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CONTENT

EFFECT OF GROWING SEASON ON QUALITY PARAMETERS OF OLD AND NEW WHEAT (*Triticum aestivum L.*) VARIETIES

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ABSTRACT

The objective of this study was to analyse genotypic variations of some important wheat quality parameters (protein content – PC, sedimentation value – SD, wet gluten content – WG and dry gluten content – DG) during two growing seasons (2010 and 2011). The trial was conducted at the experimental field of the Institute of Field and Vegetable Crops, Novi Sad, with 25 wheat varieties registered and cultivated in Serbia for the last 60 years. PC, SD and WG were determined by Kjeldahl method, Zeleny sedimentation test and manual method, respectively. Strong year and genotype effects were found for all the quality traits of the studied varieties, while the effect of their interaction was not significant. The protein content of the wheat varieties ranged between 11.2% - 17.8%, with wet and dry gluten contents of 21.2 – 47.9% and 7 – 16%, respectively. Sedimentation value varied from 14 (cv. San Pastore) to 58 ml (cv. Pesma). Total protein content was positively correlated with the wet and dry gluten contents. Also, the correlation analyses have shown that older wheat varieties had higher protein content, as well as wet and dry gluten contents, but lower sedimentation values then modern cultivars. However, it should be noted that significant genotypic variations were found for all the analysed traits and varieties with good quality parameters could be identified among old and new cultivars.
***Keywords**: protein content, sedimentation value, wet and dry gluten contents, wheat varieties*

INTRODUCTION

A complex mixture of proteins present in wheat grains possesses the unique ability to form viscoelastic dough when flour is mixed with water (Delcour et al., 2010). The protein quantity and quality are essential for bread making potential of wheat genotypes (Hruskova and Famera, 2003).The flour with specific quality characteristics including protein content, wet and dry gluten and rheological properties is required for baking industry (Miralbes, 2004).
Gluten, the protein component of flour plays a key role in determining the baking quality of wheat by influencing water absorption capacity, cohesiveness, viscosity and elasticity of dough (Wieser 2007). The gluten content is directly correlated to the grain protein and it is strongly influenced by the climatic conditions. However, the wheat genotype is also one of the most important factors influencing the qualitative characteristics of gluten (Šimić, et al. 2006). Increase in total protein content of the flour positively correlates to the gluten content (Perten et al., 1992). Ratio between wet gluten (WG) content and grain protein (P) content (WG/P) is considered as an indicator of wet gluten production per protein unit. Šimić et al. (2006) reported that wheat genotypes with WG/P ratios ranging between 2.7 and 3.0 have gluten with optimal baking characteristics, while cultivars with strong gluten characteristics showed the WG/P ratio closer to 2.3.
The sedimentation value measures the sedimentation volume of gluten in the flour dispersion and it is a function of its gluten content and the gluten quality. Thus, the sediment obtained is related to the swelling of glutenins, which are associated with the bread making quality of flours (Mutlu et al., 2011).
All these quality parameters are affected by many factors, particularly genotype, locality and growing conditions and furthermore by harvesting method, postharvest treatment and storage. Thereby it is possible to explain the differences in the technological quality of wheat industrially manufactured in various regions and various years (Hruskova et al., 2004).

The objective of this study was to analyse the effect of growing season on some important quality parameters, such as protein content, wet and dry gluten contents and sedimentation value, in a set of old and new wheat varieties, registered and grown in Serbia during last 60 years.

MATERIAL AND METHODS

The field trials were set on the experimental field of the Institute of Field and Vegetable Crops, Novi Sad, Serbia, during two growing seasons (2009/10 and 2010/11). The study was conducted with 25 winter wheat varieties registered and cultivated in Serbia for the last 60 years. The randomized complete block design with three complete blocks was used and standard agronomical practice for wheat growing in Serbia was applied. Kernel samples from the trials were mechanically harvested while further analyses were done in laboratory.
The important wheat quality parameters (protein content – PC, sedimentation value – SD, wet gluten content – WG and dry gluten content – DG) were analysed in each growing season. The protein content of the samples was determined using standard analytical (AACC, 2000) method 46-16.01. Sedimentation value was determined by Zeleny sedimentation test standard analytical (AACC, 2000) method 56-61.02, while for WG and DG manual methods were applied by SRPS EN ISO 21415-1 and SRPS EN ISO 21415-3, respectively.
In order to analyse the effect of the growing season on quality parameters of wheat, the meteorological conditions during trials were obtained from the Republic Hydro-meteorological Service of Serbia. During wheat growing season (from October to July) the following climatic variables were collected: minimum temperature (Mint, °C), maximum temperature (Maxt, °C), and total precipitations (Rainfall, mm) (Figure 1).

