GENOTYPE EFFECT ON DOUGH RHEOLOGICAL PROPERTIES AND BREAD CRUMB STRUCTURE OF FLOURS WITH DIFFERENT GLUTEN STRENGTH

Daniela HORVAT [1] *– Georg DREZNER* [1] *– Damir MAGDIĆ* [2] *– Gordana ŠIMIĆ* [1] *– Krešimir DVOJKOVIĆ* [1]

[1] Department for Cereal Breeding and Genetics, Agricultural Institute Osijek, Južno predgrađe 17, 31000 Osijek, e-mail: daniela.horvat@poljinos.hr
[2] Department of Process Engineering, Faculty of Food Technology, J.J. Strossmayer University in Osijek

Abstract: In accordance with evaluated gluten characteristics, the analyzed cultivars were classified into two groups. Cultivars Žitarka, Golubica and Janica with higher exstensibility, lower resistance and optimal elasticity were characterized as group with medium gluten. Cultivars Srpanjka, Soissons and advance line Osk. 266/03 with lower extensibility, high resistance and reduced elasticity were characterized as group with strong gluten. The cultivars with strong gluten have been characterized as bread improvers and these cultivars have shown higher contents of total glutenins and HMW glutenin subunits. Using bread improver significantly destroyed dough viscoelastic properties of these with higher gluten strength with negative effect on loaves shape and bread crumb structure.

Keywords: genotype, gluten strength, dough rheology, bread crumb structure

Introduction

The bread making quality of wheat is affected by genotype selecting, growing treatments, their interactions and conditions of technological process (Sabo and Pepó, 2007; Pepo *et al.* 2005b). The milling industry requires storing of different wheat types separately on the basis of their end-use properties and properly blending of the grain to obtain the optimal flour for the particular product of interest (Tanács, 2007). The dough improvers have been used to improve dough handling properties, increase quality of fresh bread and extend the shelf-life of stored bread. The rheological properties of input flours are very important when considering which type of improver should be used. Oxidizing agent such as L-ascorbic acid strengthened the structure of dough through oxidation of SH- group into S-S bridges**.** Its effect is more pronounced on the extensograms and alveograms through dough resistance increasing and extensibility decreasing (Hrušková and Novotná, 2003).

Materials and methods

The field trials with five winter wheat cultivars (Žitarka, Golubica, Srpanjka, Janica, and Soissons) and one advanced line Osk. 266/03 were set up on eutric cambisol soil type (pH_{KCl}=6.25, humus=2.20%) at Osijek location as RCB design with three repetitions in 2005/2006 year at the experimental field of the Agricultural Institute Osijek. Cultivars were planted in eight row plots of 7 m length and 1.08 m wide with sowing rate of 650 seeds m^{-2}. Harvested area was 7.56 m^2. The flours (ash content 0.55) were obtained by grains milling on a Brabender Quadromat Senior Mill. The protein content of flours was determined by NIT spectroscopy (Infratec 1241, Foss Tecator). Wet gluten content and gluten index were determined according to ICC standard method No 155. The dough rheologycal properties were evaluated by Farinograph and Extensograph (Brabender, Duisburg, Germany) in accordance with ICC No 115/1 and ICC No 114/1, respectively. Glutenin proteins were analyzed by RP-HPLC system

 DOI: 10.1556/CRC.36.2008.Suppl.0449

(Integral 4000, Perkin Elmer), following the quantitative extraction and HPLC procedure of Wieser *et al.* from 1998. The peak area under chromatogram was used as a direct measure for content of glutenins. The bread recipe (based on flour weight) was: water according to the farinographic absorption, 2% salt and 2% fresh yeast. Improver Ekstrapan Plus (emulgator E472e, L-ascorbic acid E300, anticoagulant substance E170 and fungal enzymes) was added in concentration of 0.4% as recommended dose by producer (Kvasac d.o.o., Croatia). The components were mixed at San Cassiano spiral mixer with slow (3 min) and high speed (6 min). Dough was divided, rounded and proofed for 50 min (28 ^{o}C, 87% RH) and baked at Roto oven (Miwe-roll-in) for 32 min at a temperature gradient from 250 to 230 ºC. Loaves volumes were measured by tailor centimeter and shape (H/D ratio) of loaves was measured too. Image analysis of the sliced loaves was done using GlobalLab Image/2 software. A crumb structure evaluation was done by calculating of average cell area as measure of cells size and total cells area as measure of crumb porosity. Statistical analysis of data was carried out in SAS System 8.2 Software.

