EVOLUTION OF HMW GLUTENIN SUBUNIT COMPOSITION OF WHEAT CULTIVARS (*TRITICUM AESTIVUM* L.) GROWN IN ROMANIA, FROM 1980 TO 1995

Ioana Hagima, Nicolae N. Sãulescu and Gheorghe Ittu [1)]

ABSTRACT

High molecular weight glutenin subunit composition of 26 winter wheat cultivars grown in Romania during the last fifteen years was established by SDS-PAGE. Alleles known to have a favourable effect on bread making quality were found to be more frequent among recently released cultivars. Percentage of total wheat area covered by various glutenin alleles was computed for each of the last 15 years, taking into account the area grown with each cultivar and the corresponding HMW glutenin subunit composition. Significant changes took place in the areas covered by alleles of all glutenin loci. Area covered by alleles *Glu-A1b* and *Glu-A1a* (controlling fractions 2* and 1) increased from 10 to more than 50%, while area covered by *Glu-D1d* (fractions 5+10) increased from 60% to more than 90%. These changes suggest that the bread making quality potential of Romanian wheat has significantly improved.

Key words: bread making quality, glutenin subunits, wheat.

INTRODUCTION

Glutenins are widely recognized as the main determinants of bread-making quality in wheat. During the last twenty years, significant progress has been made in characterizing the allelic variants of high-molecular-weight (HMW) glutenin subunits and in establishing their influence on bread-making quality (Payne, 1987; Payne et al., 1987). Differences in HMW glutenin subunit composition were found to explain 68% of the quality variation in British wheat cultivars, but only 13% of the variation in a study involving recombinant inbred lines (Rousset et al., 1992). Hagima et al. (1987) analysed 16 wheat cultivars grown in Romania and found that a linear regression on glutenin score accounted for 40% of the variation of bread volume and farinograph value.

Glutenin electrophoretic patterns have been used, along with other biochemical markers, for cultivar identification (Hagima et al., 1989) or to provide information on cultivar diversity and on effects of selection performed in various geographic regions (Graybosch 1992; Lookhart et al., 1993).

This paper presents the HMW glutenin subunit composition of the main winter wheat cultivars grown in Romania during the last 15 years and the changes in the percentage of the area covered by cultivars carrying various alleles of the genes controlling glutenin synthesis.

MATERIALS AND METHODS

HMW glutenins were separated through electrophoresis on vertical polycrylamide 10% gels with added sodium dodecyl sulphate (SDS). A trisglycocol 0.025M buffer at pH 8.3 was used, with added SDS 10%. The extraction solution contained Tris-HCI 1M at pH 6.8, SDS, 2-mercaptoethanol, pyronine Y and glycocol, 0.02 ml solution being used for each 1 mg sample. Separation was done for about 20 hours at 180V and 12-14 mA. Gels were stained with a solution containing Coomassie Brilliant Blue R-250, ethanol and tricloracetic acid, for 2-3 days.

The alleles of the glutenin genes were identified based on the HMW subunits, according to Payne and Lawrence (1983), and glutenin scores were computed according to Payne (1987).

Statistics about areas covered with the main wheat cultivars were obtained from the Ministry of Agriculture and percentage covered by each cultivar was computed taking into account the total area for which information about the cultivars was available.

RESULTS AND DISCUSSIONS

Table 1 presents the HMW glutenin subunits and the corresponding alleles of the *Glu-A1, Glu-B1* and *Glu-D1* genes, found in the main winter wheat cultivars grown in Romania during the last 15 years. On an average, the allele frequency for the genes controlling the synthesis of glutenins was:

- for the gene *Glu-A1:*
  - allele a (subunit 1) 12%
  - allele b (subunit 2*) 31%
  - allele c (null) 57%
- for the gene *Glu-B1:*
  - allele a (subunit 7) 8%

[1)] Research Institute for Cereals and Industrial Crops, 8264 Fundulea, Cãlãraºi County, Romania

Table 1. High molecular weight glutenin subunits and corresponding alleles for the main winter wheat cultivars grown in Romania during 1980-1996

