*; protein fractions; quality; gliadins; glutenins

Quality of wheat is a very important character. Soft wheat is bred for four kinds of quality requirements: bread, white pastry, fodder utilisation and starch industry. There are an increasing number of people with an allergy to wheat gluten (celiatics). Such new requirements need new sources of quality. The *Triticeae* collection of the Gene Bank, RICP Praha-Ruzyně, comprising over 900 annual species and 500 perennial species serves as a valuable resource for locating sources of such new qualities. The *Aegilops* species chosen have often been used as sources of resistance, salt and drought tolerance in wheat breeding. However, their impact on the technological quality of grain has been hardly studied (Gale & Miller 1987).

Nearly all the nitrogen in cereals is found in protein complexes. Thus, analysis of nitrogen in the grain can bring useful information about its protein content. However, applying that method, further valuable information on the quality of protein is lost (Králová 1991).

Presently generally accepted protein categorization is their division to protoplasmic (enzymatically active) and storage proteins. The storage proteins are characterised by a high genetic polymorphism and have an important role in the grain quality. The protoplasmic proteins are more conservative in structure and significantly influence the protein nutritional quality (Šašek & Černý 1977; Králová 1991).

This contribution focuses on the technological characterization of *Aegilops* accessions and further protein specification.

MATERIALS AND METHODS

For evaluation of grain quality, we chose 83 samples of *Aegilops* with homoeologous genomes to wheat (possessing diploid U, C, and M genomes in tetraploid level: *Ae. triuncialis*, *Ae. biuncialis*, *Ae. neglecta* and *Ae. geniculata*). They have large grains with a large endosperm and similar shape to wheat.

The cultivar of winter bread wheat *Triticum aestivum* Samanta was used as a check. Plants were grown in the fields of the Gene Bank Prague Ruzyně

Table 1. Mean values of thousand grain weight, crude protein content and Axford microsedimantation test of chosen *Aegilops* spp. (2001)

	Acc. No.	TGW (g)	Crude prot.cont. (g/kg DM)	Microsedim. test (ml)
Mean *Ae. triuncialis*	34	13.82	281.3	6.10
Max.		18.85	312.1	9.10
Min.		9.19	241.7	3.70
Standard deviation		2.51	16.3	1.05
Correl (TGW-Protein)			0.01	
Correl (TGW-sed)			0.35	
Correl (Protein-sed)			0.35	
Mean *Ae. biuncialis*	4	15.25	277.7	6.48
Max.		17.30	294.8	7.50
Min.		13.65	264.7	4.90
Standard deviation		1.32	1.30	0.97
Correl (TGW-Prot)			–0.72	
Correl (TGW-sed)			–0.78	
Correl (Prot-sed)			0.69	
Mean *Ae. geniculata*	39	11.90	275.5	6.49
Max.		15.34	305.8	9.20
Min.		8.96	245.5	3.40
Standard deviation		1.44	11.2	1.69
Correl (TGW-Prot)			0.15	
Correl (TGW-sed)			–0.27	
Correl (Prot-sed)			0.05	
Mean *Ae. neglecta*	6	16.07	267.4	5.05
Max.		21.93	296.2	7.30
Min.		10.28	221.6	3.60
Standard deviation		4.18	25.4	1.17
Correl (TGW-Prot)			–0.08	
Correl (TGW-sed)			–0.21	
Correl (Prot-sed)			0.53	
Mean *Aegilops*	83	12.86	259.7	5.67
Max.		21.93	312.1	9.20
Min.		8.96	221.6	3.40
Standard deviation		3.16	68.2	2.17
Correl (TGW-Prot)			0.58	
Correl (TGW-sed)			0.25	
Correl (Prot-sed)			0.58	

for 2 years (2001–2002). Glumes were removed from collected grains and thousand grain weight (TGW) was determined. Naked grains were ground to grouts and evaluated for basic technological quality. The protein content was measured by the Kjehldahl method using a Kjeltec Auto System II analyser (AACC4610). Microsedimentation SDS test was used as an indirect parameter of bread making quality, according to Axford (Hyža 1986).

The basic technologic characters (TGW, dry matter, protein content, micro-sedimentation test) were determined in the first year on the full 83 number of samples. The next year the 10 samples with the highest protein content and with higher micro-sedimentation were chosen for more detailed study of their protein characteristics. Protein fractions (albumins-globulins, gliadins and glutenins) were extracted according to Osborn's method with modification according to Martini and Kuhn (1999).