Results and discussion

The flour quality traits of analyzed cultivars are shown in Table 1. Genotypes Osk. 266/03 and Golubica had the highest value of protein and wet gluten content. The highest gluten index showed Osk. 266/03 and Soissons. Golubica and Soissons had the best flour yield, while Srpanjka, Osk. 266/03 and Soissons had the highest contents of total glutenins and HMW-GS. These results are in accordance with our previous investigations of genotypes quality in relation to different gluten characteristics (Drezner *et al.* , 2007; Dvojković *at al.* 2007; Horvat *et al.*, 2006).

Table 1. Flour quality traits

GEN	P[a]	WG	GI	Y	GLUT	HMW-GS
ŽIT[c]	10.3	25.3	91	70	681	181
GOL	12.9	33.7	77	75	714	195
JAN	11.4	25.5	97	71	739	189
SRP	12.0	28.0	97	70	892	224
OSK 266/03	13.4	28.6	99	73	775	236
SOI	12.4	27.6	99	75	839	241
MEAN	12.1	28.1	93	72	773	211

[a]P=flour protein content (%); WG=wet gluten (%); GI=gluten index; Y=yield of flour (%); TGLUT= content of total glutenins (AU [b]); THMW-GS= content of high-molecular-weight glutenin subunits (AU)
[b]AU= area under the glutenins chromatogram expressed as arbitrary units
[c]ZIT=Žitarka; GOL=Golubica; JAN=Janica; SRP=Srpanjka; OSK 266/03=advance line Osk. 266/03; SOI=Soissons

The farinograph, extensograph and gluten index tests are the most frequently used for gluten strength evaluation in Croatia (Horvat *et al.*, 2006). In some European countries, like France and Hungary, the alveograph test is used (Toth *et al*., 2006b; Tanács, 2007), while in the USA the mixograph is more prefer. The impact of bread improver on farinographic parameters was the most prounanced on degree of softening what resulted in lower quality group (Table 2). Addition of improver generally increased dough energy and disturbed R/EXT ratio as result of dough resistance increasing and extensibility decreasing. Improver addition increased loaves volume up to 14%, but it

didn't have significant influence on H/D ratio. Regarding bread crumb structure, there was noticed significant influence of improver on cells size, while the crumb porosity was on the same level as in the control group.

Table 2. The mean values of quality parameters under experimental treatments

PARAM.		WA[a]	DDT	DS	E	R_{Max}	R/Ext	V	H/D	TCA	ACA
TREAT.	1[b]	59.7	2.1	70	87	458	2.1	3197	0.66	39.3	115
	2	59.6	1.8	96	111	798	5.6	3673	0.69	39.5	129
$LSD_{0.05}$		3.1	0.6	21.5	29.7	180.8	1.4	93.9	0.05	5.5	11.8

[a]WA=water absorption (%); DDT=dough development time (min); DS=degree of softening (FU); E=energy (cm^2); R_{MAX}=resistance at curve maximum (EU); R/EXT=resistance to extensibility ratio; V=loaves volumes (cm^3); H/D=height/diameter ratio; TCA=total cell area (%); ACA=average cell area (pixells)
[b]1=control; 2=improver

The analyzed cultivars, in accordance with gluten characteristics obtained by dough rheological analysis, were divided into two groups. Žitarka, Golubica and Janica with higher exstensibility, lower resistance and good elasticity belonged to the first group with gluten characterized as medium strength (Table 3). Srpanjka, Soissons and advance line Osk. 266/03 with lower extensibility, high resistance and reduced elasticity belonged to the second group characterized with strong gluten. The genotypes with higher gluten strength have been characterized as bread improvers and these genotypes have shown higher contents of total glutenins as well as of HMW-GS (Table 1).

Table 3. Quality parameters grouped by genotypes and treatments

PARAM.			WA[a]	DDT	DS	E	R_{Max}	R/Ext	V	H/D	TCA	ACA
GEN	ZIT[b]	1[c]	64.8	1.7	117	47	278	2.0	3174	0.50	37.5	125
		2	64.4	1.7	144	55	559	6.4	3512	0.74	46.3	142
	GOL	1	60.5	3.5	73	63	254	0.9	3359	0.61	44.9	175
		2	60.4	2.8	88	120	583	2.1	3734	0.67	38.8	128
	JAN	1	61.6	2.2	39	74	326	1.4	3249	0.67	39.7	105
		2	61.7	2.0	87	98	662	3.8	3826	0.73	52.3	132
	SRP	1	60.9	1.8	55	74	452	2.2	3251	0.72	38.6	73
		2	60.6	1.7	73	98	886	7.8	3681	0.72	39.3	143
	OSK 266/03	1	57.2	1.8	52	126	694	2.7	3267	0.76	40.6	118
		2	57.0	1.5	84	159	1040	5.4	3895	0.63	32.3	104
	SOI	1	53.2	1.4	84	127	744	3.5	2885	0.70	34.7	92
		2	53.5	1.2	99	141	1058	8.1	3770	0.67	27.8	127
MEAN			59.7	1.9	83	99	628	3.9	3467	0.68	39.4	122
$LSD_{0.05}$			0.3	0.5	24.6	21.8	194.8	3.3	296.5	0.07	8.6	20.7