Cultivar	Year of registration	Glutenin subunits	Alleles of the genes		
			Glu-A1	*Glu-B1*	*Glu-D1*
Bezostaya 1	1961	2*;7+9;5+10	b	c	d
Dacia	1971	7;5+10	c	a	d
Libellula	1971	20;2+12	c	e	a
Iulia	1974	7+9;2+12	c	c	a
Ceres	1974	7+9;5+10	c	c	d
Doina	1977	7+8;5+10	c	b	d
Lovrin 24	1977	7+9;5+10	c	c	d
Partizanka	1977	2*;7+9;5+10	b	c	d
Fundulea 29	1979	2*;7+9;5+10	b	c	d
Lovrin 32	1979	7+9;5+10	c	c	d
Transilvania 1	1981	7+9;2+10	c	c	e
Lovrin 34	1981	7+9;5+10	c	c	d
Moldova 83	1983	2*/0;7+8;5+10	b/c	b	d
Turda 81	1984	2*;7;5+10	b	a	d
Fundulea 133	1984	2*;7+9;5+10	b	c	d
Arie°an	1985	2*/0;7+9;5+10	b/c	c	d
Aniversar	1986	1;7+8/7+9;5+10/2+10	a	b/c	a/d
Albota	1986	7+9;5+10	c	c	d
Lovrin 41	1987	2*/0;7+9;5+10/2+12	b/c	c	a/d
ªimnic 30	1987	1;7+8;5+10	a	b	d
Fundulea 4	1987	7+9;5+10	c	c	d
Flamura 85	1989	2*/0;7+8;5+10	b/c	b	d
Apullum	1992	1;7+8;5+10	a	b	d
Rapid	1992	7+8;5+10	c	b	d
Dropia	1993	2*;7+8;5+10	b	b	d
Delia	1993	7+9;5+10	c	c	d

- allele b (subunits 7+8) 29%
- allele c (subunits 7+9) 60%
- allele e (subunit 20) 3%

• for the gene *Glu-D1:*

- allele a (subunits 2+12) 12%
- allele d (subunits 5+10) 85%
- allele e (subunits 2+10) 3%

The high frequency of the allele *Glu-D1d* is remarkable, because many results suggested that this allele is strongly associated with gluten strength (Lawrence et al., 1987; Odenbach and Mahgoub, 1988; Lagudah et al., 1988). Based on the relatively good quality of some old Hungarian cultivars lacking the subunits 5+10, Bedö et al. (1995) concluded that the negative effect of allele *Glu-D1a* might be partially compensated by favourable alleles at other loci.

On the other hand, for the locus *Glu-A*1, the most frequent is allele c, generally associated with a lower quality, while the favourable alleles a and b have together a frequency of only 43%. The glutenin score, on an average on all analysed cultivars, was 7.82, which is a score close to that computed by Lookhart et al. (1993) for hard red winter wheat cultivars most widely grown in USA in 1984.

For a better estimation of the possible effect of the glutenin subunit composition on the quality of wheat grown in Romania, we took into consideration the area on which each cultivar was grown, and computed the percentage of the total wheat acreage covered with cultivars carrying various alleles of glutenin genes, for each year of the analysed period.

From 1980 to 1996, the area on which the allele *Glu-A1c* was present decreased from about 90% to less than 50% (Figure 1). Correspondingly, the area covered by cultivars carrying the alleles *Glu-A1b,* and lately *Glu-A1a,* has increased. These changes suggest that a definite increase of the qualitative potential of Romanian wheat has taken place, in what the glutenin subunits controlled by the locus *Glu-A1* are concerned.

The area covered by cultivars carrying at Glu-B1 locus the alleles a and e, known for their negative effect on bread making quality,

has drastically decreased, while the allele b, estimated to have the largest favourable effect on quality (Lorenzo et al., 1987; Lagudah et al. 1988), has become more and more widespread, particularly during the last few years (Figure 2).

