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END-USE QUALITY OF WHEAT CULTIVARS IN DIFFERENT ENVIRONMENTS

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SUMMARY

The end-use quality of ten winter wheat cultivars was evaluated during the two years period 2004 and 2005 and through multi location trials. A better end-use quality of cultivars was noticed in 2004 compared with 2005. The highest protein, sedimentation value and wet gluten were realized at location Nova Gradiška, while at location Osijek the highest falling number and the highest grain hardness were found. The best flour yield was noticed at location Tovarnik and Nova Gradiška. A lack of protein with the smallest wet gluten production capacity was shown at location Požega, however at this location, as well as at location Osijek, the highest gluten index was noticed. The better mixing tolerance, regarding the degree of softening, was obtained at location Osijek and Nova Gradiška, while the best dough stretching and elasticity properties were obtained at location Osijek. Based on the average values, cultivar Golubica showed the optimal values for the most indirect quality traits. Concerning the mixing behaviour of dough, cultivars Golubica, Zrnka and Janica had the highest farinograph quality number, while cultivars Srpanjka and Alka had the lowest degree of softening. Cultivars Srpanjka and Demetra showed the best dough stretching and elasticity properties.

Key words: wheat; end-use quality; environment

INTRODUCTION

The quality of wheat (*Triticum aestivum L.)* depends not only on its genetic potential for particular characters, but also on its ability to realize this potential in actual production and under different environmental conditions (Yong et al., 2004; Drezner et al., 2007; Ćurić et al., 2009). The main quality characteristics for wheat utilization

are flour extraction, flour protein concentration and dough rheology properties (Peterson, 1998). The most critical factor for obtaining optimum yield and grain end-use quality requirements is the use of the adequate cultivation practice in accordance with the plant requests (Pepo, 2007). Wheat quality properties usually are influenced by interaction of genotype and enviroment, however, magnitude of the interactions effects often are smaller compared with genotype and environment main effects. For this reason, it is very important to determine the genotype and environmental variation and their effects on the wheat end-use quality (Graybosch et al., 1996; Budak et al., 2003). The objective of this study was to evaluate the impact of cultivars and important wheat productive regions of Croatia on wheat end-use quality traits and provide the valuable knowledge for breeding purposes.

MATERIAL AND METHODS

The trial with ten winter wheat cultivars (Žitarka, Demetra, Srpanjka, Super Žitarka, Golubica, Panonka, Ševa, Zrnka, Janica and Alka) created at the Agricultural Institute Osijek was set up as randomized complete block design (RCBD) at four locations (Osijek-eutric cambisol, Nova Gradiska-alluvium, Tovarnik-blackearth and Pozega-pseudogley) in three repetitions during 2003/2004 and 2004/05 year. Cultivars were planted with sowing rate of 650 seeds m^{-2} in eight row plots of 7 m length and 1.08 m width. Harvested area was 7.56 m^2. The flours (ash content 0.55) were obtained by grains milling on a Brabender Quadromat Senior Mill. Flour and bran fractions were collected and weighed and flour yield (%) was calculated. The protein content and grain hardness were determined by NIT spectroscopy (Infratec 1241, Foss Tecator). Zeleny sedimentation value was measured according to ICC method No 116/1. Wet gluten content and gluten index were determined according to ICC method No 155. The dough rheologycal properties were evaluated by Brabender farinograph and extensograph in accordance with ICC No 115/1 and ICC No 114/1, respectively.

An analysis of variance was performed using the GLM procedure (SAS Institute Inc., 2004). Means were compared using the Duncan test (P=0.05).

RESULTS AND DISCUSSION

In the combined ANOVA, statistically significant differences for all indirect quality parameters (except FY which is not under Y affect) were found among genotypes (G), locations (L) and years (Y). Regarding interaction terms for indirect quality parameters, P, SED and GI are under all interactions, while FN is not under G x L and G x Y x L and FY is not affected by any interaction (Table 1). These results are in accordance with the earlier findings of Graybosch et al. (1995, 1996), Drezner et al. (2007) and Marić et al. (2007) for agronomic and some indirect quality traits.