[a]WA=water absorption (%); DDT=dough development time (min); DS=degree of softening (FU); E=energy (cm^2); R_{MAX}=resistance at curve maximum (EU); R/EXT=resistance to extensibility ratio; V=loaaves volumes (cm^3); H/D=height/diameter ratio; TCA=total cell area (%); ACA=average cell area (pixells)
[b]ZIT=Žitarka; GOL=Golubica; JAN=Janica; SRP=Srpanjka; OSK 266/03=advance line Osk. 266/03; SOI=Soissons
[c]1=control; 2=improver

The improver addition had positive impact on Žitarka through increased loaf volume up to 10% and significant increasing of H/D ratio as well as of bread crumb structure (Table 3). Regarding Golubica, the R/Ext ratio with improver had obtained optimal

 DOI: 10.1556/CRC.36.2008.Suppl.0449

value. Loaf volume of this cultivar was increased for 10% accompanied by H/D ratio increasing and crumb structure parameters decreasing. Improver addition had also positive effect on bread properties of Janica through increasing of loaf volume for 15% and H/D ratio, without destroying the crumb structure. The improver had negative effect on Srpanjka through significant increasing of R/Ext followed by loaf volume increasing for 12% without changing H/D ratio, but there was observed totally destroyed bread crust and significant increasing of cells size without crumb porosity changing (Table 3). The line Osk 266/03 had the second biggest loaf volume in control group with satisfying crumb cell characteristics. However, in combination with improver there was not noticed a significant distortion of R/Ext. Addition of improver increased loaf volume for 16% followed by significant decreasing of H/D ratio as well as significant decreasing of crumb porosity. Addition of improver had also negative effect on bread properties of Soissons through high increasing of R/Ext. This cultivar also showed the largest increase in loaf volume (23%) followed by decreasing of H/D ratio. Improver addition significantly increased the cells size of this cultivar without significant crumb porosity changing. There was also noticed appearance of several very large cells on slice's area as well known characteristic of flours with disturbed viscoelastic properties.

Conclusions

The gluten strength characteristics of genotypes should be taken into consideration before the decision about baking conditions and recepies is made. Addition of improver had possitive effect on flours with medium gluten strength, through improvment of loaves volumes and shape with satisfying crumb structure. However, the added improver significantly destroyed viscoelastic dough properties, as well as bread crumb structure of flours with stronger gluten. Considering the frequently implementation of oxidative additives in the bakery industry, the cultivars with stronger gluten should be used in combination with flours of weak baking characteristics.

References

Drezner G., Dvojkovic K., Horvat D., Novoselovic D., Lalic A. 2007. Environmental impacts on wheat agronomic and quality traits. Cereal Research Communications, **35:** 2. 357-360.

Dvojkovic K., Drezner G., Horvat D., Novoselovic D., Španić V. 2007. Fusarium head blight influence on agronomic and quality traits of winter wheat cultivars. Cereal Research Communications, **35:** 2. 365-368.

Horvat D., Jurković Z., Drezner G., Šimić G., Novoselović D., Dvojković K. 2006. Influence of Gluten Proteins on Technological Properties of Croatian Wheat Cultivars. Cereal Research Communication, **34:** 2-3. 1177-1184.

Hrušková M. and Novotná D. 2003. Effect of Ascorbic Acid on the Rheological Properties of Wheat Fermented Dough. Czech Journal of Food Science, **21:** 4. 137–144.

Pepo P., Tóth Sz., Oskolás H., Bódi Z., Erdei E. 2005b. Analysis of the quality of winter wheat (*Triticum aestivum L.)* lines in different years. Növénytermelés, **54:** 3. 137-143.

Szabo E., Pepó P. 2007. Selection of winter wheat *(Triticum aestivum L.)* cultivars meeting complex EU quality requirements. Cereal Research Communications, **35:** 2. 1125-1128.

Tanács L. 2007. Seasonal and genotype effect on the alveographic value of winter wheats. Cereal Research Communications, **35:** 2. 1197-1200.

Toth A., Sipos P., Gyıri Z. 2006b. Alveograph analysis of the rheological properties of winter wheat *(Triticum aestivum L.)* varieties. Novenytermeles, **55:** 1-2. 3-13.