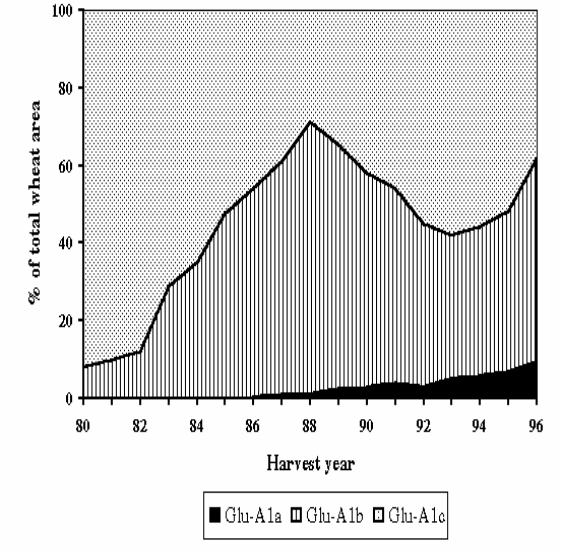

Figure 1. Area (% of total) covered by cultivars with various alleles at *Glu-A1* locus

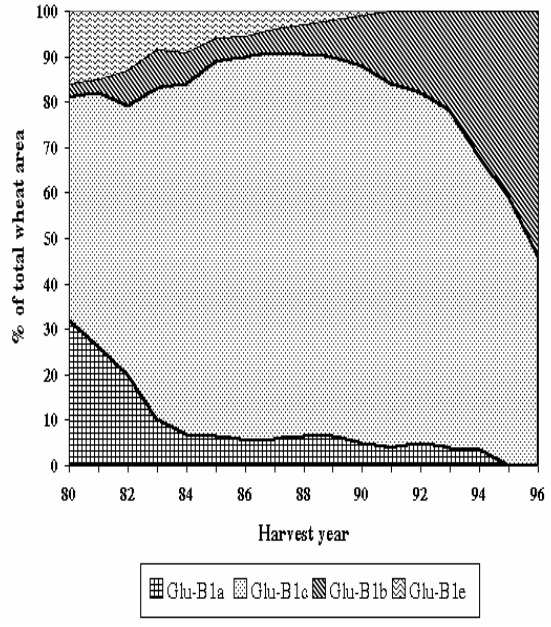

Figure 2. Area (% of total) covered by cultivars with various alleles at *Glu-B1* locus

The area covered with the favourable allele *Glu-D1d* has also increased from about 60%, in 1980, to more than 90% in 1996, while cultivars with the allele *Glu-D1a,* described as having a negative effect on bread making quality, are not grown in Romania any more. Cultivars carrying the allele *Glu-D1e* have been grown during the whole period on a small, but relatively constant acreage (Figure 3).

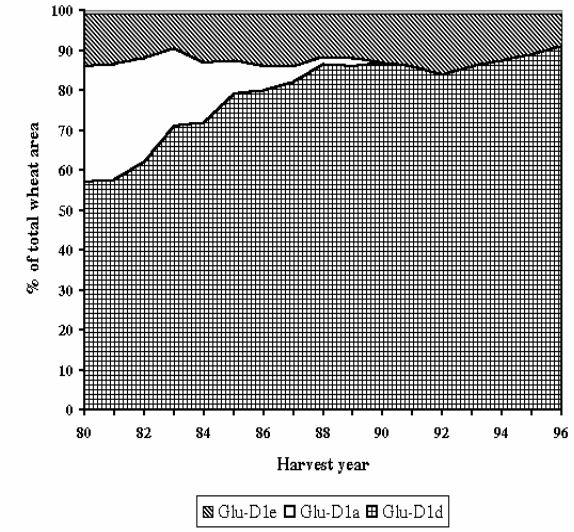

Figure 3. Area (% of total) covered by cultivars with various alleles at *Glu-D1* locus

The changes in the allele frequency for all three loci controlling the synthesis of glutenins produced changes of the glutenin scores (Figure 4).

