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EFFECTS OF Glu-1 AND Sec-1 LOCI ON BREAD MAKING QUALITY IN WHEAT CULTIVARS

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SUMMARY

Effects of Glu-1 loci allelic composition and Sec-1 locus presence on wheat bread-making quality were studied. Allelic variability in Glu-1 loci was examined by sodium-dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) of reduced seed proteins in 18 wheat cultivars from Institute of Field and Vegetable Crops in Novi Sad. The presence of Sec-1 locus was detected using the presence of secalines, by SDS-PAGE of unreduced seed proteins. Flour quality classes were designated for each cultivar based on data evaluated for two growing seasons. Three subunits were found at Glu-A1 locus, with predominance of 2 subunit (44.44%). Five subunits were detected at Glu-B1 locus, with dominance of 7+9 subunits (55.56%). At Glu-D1 locus three subunits were revealed, with highest frequency (61.11%) of 5+10 subunits. The presence of Sec-1 locus was discovered in 8 cultivars, although four of them were heterogenous. Comparison of these results with flour quality classes showed that all high-quality cultivars possess 5+10 subunits at Glu-D1 locus. High-quality cultivars also possess 2* subunit at Glu-A1 locus and 7+9 subunits at Glu-B1 locus in the highest frequencies. Presence and expression of Sec-1 locus didn't show significant effect on flour quality in analyzed genotypes.*

KEY WORDS:
bread-making quality, electrophoresis, Glu-1 loci, Sec-1 locus, wheat

1. INTRODUCTION

When flour is hydrated and mixed, the changes that occur during mixing usually depend on genetic variance of visco-elastic properties associated with polymeric proteins and their interaction with other proteins (Hammer et al., 1992; Hussain et al., 1997). Therefore, geneticaly determined variation in protein composition is expected to

produce changes in physicochemical and mechanical properties during repolymerisation of the gluten macropolymer in end-use products.

The bread making quality (BMQ) of wheat is mainly determined by the quality of endosperm storage proteins. There are two major groups of these proteins – glutenins and gliadins. Glutenins are composed of high-molecular weight (HMW) subunits, coded by the complex *Glu-1* loci and low-molecular weight (LMW) subunits, coded by *Glu-3* loci . *Glu-1* loci are located on the long arms, and *Glu-3* loci on the short arms of chromosomes 1A, 1B and 1D (Payne, 1987). Gliadins are monomeric proteins coded by *Gli-1* loci located on the short arms of chromosomes 6A, 6B and 6D. Additive and epistatic effects on bread making quality have been described between the allelic variation of the *Glu-1* and *Glu-A3/Glu-A1* loci (Gupta et al., 1989; Dencic and Vapa, 1996). It is proved that some BMQ parameters are improved in cultivars possesing 2* subunit at *Glu-A1* locus and subunits *5+10* at *Glu-D1* locus (Payne, 1987; Luo et al., 2001).

Translocation of the short arm 1R of rye chromosome to wheat is the most common way by which alien rye chromatin has been introduced to wheat germplasm. In wheat cultivars with 1BL/1RS translocation, the short arm of 1B wheat chromosome is replaced by the short arm of 1R rye chromosome. This part of rye genome carries homoelogous locus to wheat locus on 1BS, *Sec-1* (*Gli-R1*), that code rye prolamins or monomeric secalines in 1BL/1RS wheats (Carillo et al., 1992). The 1RS arm is widely used in wheat breeding programs as a resistance source to various of diseases and as a source of increased yield productivity (Martín et al., 2001). However, serious defects of bread-making quality (dough stickness and poor baking performance) have been associated with the presence of the translocation. Named factors that brought to these changes are: increasing quantity of soluble proteins (Zeller and Fuchs, 1983), the changes in glutenin-gliadin ratio (Lee et al., 1995) and quality of polymeric and monomeric proteins (Hussain and Lukow, 1994).

Effects of *Glu-1* loci allelic composition and *Sec-1* locus presence on wheat bread-making quality were studied in wheat cultivars.

2. MATERIAL AND METHODS

In this study 18 wheat cultivars from Institute of Field and Vegetable Crops, Novi Sad, were used.

Reduced proteins from a single seeds were extracted and separated by sodium-dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) as described by Vapa and Savic (1988), in order to determine high-molecular weight glutenin subunits (HMW-GS) composition of each cultivar, indicating composition of *Glu-1* loci.

Unreduced proteins from a single grains were extracted and fractionated by SDS-PAGE (Vapa and Savic, 1988), in order to detect presence of secalines bands, indicating the presence of *Sec-1* locus in a wheat genome of each cultivar.

The bread-making quality parameters were measured during two growing seasons, years 2000. and 2001. Farinogram parameters measurements grouped cultivars into quality classes according to flour quality.