RESULT AND DISCUSSION

The values of TGW were very low (ranging from 8.96 to 21.93 g, Table 1) compared to commercial wheat cultivars and also lower than wild wheat species, even though the grains were full, not shrunken. The average crude protein content in both years was always significantly higher than in wheat cultivars. It was found to be between 187 and 339 g/kg DM. (g per kg of dry matter). The average for 83 accessions was 259.7 g/kg DM. The most interesting results were found in evaluation of SDS micro-sedimentation test. Several accessions showed high values of micro-sedimentation comparable to the best commercial bread wheat cultivars e.g. *Ae. triuncialis* 7105 (9.10 ml) and *Ae. geniculata* 9095 (9.20 ml). The highest value of SDS micro-sedimentation was found in our previous experiments in *Ae. tauschii* (9.6 ml, Holubec *et al*. 1992). Correlation coefficients among observed characters were generally low except for *Ae. biuncialis*, where relations appeared to be much closer. This means that the grains with lower TGW generally had a higher technological quality.

Further evaluation of selected accessions in 2002 confirmed the previous results of high protein content (Table 2). The protein fractions showed different levels of variation (Table 3). A closer range of values was found in albumin and globulin fractions (57.0–64.8 g/kg DM). On the other hand a wider range of variability was found in both storage protein fractions, gliadins (96.2–146.6 g/kg DM) and glutenins (31.8–57.8 g/kg DM). Compared to the check cultivar, all three protein fractions were significantly higher. It is important to admit that the highest variability was found in insoluble protein (insoluble glutenin) which ranged between 48.2 and 125.7 g/kg DM.

The results of protein composition in *Aegilops* revealed a high conservativeness in the share of albumin-globulin fraction and significantly higher solubility differences in the storage protein fractions (gliadins and glutenins). A wider ratio in gliadin and glutenin content in *Aegilops* accessions, compared to the commercial bread wheat cultivars, must significantly influence their technological (baking) properties (Pomeranz *et al*. 1988).

It is interesting to evaluate the relative share of particular protein fractions to the whole grain

Table 2. Top 10 *Aegilops* spp. with the highest crude protein content (2002)

	Acc. No.	TGW (g)	Crude protein (g/kg DM)	Microsedimentstion test (ml)
Aegilops triuncialis	7105	12.96	301.8	9.10
	7111	10.76	299.8	5.10
	7115	12.30	312.1	6.40
	7125	12.68	295.1	5.60
	7128	18.09	294.0	5.90
	7136	14.37	294.1	5.50
	7138	12.91	305.8	5.80
Aegilops biuncialis	1239	13.65	294.8	6.90
Aegilops neglecta	8048	15.14	296.2	4.60
Aegilops geniculata	9110	12.16	305.8	6.00

Table 3. Protein and protein fraction characteristics of top 10 selected *Aegilops* species (2002)

Species	Protein g/kg DM	Albumins-Globulins g/kg DM	Gliadins g/kg DM	Glutenins g/kg DM	Ratio Gli/Glu	Insoluble protein g/kg DM	Sum glutenins g/kg DM
7105	291.4	63.4	122.0	57.8	2.11	48.2	106.0
7111	318.0	57.0	126.8	50.4	2.52	83.8	134.2
7115	330.7	59.8	146.6	48.6	3.02	75.7	124.3
7125	326.3	64.8	135.8	52.6	2.58	73.1	125.7
7128	321.8	59.4	112.4	35.2	3.19	114.8	150.0
7136	325.2	53.2	114.0	51.6	2.21	106.4	158.0
7138	339.9	61.6	111.8	40.8	2.74	125.7	166.5
1239	309.2	63.0	96.2	31.8	3.03	118.2	150.0
8048	316.5	56.2	136.2	38.8	3.51	85.3	124.1
9110	324.6	61.0	121.2	53.6	2.26	88.8	142.4
Samanta	104.3	27.0	30.6	15.8	1.94	30.9	46.7

proteins (Figure 1). In spite of having significantly higher absolute share of albumin-globulin, the proportion of this protein fraction in the total protein was lower (16.36–21.76%) in *Aegilops* species than in the check wheat cultivar Samanta (25.89%). On the other hand, the relative share of gliadins was significantly higher (31.11–44.33%) in all *Aegilops* accessions. The Relative share of other protein fractions (glutenins, Ins. Protein) varied in the level of the check cultivar. From the nutritional point of view the albumin-globulin fraction is valued over the others. Gliadins and glutenins of wheat grain influence mainly the baking quality, i.e. they affect physical gluten characters and the whole loaf volume. While gliadins are preferable sources of tensility, glutens influence elasticity and swelling ability of gluten (Pomeranz *et al*. 1988).

