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Variability of seed protein composition of hulless mutants of spring barley (*Hordeum vulgare* L.)

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Abstract. Nutritional value of protein in 146 mutants of hulless spring barley was estimated. Evaluation of protein quality was based on the portion of a relative content of protein fractions with different amino acid composition and, therefore, with different nutritional value. The ratio of albumins, globulins and glutelins to hordein, determining nutritional value of protein in the initial genotype was 1.1; in mutants it was within the range of 0.9-1.5. Several mutants with a high protein content and good nutritional value have been distinguished.

Key words: hulless mutants, *Hordeum vulgare*, nutritional value, spring barley, protein fractions.

Hulless barley has been in existence as long as hulled barley. It yields, on average, 80-90% of hulled barley and the hull constitutes about 10-13% of the dry weight of barley grain (BHATTY 1986b). The feeding value of hulless barley was a subject of studies in different research centres, chiefly in the United States and in Canada (BHATTY 1986a, 1987). The grain of these forms distinguishes from other cereals by a relatively high protein content and a lower content of pentozans and crude fibre (JOHNSON, SUNDERMAN 1979). Regarding exogenous amino acid content it equals and sometimes exceeds that of hulled forms (SUMNER et al. 1985). In animals feeding, especially swine and poultry, hulless barley is noticeably superior to hulled barley and can be successfully replaced by corn (BHATTY 1986 b).

A number of mutants of spring hulless barley have been obtained at the Institute of Plant Genetics, Polish Academy of Sciences, in Poznań. They were analysed for the protein composition to establish the range of genetic variability

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induced by chemical mutagenesis. A special emphasis was placed on variability concerning nutritional value of proteins.

Material and methods

Plant material

An object of the studies were 146 mutants of hulless spring barley obtained after treating kernels of the 2-rowed hulless Polish strain 1N/86 with N-nitroso-N-methylurea (MNU) and sodium azide. The mutants were analysed in comparison to the initial strain, four hulless Canadian cultivars (Scout, Tupper, CDC Richard, CDC Buck) and six hulled cultivars (Apex, Dema, Edgar, Grosso, Maresi, Rudzik).

Analytical technique

Protein quality was evaluated on the basis of the portion of major protein fractions with different the amino acid composition in the total protein of barley kernels. The contents of albumins and globulins, hordein (prolamin) and glutelin were quantitated according to the previously developed method (KAPAŁA 1989, 1994). Nutritional protein value was evaluated on the basis of ratio of proteins rich in exogenic amino acids (albumins, globulins and glutelins) to hordein (JENSEN 1991).

Results

The mutants of hulless spring barley show large variation in the 1000-kernel weight, which was low in 99 examined mutants (17-29 g), medium in 39 (30-38 g) and high in 8 mutants (39-43 g), 3 of which had the 1000-kernel weight above 40 g. The studied cultivars of hulled barley distinguished by a high 1000-kernel weight – from 47 to 51 g.

Protein content in the examined mutants ranged from 13.8 to 19.0%, that of the initial strain 1N/86 being 16.0%. In the studied group of mutants, 13 had the protein content from 13.8 to 15.0%, 73 – from 15.0 to 17.0% and 60 – from 17.0 to 19.0%. Cultivars of hulless barley were characterized by a medium protein content ranging from 14.5% to 15.1%, whereas cultivars of hulled barley had a low protein content from 10.5% to 12.7%.