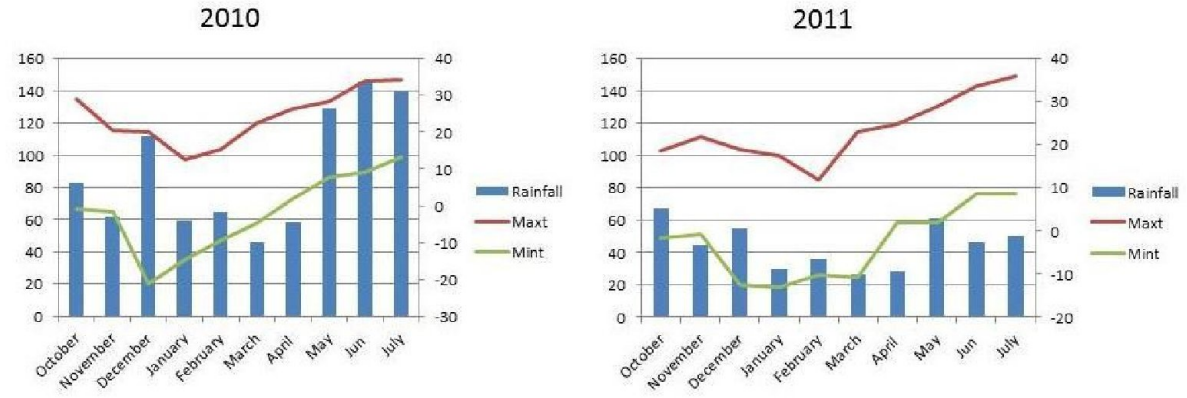

Figure 1. Basic meteorological data: minimum temperature (Mint, °C), maximum temperature (Maxt, °C), and total precipitations (Rainfall, mm) in two growing seasons.

The basic variability indicators (mean, standard deviation - StDev, and coefficient of variation - CV) for each trait, comparison of means, as well as the Pearson correlation coefficients among them were calculated in STAR- Statistical Tool for Agricultural Research v. 2.0.1.program.

RESULTS AND DISCUSSION

The results for investigated quality parameters are shown in Table 1. The protein content of the wheat varieties ranged between 13.9 (cvs. NS 40S and Zlatna Dolina) and 16.5% (cvs. Banatka and Bankut-1206) in 2010 and between 12.8 (cv. Simonida) and 15.4% (Banatka) in 2011, indicating strong genotype and year effects on this trait. The overall mean for PC was 14.3%, with coefficient of variation (CV) of 6.8%, showing high potential for PC in the

material. Sedimentation value also varied significantly among cultivars and years, with average values of 41.2 ml in 2010 and 33.1 ml in 2011, and CV of 12.8%. Significant difference was found between average values for WG obtained in two growing seasons (32.6 and 31.0% in 2010 and 2011, respectively). The dry gluten content varied significantly among the cultivars (from 8.7 to 12.9%), with CV of 11.3%, but not between the years.

Table 1. Quality parameters (PC, SV, WG and DG9) of 25 winter wheat varieties with different years of release (YOR) in two growing seasons.