In this respect the observed accessions can be divided into two groups. The first one (7105; 7136; 9110) is characterized by lower ratio among gliadins and glutenins, in some instances as low as in the check cultivar. In particular, *Ae. triuncialis* 7105 exhibited a low ratio of both storage fractions (2.11) and a very low share of insoluble protein (48.2 g/kg DM). It is reasonable to suggest, that the other technological parameters of this species are likely to correspond with parameters suitable for bread making quality. In addition, this accession possessed the second highest content of the nutritionally important albumin-globulin fraction.

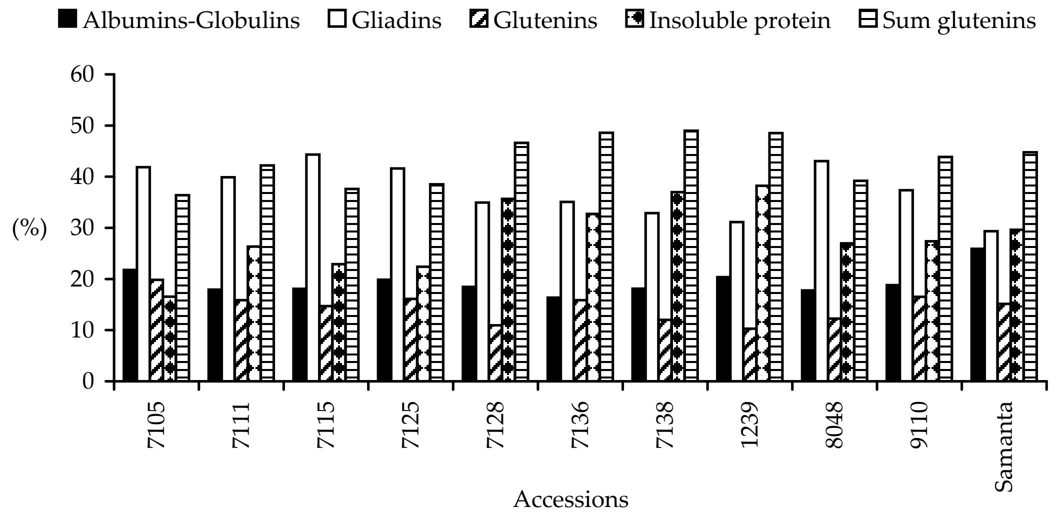

Figure 1. Protein fractions ratio in crude protein of grain

The accessions of the second group had a higher ratio between the storage proteins. In accessions 7128, 7138 and 1239, an extremely high share of insoluble protein fraction was found, comparable to the share of gliadins. For more detailed conclusions, especially of nutritional and technological influence of a high share of insoluble proteins it will be necessary to continue with more detailed evaluation including amino acid composition and other technologic evaluations (Zeleny sedimentation test, content of wet gluten, gluten index, and rheological analyses).

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References

Gale M.D., Miller T.E. (1987): The introduction of alien genetic variation in wheat. In: Lupton F.G.H. (ed.): Wheat Breeding: Its Scientific Basis. Chapman and Hall, London, 173–210.

Holubec V., Hanušová R., Kostkanová E. (1992): The *Aegilops* collection in the Prague-Ruzyně (Czechoslovakia) Gene Bank: collecting, evaluation and documentation. Hereditas, **116**: 271–276.

Hyža V. (1986): Microsedimentation method on evaluation of wheat breeding materials. Genetika a šlechtění, **22**: 117–122. (in Czech)

Králová M. (1991): Vybrané metody chemické analýzy půd a rostlin. Studie ČSAV, č. 12, Academia, Prague.

Martini A., Kuhn M. (1999): Einfluss der Stickstoffdüngung auf die Zusammensetzung und die Eigenschaften von Dinkelproteine. Getreide Mehl und Brot, **53:** 282–290.

Pomeranz Y. *et al*. (ed.) (1988): Wheat Chemistry and Technology I. AACC, Minesota, 159–253.

Šašek A., Černý J. (1997): Gliadinové a gluteninové signální geny pšenice špady (*Triticum spelta* L.). Rostlinná výroba, **43**, 149–151.