Table 1 Analysis of variance for indirect quality traits
Tablica 1. Analiza varijance indirektnih parametara kakvoće

Source of variation *Izvor varijacija*	df *ss*	Means of squares (σ^2) *Sredina kvadrata*						
		P[a] *P[a]*	SED *SED*	WG *VG*	GI *GI*	FN *BP*	H *T*	FY *IZB*
Genotype G *Genotip*	9	3.4*	834.7*	209.6*	1286.7*	33313.3*	2072.9*	32.9*
Year Y *Godina*	1	1.8*	819.0*	1024.7*	1510.8*	482680.9*	6379.4*	3.0^{ns}
Location L *Lokacija*	3	35.0*	1062.6*	578.9*	754.7*	8318.3*	1444.7*	19.8*
G x Y	9	0.7*	65.0*	22.9*	82.6*	31817.1*	54.1*	13.5*
G x L	27	0.3*	48.1*	7.0*	51.3*	946.6^{ns}	58.6*	4.8^{ns}
Y x L	3	16.2*	1075.3*	280.4*	251.4*	8404.2*	2502.2*	2.1^{ns}
G x Y x L	27	0.3*	35.5*	7.5*	54.7*	629.5^{ns}	69.3*	4.6^{ns}

[a]P=grains protein content (%); SED=sedimentation value (cm^3); WG=wet gluten (%); GI=gluten index; FN=falling number (s); H= grain hardness; FY=flour yield (%)
* - significant at P=0.05 / ^{ns} - non significant
[a]P=udio protein u zrnu (%); SED=sedimentacijska vrijednost (cm^3); VG=vlažni gluten (%); GI=gluten indeks; BP=broj padanja (s); T= tvrdoća zrna; IZB=izbrašnjavanje (%)
** - značajno na p=0,05 / – nije značajno*

Considering dough rheological properties, statistically significant differences for all analyzed parameters were found among G, L and Y, as well as their interactions, except for DDT and R_{MAX} which are not affected by G x Y x L interaction (Table 2). Concerning interaction effects, Y x L interaction had the main effect on quality traits with stronger influence on indirect quality parameters compared with dough rheological properties. Y was dominant source of variation for the most analyzed traits (WG, GI, FN, H, DDT, DS, FQN, R/EXT), while L was dominant for P and SED. G had the main effect on FY, WA, E and R_{MAX}) (Table 1 and 2).

Table 2 Analysis of variance for rheological dough parameters
Tablica 2. Analiza varijance reoloških svojstava tijesta

Source of variation *Izvor varijacija*	df *ss*	Means of squares (σ^2) *Sredina kvadrata*						
		Farinographic parameters *Farinografska svojstva*				Extensographic parameters *Ekstenzografska svojstva*		
		WA[a] *UV*[a]	DDT *RAZ*	DS *SO*	FQN *FBK*	E *E*	R_{MAX} O_{MAKS}	R/EXT *O/RAS*
Genotype G *Genotip*	9	72.7*	8.3*	7567.3*	3755.6*	8845.6*	257958.9*	5.0*
Year Y *Godina*	1	35.4*	12.88*	34987.2*	37546.3*	3124.1*	163328.4*	10.9*
Location L *Lokacija*	3	50.1*	7.0*	1671.6*	3072.2*	3233.2*	78256.1*	4.3*
G x Y	9	7.5*	1.7*	2922.3*	1277.5*	448.4*	15596.6*	0.5*
G x L	27	0.8*	0.8*	305.3*	1119.3*	198.4*	4757.9*	0.2*
Y x L	3	10.5*	6.3*	1633.3*	3114.4*	845.0*	29754.7*	2.4*
G x Y x L	27	1.0*	0.4^{ns}	446.6*	770.9*	180.2*	4131.4^{ns}	0.1*

[a]WA=water absorption (%); DDT=dough development time (min); DS=degree of softening (FU); FQN=farinograph quality number; E=dough energy (cm^2); R_{MAX}=maximum resistance (EU); R/EXT=resistance to extensibility ratio
[a]UV=upijanje vode (%); RAZ=razvoj tijesta (min); SO=stupanj omekšanja (FJ); FBK=farinografski broj kakvoće; E=energija tijesta (cm^2); O_{MAKS}=maksimalni otpor (EJ); O/RAS=omjer otpora i rastezljivosti