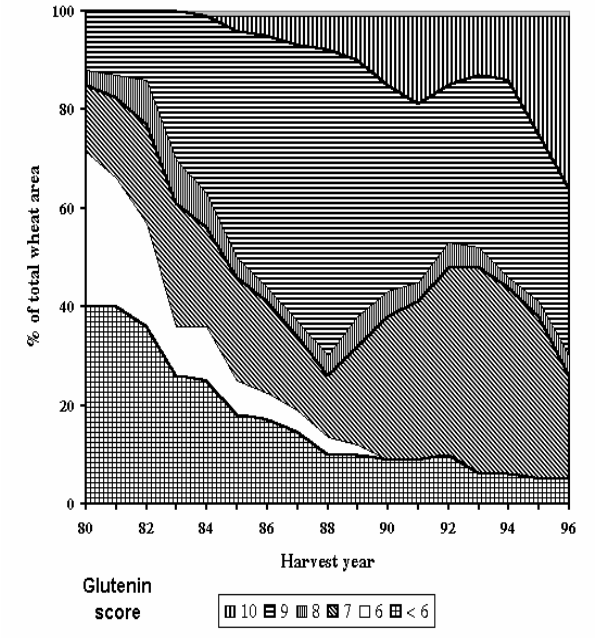

Figure 4. Area (% of total) covered by cultivars with various glutenin scores

The area covered by cultivars with glutenin scores less or equal to 6 has rapidly decreased, from more than 70% in 1980, to less than 5% in 1996. Meanwhile, cultivars having the maximum score of 10, not grown until 1984, were sown last autumn on more than 30% of the wheat area.

Consequently, the mean glutenin score for all cultivars, weighed on the area on which each cultivar was grown, increased, from only 5.7 in 1980, to 8.6 in 1996 (Figure 5).

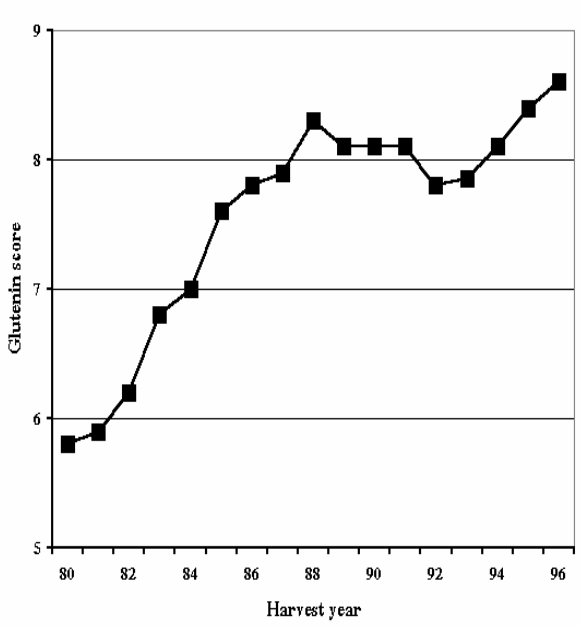

Figure 5. Average glutenin scores weight on area covered

This last score is higher than the score of 8, found by Lookhart et al. (1993) for the hard red winter cultivars grown in U.S.A in 1984.

CONCLUSIONS

Our data on the frequency of the alleles at the glutenin loci and on the area covered by winter wheat cultivars carrying various alleles suggest that the qualitative potential of Romanian wheat, as determined by its HMW glutenin subunit composition, has significantly improved. This trend is likely to continue, as some of the newest registered cultivars (Dropia, Apullum) are carriers of the most favourable glutenin subunits.

Further improvement of bread making quality in Romanian wheat might come from an increase in the frequency of alleles *Glu-A1a* and *Glu-A1b*, as well as through an improvement of gliadin or other grain components properties.

REFERENCES

Bedö, Z., Kárpáti, M., Vida, G., Kramarik-Kissimon, J., Láng, L., 1995. Good bread making quality wheat (*Triticum aestivum* L.) genotypes with 2+12 subunit composition at the *Glu-D1* locus. Cereal Research Communications, 23 (3): 283 – 289.

Graybosch, R.A., 1992. High molecular weight glutenin subunit composition of cultivars, germplasm, and parents of U.S. red winter wheat. Crop Science, 32: 1151-1155.

Hagima, I., Mihãilescu, Fl., Sãulescu, N.N., 1989. Caracterizarea unor soiuri de grâu de toamnã prin electroforeze gliadinelor ºi a gluteninelor. Analele I.C.C.P.T., 57: 385-392.

Hagima, I., Oproiu, E., Sãulescu, N.N., 1987. Corelaþia între compoziþia subunitãþilor gluteninice cu greutatea moleculară mare ºi unii indici ai calitãþii de panificaþie la grâu. Probl. genet. teor. aplic., 19 (2): 73-86.