3. RESULTS AND DISCUSSION

The analysis of *Glu-1* loci composition by SDS-PAGE revealed three different subunits at *Glu-A1* locus: 2* (44.44%), N (33.33%) and 1 (22.23%). Five different alleles were found at *Glu-B1* locus coding for subunits: 7+9 (55.56%), 7+8 (16.67%), 7 (11.11%), 20 (11.11%) and 13+16 (5.55%). Subunits 5+10 (61.11%), 2+12 (33.36%) and 4+12 (5.55%) were detected at *Glu-D1* locus (Table 1; Figure 1).

TABLE 1. FLOUR QUALITY CLASSES IN YEARS 2000. AND 2001. Glu-1 LOCI COMPOSITION AND Sec-1 LOCUS PRESENCE OF 18 WHEAT CULTIVARS

Cultivar	Flour quality classes		Glu-A1	Glu-B1	Glu-D1	Sec-1
	2000.	2001				
Klein Toledo	16.9 – C2	19.5 – C2	1	20	2+12	-
Orso	20.8 – C2	23.5 – C2	1	20	2+12	-
Argelato	33.5 – C1	31.9 – C1	N	7	2+12	-
Roazon	32.6 – C1	42.0 – C1	N	7	2+12	-
Talent	46.4 – B2	34.2 – C1	N	7+9/7	4+12/2+12	-
Akakomughi	36.1 – C1	52.4 – B2	N	7+8	2+12	-
NS 82/00	51.1 – B2	45.0 – B2	1	7+9	5+10	-
Diplomat	51.8 – B2	45.0 – B2	1	7+8	2+12	+/-
Lerma Rojo	61.0 – B1	58.7 – B2	2*	13+16	5+10	-
Pitikul	50.2 – B2	66.2 – B1	2*	7+9	5+10	-
Gaboto	61.7 – B1	60.9 – B1	N	7+8	5+10	+/-
MV-21	64.2 – B1	61.5 – B1	2*	7+9	5+10	+
NS 121/98	84.2 – A2	66.4 – B1	2*	7+9	5+10	+
Chris	58.5 – B1	71.6 – A2	2*	7+9	5+10	+
Amadeus	74.0 – A2	75.6 – A2	2*	7+9	5+10	+
Perlo	74.0 – A2	78.4 – A2	2*/1	7+9	5+10	+/-
Jubilnaja 50	79.6 – A2	100.0 – A1	2*	7+9	5+10	-
NS 0.1079	76.0 – A2	100.0 – A1	N	7+9	5+10	+/-

Among analyzed cultivars, two of them were heterogenous (Talent and Perlo), showing two different electromorphs each.

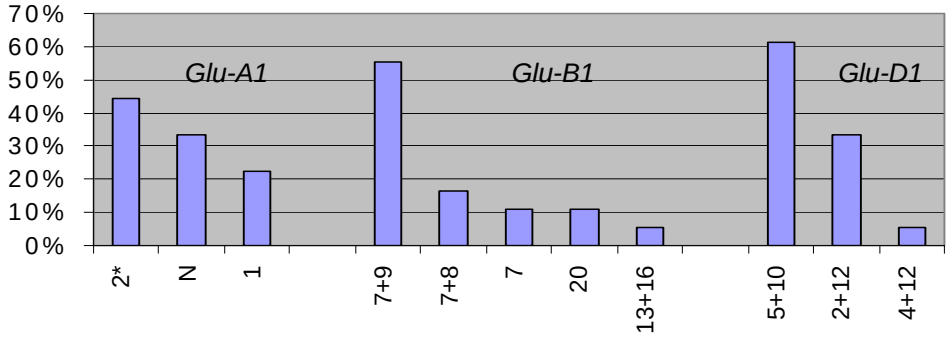

FIGURE 1. GLUTENIN SUBUNITS FREQUENCIES IN 18 WHEAT CULTIVARS

Nine different *Glu-1* loci compositions were detected, with the predominance of 2*, 7+9, 5+10 HMW-GS composition (38.89%) (Figure 2).

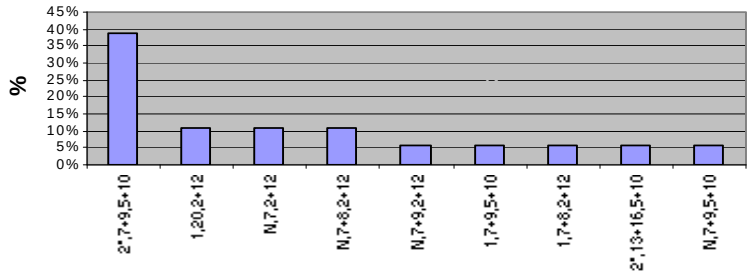

FIGURE 2. DISTRIBUTION OF HMW-GS COMPOSITION IN ANALYZED CULTIVARS

The analysis of *Sec-1* locus presence in 18 wheat genotypes showed presence of secaline bands in electrophoregram of 8 cultivars (44.44%), among which four (22.22%) were heterogenous (Diplomat, Gaboto, Perlo and NS 0.1079) (Table 1).