Williams et al. (2008) summarised the knowledge of the relative contributions of G, E and G x E interaction effects on wheat quality from 4 major international basis and concluded that in North America and Europe the relative contributions varied across the studies, but traits associated with protein content were more influenced by E and G x E than those associated with protein quality such as dough rheology and starch characteristics, where G effect was more important. In this study, dough E and R_{MAX}, traits associated with protein quality, were more influenced by G, what is partially consistent to Barić et al. (2004) who found larger components of variation due to genotype for all dough rheology properties. Other dough rheological properties, as well as majority quality traits, were under stronger environmental impact what is in accordance with findings of other authors (Peterson et al., 1998; Grausgruber et al., 2000; Rharrabti et al., 2003). The mean values of indirect quality parameters are presented in Table 3. Cultivar Golubica resulted in significantly higher P (14.6%), WG (39.6%) and SED (63.1 cm^3). Cultivars Demetra (97.8) and Srpanjka (97.5) showed the highest value of GI, as direct measure of gluten quality (Ćurić et al., 2001; Lasztity,

2003; Šimić et al., 2006). All cultivars, except Demetra and Alka, had the optimal alpha-amylase activity (FN=250-350 s). Cultivars Žitarka (64.0) and Golubica (59.1) had the highest grain H, while the best FY (above 72%), what is important economic factor, was obtained by cultivars Demetra, Srpanjka, Golubica and Alka.

Table 3 Means for indirect wheat quality parameters
Tablica 3. Srednje vrijednosti indirektnih parametara kakvoće

Treatment *Tretman*		P[a] *P[a]*	SED *SED*	WG *VG*	GI *GI*	FN *BP*	H *T*	FY *IZB*
Genotype *Genotip*	Žitarka	14.4 b*	54.1cd	38.7 ab	76.4 f	344.6 a	64.0 a	68.6 d
	Demetra	13.3 h	56.1 c	30.1 f	97.8 a	240.8 d	28.8 h	72.3 ab
	Srpanjka	13.8 de	49.1 ef	29.3 f	97.5 a	347.1 a	36.5 g	72.9 a
	Super žitarka	13.6 ef	51.4 de	34.2 d	84.5 cd	314.1 bc	56.2 c	69.5 d
	Golubica	14.6 a	63.1 a	39.6 a	82.1 ed	304 c	59.1 b	72.2 abc
	Panonka	14.1 c	46.3 f	38.5 b	73.0 g	330.8 ab	45.2 f	71.3 bc
	Ševa	14.3 bc	43.1 g	36.2 c	74.0 fg	317.6 bc	50.1 e	71.9 abc
	Zrnka	13.5 fg	40.1 g	31.9 e	85.4 c	346.9 a	52.3 de	69.8 d
	Janica	13.9 d	59.6 b	33.4 d	90.7 b	323.1 b	54.4 cd	71.0 c
	Alka	13.3 gh	48.5 ef	33.5 d	79.3 e	213.4 e	35.8 g	72.5 a
Year *Godina*	2004	14.0 a	48.9 b	37.1 a	81.0 b	363.2 a	54.6 a	71.3 a
	2005	13.8 b	53.4 a	32.0 b	87.1 a	253.3 b	41.9 b	71.0 a
Location *Lokacija*	Osijek	14.2 b	52.9 b	35.7 b	86.8 a	321.5 a	56.1 a	70.8 bc
	Tovarnik	13.8 c	50.0 c	35.0 c	83.0 b	308.1 b	45.5 c	71.9 a
	Nova Gradiška	14.9 a	56.9 a	38.2 a	78.4 c	288.2 c	49.4 b	71.6 ab
	Požega	12.7 d	44.7 d	29.2 d	88.1 a	315.2 ab	42.0 d	70.4 c
Mean / *Srednja vrijednost*		13.9	51.1	34.5	84.1	308.3	48.3	71.2