Genotype	YOR	PC (%)		SD		WG		DG	
		2010	2011	2010	2011	2010	2011	2010	2011
Banatka	1955	16.5	15.4	28.0	24.3	34.3	33.5	11.5	11.2
Bankut-1206	1955	16.5	14.9	44.7	33.2	38.8	38.0	12.9	12.4
San Pastore	1958	14.4	13.2	25.7	20.3	31.6	28.9	10.9	9.6
Bezostaja 1	1959	15.4	14.2	43.3	37.7	33.4	37.6	11.2	12.6
Libelula	1962	14.5	13.7	32.7	26.7	32.4	30.6	10.8	10.2
Zlatna Dolina	1970	13.9	13.8	35.8	27.3	31.8	30.2	10.7	10.4
Sava	1970	15.3	14.7	35.8	31.7	33.3	33.3	11.0	11.2
Partizanka	1973	14.8	13.8	40.3	35.2	33.0	30.9	11.0	10.5
Ns Rana 2	1975	14.9	14.3	41.0	36.7	31.1	31.1	10.4	10.4
KG 56	1975	15.2	13.7	44.2	36.3	32.6	31.2	10.9	10.4
Balkan	1979	14.9	13.8	45.8	35.0	31.7	30.5	10.7	10.2
Jugoslavija	1980	15.2	13.8	41.2	31.3	32.6	30.4	10.9	10.1
Skopljanka	1982	15.3	13.7	41.0	31.0	32.9	29.5	11.0	9.7
Lasta	1987	14.7	13.2	38.7	30.8	27.6	26.1	9.4	8.7
Evropa 90	1990	14.5	13.2	42.2	35.8	31.2	29.9	10.4	10.0
Ns Rana 5	1990	15.0	13.5	45.7	33.7	32.2	30.5	10.9	10.2
Pobeda	1992	15.3	13.5	48.3	35.7	34.7	31.9	11.5	10.5
Renesansa	1994	15.6	13.2	43.3	33.0	34.5	31.0	11.2	10.4
Pesma	1995	15.1	13.7	50.0	37.0	32.9	31.4	11.0	10.3
Ljiljana	2000	14.5	13.3	37.3	33.7	32.3	29.7	10.8	9.8
Cipovka	2002	14.8	13.9	45.0	34.3	32.6	31.4	10.9	10.5
Dragana	2002	14.4	13.3	36.2	33.2	32.2	30.8	10.8	10.2
Simonida	2003	14.0	12.8	43.2	34.3	32.4	28.5	10.9	9.5
NS 40S/00	2006	13.9	13.4	50.0	40.2	27.3	27.7	9.2	9.3
Zvezdana	2006	14.8	13.6	51.7	38.0	34.7	30.8	11.6	10.3
Mean		14.9^{a}	13.7^{b}	41.2^{a}	33.1^{b}	32.6^{a}	31.0^{b}	10.9^{a}	10.4^{a}
Total mean		14.3		37.5		31.8		10.6	
StDev		1.2		7.9		3.6		1.2	
CV (%)		6.8		12.8		10.2		11.3	

The first growing season was characterised with significantly higher amount of precipitation then the second, while temperature conditions were similar in the both seasons. The most of the quality parameters had significantly higher values in the first then in the second growing season (Table 1), indicating a high importance of the water supply for baking quality of wheat.

Hruskova et al. (2004) in their study on the quality of commercial wheat manufactured in an industrial mill over the years 2001 and 2002 reported no significant difference between the years in protein content (2001 – average 12.4%. 2002 – average 12.8%) and Zeleny test (2001 – average 52 ml. 2002 – average 55 ml). The average values for PC obtained in this study are significantly lower, while for SD are significantly higher than in our experiment. They used modern commercially used wheat varieties, different analytical methodologies and

also had very similar growing conditions in both seasons, while in our study old and new varieties are used and growing seasons differed significantly in temperature and precipitation conditions (Figure 1).

In the study of Mutlu et al. (2015), Zeleny value was measured between 19 and 63 ml, with the average value of 33.9 ml, which is very close to our results. They also stated that wheat flour with more than 36 ml of Zeleny sedimentation value is considered as a good quality. In the present study, 20 genotypes in 2010 and 6 genotypes in 2011 had more than 36 ml of Zeleny sedimentation value, indicating more favourable conditions for this quality trait in the first growing season.