Cultivars of hulled barley as compared to the studied hulless genotypes are characterized by a higher weight of 1000-kernel weight and a lower total

Table 1. Origin of the seeds sample and characterization of spring barley (*H. vulgare*) genotypes

Genotypes	Origin	Hulled or hulless	Number of rows	1000-kernel wt., g	Total protein content (%)
Mutants: No. 1-152	Poland	hulless	2	17.0-43.3	13.8-19.0
1N/86 initial strain	Poland	"	2	30.0	16.0
CDC Richard cv.	Canada	"	2	48.7	14.5
Scout cv.	Canada	"	2	35.6	15.1
CDC Buck cv.	Canada	"	6	45.8	14.8
Tupper cv.	Canada	"	6	33.6	14.7
Apex cv.	Holland	hulled	2	46.8	10.8
Dema cv.	Poland	"	2	47.2	12.7
Edgar cv.	Poland	"	2	48.2	11.9
Grosso cv.	Holland	"	2	50.8	10.5
Maresi cv.	Germany	"	2	48.7	11.5
Rudzik cv.	Poland	"	2	49.0	11.0

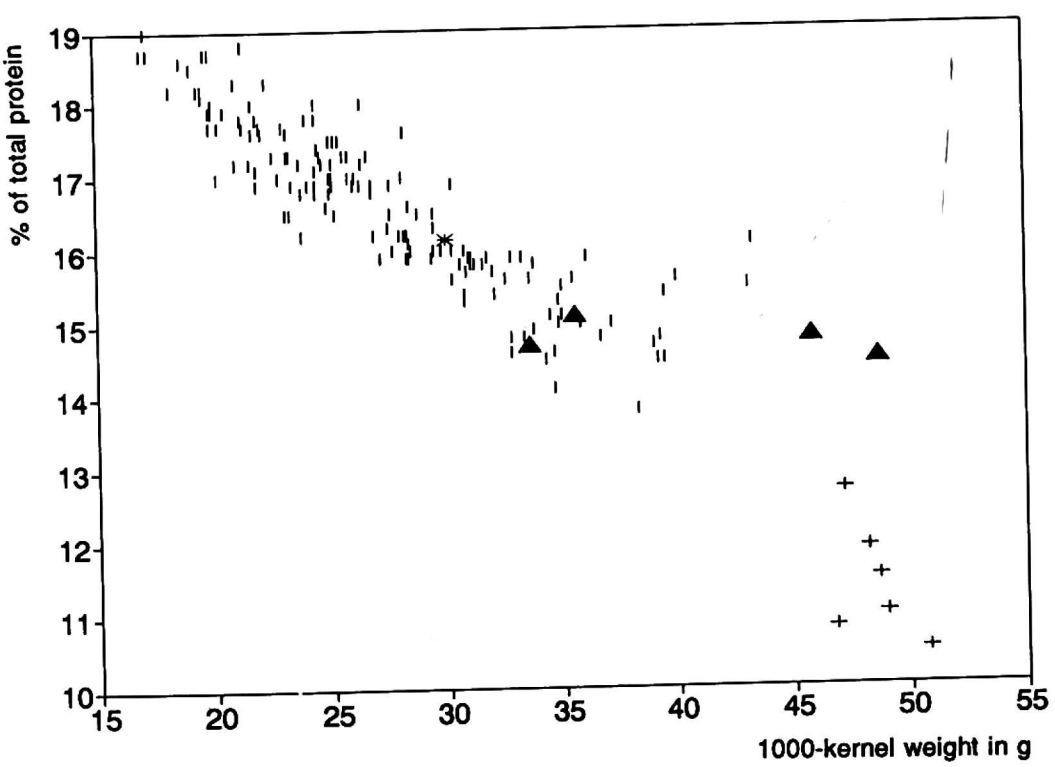

Fig. 1. A diagram of the 1000-kernel weight and % of total protein content in 146 hulless mutants (|), initial strain (*), 4 Canadian cultivars of hulless barley (Δ) and 6 cultivars of hulled barley (+)

Table 2. The main protein fractions content and index of nutritional value of protein in seeds of studied barley genotypes