[a]P=grains protein content (%); SED=sedimentation value (cm^3); WG=wet gluten (%); GI=gluten index; FN=falling number (s); H=grain hardness; FY=flour yield (%)
* - different letters means significant difference among treatments at P=0.05 by Duncan's MRT
[a]P=udio protein u zrnu (%); SED=sedimentacijska vrijednost (cm^3); VG=vlažni gluten (%); GI=gluten indeks; BP=broj padanja (s); T= tvrdoća zrna; IZB=izbrašnjavanje (%)
** - različita slova označavaju signifikatnu razliku između tretmana na razini p=0,05 prema Duncan testu*

The year 2004 resulted in significant higher P, WG, FN, H and FY in comparison to 2005 year. Considering locations, the highest P, SED and WG were realized at location Nova Gradiška, while at location Osijek and Požega were found the highest GI. The highest FN and grains H were obtained at location Osijek, while the best FY was noticed at locations Tovarnik and Nova Gradiška. Location Požega showed a lack of P with the smallest WG production capacity, which accords with the findings of Šimić et al. (2006) and Drezner et al. (2007).

Table 4 Means for rheological dough properties
Tablica 4. Srednje vrijednosti reoloških svojstava tijesta

Treatment *Tretman*		Farinographic parameters *Farinografska svojstva*				Extensographic parameters *Ekstenzografska svojstva*		
		WA[a] *UV[a]*	DDT *RAZ*	WA[a] *UV[a]*	DDT *RAZ*	WA[a] *UV[a]*	DDT *RAZ*	WA[a] *UV[a]*
Genotype *Genotip*	Žitarka	61.2a	3.0 bc	78.6 c	72.1 de	58.3 de	266.2 d	1.3 c
	Demetra	56.5g	2.0 f	70.1 d	72.9 d	106.4 a	525. a	2.2 a
	Srpanjka	57.0 f	2.3 ef	59.8 ef	74.9 cd	87.4 b	455.0 b	2.2 a
	Super žitarka	61.4 a	2.5 efd	80.3 c	65.1def	69.4 c	381.2 c	2.3 a
	Golubica	60.1 c	3.9 a	65.8 ed	104.6 a	64.6 cd	265.6 d	1.1 d
	Panonka	60.6 b	2.8 bcd	102.5 b	58.8 ef	33.8 g	140.4 e	0.8 e
	Ševa	57.1 f	4.0 a	103.3 b	67.7 de	34.4 g	149.3 e	0.8 e
	Zrnka	59.3 d	3.9 a	78.0 c	88.8 b	44.2 f	233.9 d	1.6 b
	Janica	58.5 e	3.0 b	56.2 f	86.6 bc	81.1 b	373.3 c	1.7 b
	Alka	55.5 h	2.5 cde	124.3 a	52.9 f	54.1 e	242.4 d	1.2 cd
Year *Godina*	2004	58.2 b	3.3 a	67.1 b	89.8 a	67.8 a	335.3 a	1.8 a
	2005	59.1 a	2.7 b	96.7 a	59.1 b	59.0 b	271.4 b	1.3 b
Location *Lokacija*	Osijek	59.7 a	3.3 a	79.6 bc	83.2 a	73.2 a	338.2 a	1.5 b
	Tovarnik	58.7 c	3.0 b	91.1 a	74.2 b	67.9 b	315.8 a	1.5 b
	Nova Gradiška	59.4 b	3.3 ab	76.0 c	77.9 ab	52.9 d	238.6 b	1.1 c
	Požega	57.2 d	2.4 c	81.1 b	62.5 c	59.6 c	320.9 a	1.9 a
Mean / *Srednja vrijednost*		58.8	3.0	82.0	74.5	63.4	303.4	1.5

[a]WA=water absorption (%); DDT=dough development time (min); DS=degree of softening (FU); FQN=farinograph quality number; E=dough energy (EU); R_{MAX}= maximum resistance (EU); R/EXT= resistance to extensibility ratio

* - different letters means significant difference among treatments at P=0.05 by Duncan's MRT

[a]UV=upijanje vode (%); RAZ=razvoj tijesta (min); SO=stupanj omekšanja (FJ); FBK=farinografski broj kakvoće; E=energija tijesta (EJ); O_{MAKS}=maksimalni otpor (EJ); O/RAS=omjer otpora i rastezljivosti

*- različita slova označavaju signifikatnu razliku između tretmana na razini p=0,05 prema Duncan testu

Evaluated cultivars responded in specific manner in respect of dough rheological properties regarding the years-locations trials. Concerning the mixing behaviour of dough, cultivars Žitarka, Super Žitarka, Golubica and Panonka had the highest WA capacity (above 60%), while cultivars Golubica, Zrnka and Ševa had the highest DDT (3.9 and 4.0 min, respectively). Cultivars Srpanjka and Janica, with DS below 60 FU, showed the highest mixing tolerance (Table 4).