The Pearson correlation coefficients showed significant positive associations between PC and WG, PC and DG, and WG and DG in both growing seasons (Table 2). Similar results were obtained by other authors (Šíp et al., 2000; Mutlu et al., 2015). Sedimentation value had no significant correlations with other traits, which is not in agreement with findings of other authors (Kučerová, 2006; Laidig et al., 2017).

Table 2. Correlations among quality parameters (PC. SV. WG and DG9) of 25 winter wheat varieties with different years of release (YOR) and during two growing seasons.

	2010					2011				
	PC	SD	WG	DG	YOR	PC	SD	WG	DG	YOR
PC		0.014	0.695	0.679	-0.473		-0.171	0.721	0.733	-0.660
SD	0.014		0.067	0.021	0.583	-0.171		0.101	0.075	0.565
WG	0.695	0.067		0.991	-0.318	0.721	0.101		0.991	-0.530
DG	0.679	0.021	0.991		-0.366	0.733	0.075	0.991		-0.559
YOR	-0.473	0.583	-0.318	-0.366		-0.660	0.565	-0.530	-0.559	

In our study all estimated correlations were less pronounced in the first and stronger in the second growing season. Other authors who described the relationships between quality parameters of wheat varieties (Muchová, 2003; Werteker, 2003; Zimolka et al., 2005), also reported that environmental factors have an influence on quality traits and their relationships.

When quality parameters were correlated with the year of release, it was shown that only SD was positively correlated, while other traits were in negative correlations with the YOR (Table 2). It means that older wheat varieties had higher protein content, as well as wet and dry gluten contents, but lower sedimentation values then modern cultivars. High baking quality of grain is usually negatively correlated with grain yield. Since wheat breeding during last 60 years was mostly focused to higher yield it consequently caused a decrease of some quality parameters in modern wheat cultivars. Fortunately, high yield does not necessary indicates low quality and low yield high quality (Kučerová, 2006). It was also proved in our study because significant genotypic variations were found for all the analysed traits and varieties with good quality parameters could be identified among old and new cultivars.

It was also confirmed in the study of Laidig et al. (2017) investigating breeding progress, environmental variation and correlation of winter wheat yield and quality traits in German official variety trials and on-farm during 1983–2014. They found a large gain in grain yield (24%), but a strong decline in protein concentration (−8.0%) and loaf volume (−8.5%) relative to 1983. Improvement of baking quality was achieved for falling number (5.8%), sedimentation value (7.9%), hardness (13.4%), water absorption (1.2%) and milling yield (2.4%). Grain yield, falling number and protein concentration were highly influenced by environment, whereas for sedimentation value, hardness, water absorption and loaf volume genotypes accounted for more than 60% of total variation. Breeding progress was very successfully transferred into both progress in grain yield and on-farm baking quality.

On the other hand, Migliorini et al. (2016) analysed agronomic and quality characteristics of old, modern and mixture wheat varieties and landraces for organic bread chain in diverse environments of northern Italy. They reported that the bread produced with old wheat varieties was preferred by consumers when compared with the bread produced with modern wheat varieties. The old varieties and their mixtures yielded less than the modern varieties but with higher stability and robustness. Therefore, the use of old bread wheat varieties and

their mixtures, assessed with participatory and evolutionary plant breeding, in some cases could represent a strategy for local communities to cope with climate change while improving food security and food quality.

CONCLUSION

The obtained results have shown a large variation among the genotypes for all investigated traits in different growing seasons. The most of the quality parameters had higher values in the first season with high precipitation, indicating that by providing the optimal water supply during wheat growth and development the baking quality could be significantly improved. The most variable trait was SD, while the variations of PC were significantly lower. PC was positively correlated with the wet and dry gluten contents. The established correlations between the traits and the year of release of the genotypes have shown that older wheat varieties had higher protein content, as well as wet and dry gluten contents, but lower sedimentation values then the modern cultivars. All estimated correlations were less pronounced in the first (more favourable) and stronger in the second growing season (less favourable for wheat quality). It was possible to identify stable genotypes with high average values for each of the traits among the old and new cultivars. The identified genotypes can serve as parents in wheat breeding for high baking quality and high yield.

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