Genotype	Main protein fractions content (% of dry matter)			Index of nutritional value*
	albumins + globulins	glutelins	prolamins (hordein)	
Mutants: No. 1-152	3.4-5.1	3.5-5.6	5.8-9.0	0.9-1.5
1N/86 initial strain	4.0	4.2	7.4	1.1
CDC Richard cv.	3.7	4.0	6.2	1.2
Scout cv.	3.6	4.1	6.7	1.1
CDC Buck cv.	3.8	4.1	6.4	1.2
Tupper cv.	3.8	4.0	6.8	1.1
Apex cv.	2.7	2.8	4.9	1.1
Dema cv.	3.1	3.4	6.0	1.1
Edgar cv.	2.9	3.0	5.5	1.1
Grosso cv.	2.7	2.8	4.7	1.2
Maresi cv.	2.9	3.2	5.1	1.2
Rudzik cv.	2.8	3.0	4.8	1.2

* (Albumins + globulins + glutelins)/hordein

Table 3. Characterization of 1N/86 initial strain and selected hulless mutants of barley in respect of 1000-kernel weight, total protein, main protein fractions content and index of nutritional value

Genotype	1000-kernel wt., g	Total protein content (%)	Main protein fractions content (% of dry matter)			Index of nutritional value*
			albumins + globulins	glutelins	prolamins (hordein)	
1N/86 strain	30.0	16.0	4.0	4.2	7.4	1.1
Mutant-9	33.8	14.9	3.9	4.6	6.0	1.4
Mutant-12	28.8	16.5	4.7	5.0	6.3	1.5
Mutant-31	36.7	14.8	4.2	4.2	6.0	1.4
Mutant-36	39.2	14.5	3.8	4.3	6.0	1.4
Mutant-41	26.4	18.0	4.5	6.0	7.0	1.5
Mutant-52	33.6	15.6	4.5	4.6	6.0	1.5

* (Albumins + globulins + glutelins)/hordein

protein content. Generally, a higher protein content is associated with the smaller grain, while fertility is chiefly dependent on filling the grain with starch. Nevertheless, however, among the studied mutants were also genotypes with a large 1000-kernel weight and high protein content (Table 1, Fig. 1).

The analysed mutants of hulless spring barley showed certain differences in the contents of individual protein fractions in kernel dry weight (Tables 2 and 3). The content of albumins and globulins from 3.4 to 5.1% like that of glutelins ranged from 3.5 to 5.6%. Hordein content was significantly higher (from 5.8 to 9.0%). A similar content of the main protein fractions was found in the initial strain 1N/86 and Canadian cultivars of hulless barley. The analysed cultivars with hulled grain were observed to have lower contents of albumins and globulins, glutelins as well as hordein in kernel dry weight, which results from a lower total protein content.