Regarding dough resistance to stretching and elastic properties of dough, the cultivars Demetra and Srpanjka showed the highest R_{MAX} (525 EU and 455 EU, respectively) as well as the highest area under the extensogram curve (E=106.4 cm^2 and 87.4 cm^2, respectively), followed by balanced R/EXT ratio (2.2). In our previous dough rheological studies (Jurković et al., 2000; Magdić et al., 2006; Horvat et al., 2008), the cultivar Golubica showed optimal indirect properties regarding farinographic parameters, while cultivars Srpanjka and Demetra also showed the higher gluten strength regarding GI and extensographic parameters. The year 2004 resulted in better almost all physical dough properties (except WA) when comparing to year 2005. Among locations, location Osijek resulted in statistically higher WA, FQN and dough E. The highest values of DDT was noticed at locations Osijek and Nova Gradiška. The better mixing tolerance, regarding DS value, was obtained at locations Osijek and Nova Gradiška, while the best dough resistance to stretching and the best dough elasticity, considering E and R_{MAX}, were obtained at location Osijek.

CONCLUSIONS

Results pointed out the significant differences among cultivars for observed end-use quality traits. Environmental variance in the end-use quality traits was greater than the variance associated with cultivars. Genotype-environment interaction had a significant influence on end-use quality parametes, but contributed a smaller proportion of variability when compared with environment or genotype main effects. Overall, cultivars were obtained the best indirect quality traits at location Nova Gradiška, while the best dough rheological properties were obtained at location Osijek. Analyzing multi-environment trial data, cultivars Golubica, Demetra, Srpanjka and Janica showed the most favorable end-use quality traits.

NAMJENSKA KAKVOĆA KULTIVARA PŠENICE U RAZLIČITIM OKOLIŠNIM UVJETIMA

SAŽETAK

Namjenska kakvoća deset kultivara ozime pšenice je analiziran tijekom dvije 2004. i 2005. godine na višelokacijskom pokusu. U 2004. godini kultivari su na razini prosječnih vrijednosti ostvarili bolju namjensku kakvoću u usporedbi s 2005. Najveće vrijednosti proteina, sedimentacijske vrijednosti i vlažnog glutena ostvarene su na lokaciji Nova Gradiška, dok su na lokaciji Osijeku dobivene najveće vrijednosti broja padanja i tvrdoće zrna. Najbolje izbrašnjavanje je zabilježeno na lokaciji Tovarnik. Lokacija Požega je imala najniži udio proteina s najmanjim kapacitetom produkcije vlažnog glutena, međutim na ovoj lokaciji kao i na lokaciji Osijek ostvarena je najveća vrijednost gluten indeksa. Bolja tolerancija na zamjes, obzirom na stupanj omekšanja tijesta, ostvarena je na lokaciji Osijek i Nova Gradiška, dok su najveći otpor na rastezanje tijesta i najbolja elastičnost tijesta, obzirom na energiju i maksimalni otpor, ostvareni na lokaciji Osijek. Sveukupno, kultivar Golubica je imao najbolje vrijednosti za većinu indirektnih pokazatelja kakvoće. Promatrajući svojstva tijesta pri zamjesu, kultivari Golubica, Zrnka i Janica su imali najveći farinografski broj kakvoće, dok su najmanji stupanj omekšanja tijesta imali kultivari Srpanjka i Alka. Što se tiče otpora tijesta na rastezanje i svojstva elastičnosti, najbolja svojstva su ostvarili kultivari Srpanjka i Demetra.

Ključne riječ: pšenica, kakvoća pšenice za namjensku uporabu, okolina

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