Lagudah, E.S., O'Brien, L., Halloran, G.M., 1988. Influence of gliadin composition and high-molecular-weight subunits of glutenin on dough properties in an F_3 population of a bread wheat cross. J. Cereal Sci. 7: 33-42.

Lawrence, G.J., Moss, H. J., Shepherd K. W., Wrigley C. W., 1987. Dough quality of biotypes of eleven Australian wheat cultivars that differ in high-molecular-weight glutenin subunit composition. J. Cereal Sci. 6: 99-101.

Lookhart, G.L., Kayla Hagman, Kasarda, D. D., 1993. High-molecular-weight glutenin subunits of the most commonly grown wheat cultivars in the U.S. in 1984. Plant Breeding 110: 48-62.

Lorenzo, A., Kronstad W.E., Vieira, L. G. E., 1987. Relationship between high molecular weight glutenin subunits and loaf volume in wheat as measured by the sodium dodecyl sulfate sedimentation test. Crop Sci., 27: 253-257.

Odenbach, W., Mahgoub El-S., 1988. Relationship between HMW glutenin subunit composition and the sedimentation value in reciprocal sets of inbred backcross lines derived from two winter wheat crosses. Proc. 7th Int. Wheat Genet. Symp. Cambridge, England: 987-991.

Payne, P.I., 1987. Genetics of wheat storage proteins and the effect of allelic variation on bread making quality. Ann. Rev. Plant Physiol. 38: 141-153.

Payne, P.I., Lawrence G.J., 1983. Catalogue of alleles for the complex gene loci *Glu-A1, Glu-B1* and *Glu-D1*, which code for high-molecular-weight subunits of glutenin in hexaploid wheat. Cereal Res. Comm., 11: 29:35.

Payne, P.I., Nightingale .A., Krattinger A. F., Holt L. M., 1987. The relationship between HMW glutenin subunit composition and the bread making quality of British-grown wheat varieties. J. Sci. Food Agric. 40: 51-65.

Rousset, M., Carillo J. M., Qualset C.O., Kasarda D. D., 1992- Use of inbred recombinant lines of wheat for study of association of high-molecular-weight glutenin subunit alleles to quantitative traits. 2. Milling and breadbaking quality. Theor. Appl. Genet. 83: 403-412.

Table 1. High molecular weight glutenin subunits and corresponding alleles for the main winter wheat cultivars grown in Romania during 1980-1996.

Cultivar	Yeaf of registration	Glutenin subunits	Alleles of the genes		
			Glu-A1	*Glu-B1*	*Glu-D1*
Bezostaya 1	1961	2*;7+9;5+10	b	c	d
Dacia	1971	7;5+10	c	a	d
Libellula	1971	20;2+12	c	e	a
Iulia	1974	7+9;2+12	c	c	a
Ceres	1974	7+9;5+10	c	c	d
Doina	1977	7+8;5+10	c	b	d
Lovrin 24	1977	7+9;5+10	c	c	d
Partizanka	1977	2*;7+9;5+10	b	c	d
Fundulea 29	1979	2*;7+9;5+10	b	c	d
Lovrin 32	1979	7+9;5+10	c	c	d
Transilvania 1	1981	7+9;2+10	c	c	e
Lovrin 34	1981	7+9;5+10	c	c	d
Moldova 83	1983	2*/0;7+8;5+10	b/c	b	d
Turda 81	1984	2*;7;5+10	b	a	d
Fundulea 133	1984	2*;7+9;5+10	b	c	d
Arie^{o}an	1985	2*/0;7+9;5+10	b/c	c	d
Aniversar	1986	1;7+8/7+9;5+10/2+10	a	b/c	a/d
Albota	1986	7+9;5+10	c	c	d
Lovrin 41	1987	2*/0;7+9;5+10/2+12	b/c	c	a/d
^{a}imnic 30	1987	1;7+8;5+10	a	b	d
Fundulea 4	1987	7+9;5+10	c	c	d
Flamura 85	1989	2*/0;7+8;5+10	b/c	b	d
Apullum	1992	1;7+8;5+10	a	b	d
Rapid	1992	7+8;5+10	c	b	d
Dropia	1993	2*;7+8;5+10	b	b	d
Delia	1993	7+9;5+10	c	c	d