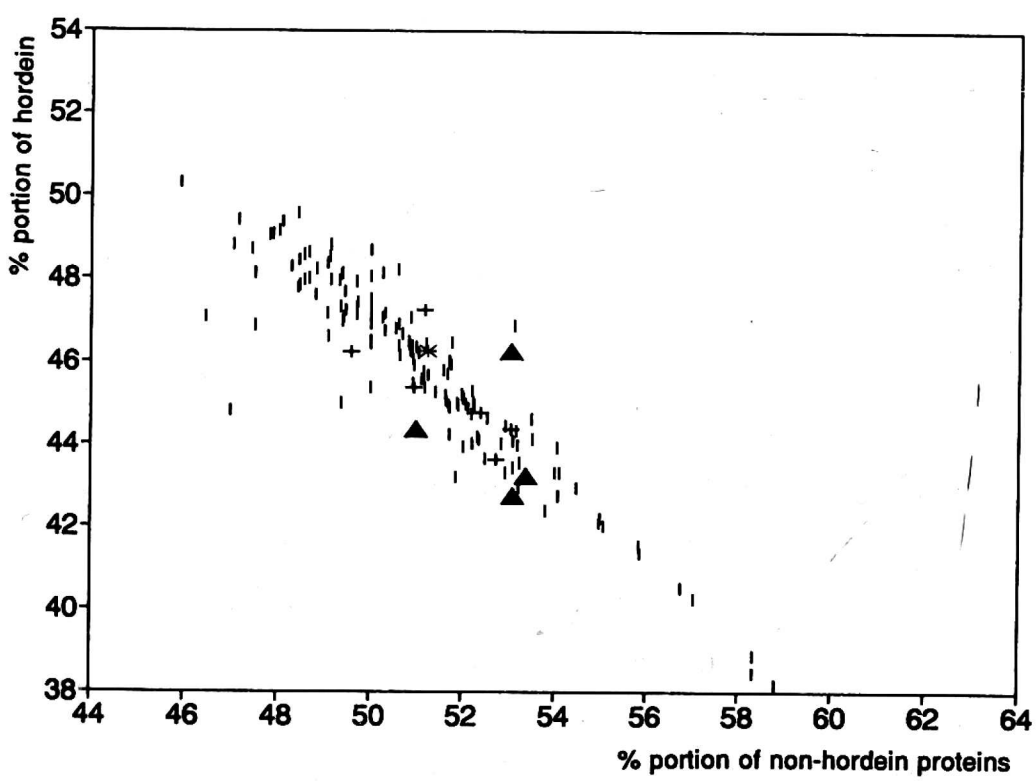

Fig. 2. A diagram of non-hordein proteins and hordein in total protein of kernels of 146 hulless mutants (|), initial strain (*), 4 Canadian cultivars of hulless barley (Δ) and 6 cultivars of hulled barley (+)

The portion of different fractions in total protein of the mutants ranged from 22 to 30% for albumins and globulins, from 21 to 33% for glutelins and from 38 to 50% for hordein. The portion of the main fractions in total protein of the analysed hulless barley cultivars, strain 1N/86 and hulled cultivars was similar: from 24 to 26% for albumins and globulins, from 26 to 28% for glutelins and 34-47% for hordein (Fig. 2).

The studied mutants differed in the feeding value of kernel protein. That value index, i.e. the ratio of albumins, globulins and glutelins to hordein ranged from 0.9 to 1.5. The nutritional value of a decisive majority (130 forms) of the analysed mutants was similar to the feeding value of the initial strain and hulless and hulled cultivars. The nutritional index for these genotypes was from 1.0 to 1.2. A higher nutritional value was exhibited by 15 mutants including three mutants with the highest nutritional index – 1.5. Particularly interesting are mutants No. 12 and No. 41; mutant 41 shows a higher protein content than the initial strain as well as a better quality. Mutant No. 12 has the same level of total protein, but its nutritional value is significantly better.

Discussion

Fully valuable fodder barley should have about 15-17% protein and a possibly high lysine level (CZEMBOR et al. 1979). Therefore, the majority of the analysed mutants of hulless barley show a sufficiently high protein content to be a genetic source in breeding fodder barley.

Not only the quantity but also composition of protein are of significant importance for feeding value. Amino acid composition of total protein is a resultant of its individual fraction composition. From the point of view of the nutritional value the most desirable amino acid composition is shown by albumins and globulins. They distinguish not only by a high content of lysine, but also by all other amino acids in well-balanced quantities. The lowest feeding value is characteristic of hordein containing much proline and glutamic acid, but poor in lysine, methionine, threonine, histidine, valine and arginine. Glutelins in relation to the mentioned fractions show intermediate contents of exogenic amino acids.

There is a certain regularity that a higher total protein content in barley grain is associated with an increased hordein portion in protein. Just this association interprets the unfavourable relationship between total protein content and its amino acid composition. A negative correlation between the level of total protein in barley grain and relative contents of lysine and other exogenic amino acids is observed when differentiation of protein content is determined genetically as well as when it is induced by environmental factors, for instance, nitrogen fertilizing (PRZYBYLSKA 1976).

It should be underlined that superiority of hulless barley over hulled forms in feeding swine and poultry has been already found earlier (ROSSNAGEL et al. 1983, 1985). The analysed mutants of hulless barley as compared to hulled

cultivars show a higher content of total protein of the same or better nutritional value. This is especially important for forage barley breeding aimed at increasing the level of highly valuable protein in the grain of that plant.

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