In examined cultivars in which, besides predominant pattern, some additional electromorphs were detected, it is difficult to conclude whether this occur due to different biotypes or seed mixture. Pedigree analysis or seed analysis from different localities is necessary for correct estimation.

According to the farinogram measurements, flour quality classes from C2 to A1 were designated for each cultivar in each growing season. Ten cultivars remained in same group in both years, while 8 cultivars showed differences in flour quality probably depending of specific environmental conditions (Table 1).The analysis of bread-making quality parameters grouped all cultivars in two major groups: lower quality from C2 to B2 (8 cultivars) and higher quality from B1 to A1 (10 cultivars) classes.

Estimating effects of *Glu-1* loci composition to bread-making quality, it is clear that all ten analyzed cultivars in higher quality group possess 5+10 subunits at *Glu-D1* locus. Previous researches (Payne, 1987; Martin et al., 2001; Luo et al., 2001) suggested that 5+10 subunits, coded by *Glu-D1* locus have positive effects to bread-making quality comparing to 2+12 subunits, namely weak alleles. Also, when 5+10 subunits occur together with the subunit 2* (*Glu-A1*) the obtained bread-making quality is better then in the combination of 5+10 subunits with the subunit 1 or null allele (Payne, 1987; Dencic and Vapa, 1996; Hussain et al., 1997). Furthermore,subunit 2* had a positive effect on dough-strength parameters (Luo et al., 2001). Our results show that eight cultivars possess 5+10 subunits together with 2* subunit (Table 1), and that all of them belong to higher quality classes. High-molecular weight glutenin subunits combination 2*, 7+9, 5+10 (the predominant one in analyzed material) was present in 7 cultivars within the highest quality groups. It seems that 7+9 subunits coded by *Glu-B1* locus give even better quality characteristics to 5+10 (*Glu-D1*) and 2* (*Glu-A1*) combination.

Six out of eight cultivars belonging to lower quality class possess 2+12 subunits coded by *Glu-D1* locus. Among those, the cultivars possessing subunits 2+12 and null allele are of better BMQ when compared to those having 2+12 subunits and 1 subunit, probably due to interaction between those alleles. Similar data were previously obtained by Dencic and Vapa (1996) and Martin et al. (2001), suggesting better effects of N and 2+12 subunits to BMQ, then 1 or 2* and 2+12 subunits.

Presence and expression of *Sec-1* locus didn't show significant effect on flour quality in analyzed genotypes. The presence of 1BL/1RS translocation might have negative impact to BMQ in MV-21 and Chris cultivars, that belong to high quality class beside the ideal HMW-GS combination. On the other hand, cultivars Gaboto, NS 121/98, Amadeus, Perlo and NS 0.1079, with the presence of translocation, didn't show decline in BMQ parameters. This can be explained by the fact that the subunits 5+10, present in these cultivars, may play a compensating role for the loss of dough strength associated with the 1BL/1RS translocation (Lee et al., 1995; Graybosch, 2001). According to Martin et al. (2001), changes on polymeric protein size distribution associated with the allelic variation for *Glu-D1* locus seem to affect some quality parameters to a greater extent than changes in monomeric and polymeric protein proportions associated with the presence of 1BL/1RS rye translocation. This conclusion is confirmed by our results. Also, simultaneous presence of HMW GS 2+12 and 1BL/1RS translocation produce a remarkable decline in gluten strength (Martin et al., 2001). None of our low quality cultivars didn't possess rye chromatin in their genomes, so detected low quality can't be the consequence of alien chromatin. In order to scope whole effects of 1BL/1RS translocation to bread-making quality it is necessary to study allelic variants of *Glu-1* loci and also variants of *Glu-3/Gli-1* and *Gli-2* loci (Martin and Carillo, 1999).

4. CONCLUSION

In the analysis of *Glu-1* loci composition in 18 wheat cultivars from the Institute of Field and Vegetable Crops in Novi Sad, three subunits were found at *Glu-A1* locus, with predominance of 2* subunit (44.44%). Five subunits were detected at *Glu-B1* locus, with dominance of 7+9 subunits (55.56%). At *Glu-D1* locus three subunits were revealed, with highest frequency (61.11%) of 5+10 subunits. The presence of *Sec-1* locus was discovered in 8 cultivars, although four of them were heterogenous. Comparation of these results with flour quality classes showed that all high-quality cultivars possess 5+10 subunits at *Glu-D1* locus. High-quality cultivars also possess 2* subunit at *Glu-A1* locus and 7+9 subunits at *Glu-B1* locus in highest frequencies. Presence and expression of *Sec-1* locus didn't show significant effect on flour quality in analyzed genotypes.

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