EFFECT OF AN OXIDIZING IMPROVER ON DOUGH RHEOLOGICAL PROPERTIES AND BREAD CRUMB STRUCTURE IN WINTER WHEAT CULTIVARS (*TRITICUM AESTIVUM L.)* WITH DIFFERENT GLUTEN STRENGTH

Daniela Horvat[1]*, Georg Drezner[1], Damir Magdić[2], Gordana Šimić[1], Krešimir Dvojković[1], Jasmina Lukinac[2]

ABSTRACT

The influence of an oxidizing bread improver on dough rheology and bread properties of the wheat (*Triticum aestivum L.*) flours with different gluten characteristics was investigated. The effect of bread improver on extensographic parameters was more pronounced in comparison with farinographic ones. In accordance with evaluated gluten characteristics, the analyzed cultivars were classified into two groups. Cultivars Žitarka (N, 7+8, 2+12), Golubica (N, 7+9, 2+12) and Janica (N, 7+9, 2+12) with higher extensibility, lower resistance and optimal elasticity were characterized as group with medium gluten strength. Cultivars Srpanjka (N, 7+8, 2+12), Soissons (2*, 7+8, 5+10) and advance line Osk. 266/03 (N, 7+8, 5+10) with lower extensibility, high resistance and reduced elasticity were characterized as group with strong gluten. The cultivars with strong gluten had higher contents of total glutenins and HMW glutenin subunits. Using bread an oxidizing improver significantly destroyed dough viscoelastic properties of cultivars with higher gluten strength with negative effect on loaves shape and bread crumb structure.

Key words: wheat genotype, gluten strength, dough rheology, bread crumb structure, oxidizing improver

INTRODUCTION

Protein composition and content as the main determinants of wheat bread making quality are affected by genetics, environmental conditions and crop menagment (Pepo et al. 2005b; Horvat et al., 2006; Drezner et al., 2007). The milling industry requires storing of different wheat types separately on the basis of their end-use properties and proper blending of the grain to obtain the optimal flour for the particular product of interest (Tanács, 2007; Stanciu and Neacşu, 2008).

In modern bread-making, the dough improvers have been used to improve dough handling properties, increase quality of fresh bread and extend the shelf-life of stored bread (Larre et al, 2000; Grausgruber et al, 2008). The rheological properties of input flours are very important when considering which type of improver should be used. While reducing agent such as glutathione and L-cysteine (E920) reduced kneading force and dough fermentation time by accelerating gluten disrupture and then increasing SH- groups, oxidizing agents such as L-ascorbic acid (E300), bromate, kalium iodate and azodicarbonamide strengthened the structure of dough through oxidation of SH- groups into S-S bridges**.** Their effect is more pronounced on the extensogram and alveogram through increasing dough resistance and decreasing extensibility. Oxidation generally affects the farinogram or mixogram of wheat flour only slightly (Morita et al., 1996; Hrušková and Novotná, 2003; Lagrain et al., 2006).

[1] Agricultural Institute Osijek, Južno predgrađe 17, 31000 Osijek, Croatia;
Email: daniela.horvat@poljinos.hr
[2] Faculty of Food Technology, J.J. Strossmayer University in Osijek, Franje Kuhača 18, 31000 Osijek, Croatia

Considering the usage of the oxidative improvers in the bakery industry, the objective of study was to evaluate their impact on dough rheological properties and bread crumb structure of genotypes with different gluten strength.

MATERIALS AND METHODS

Yield trials with five winter wheat cultivars (Žitarka, Golubica, Srpanjka, Janica, and Soissons) and advanced line Osk. 266/03 were set up at the experimental field of the Agricultural Institute Osijek, on eutric cambisol soil type (pH_{KCl}=6.25, humus=2.20%), using a RCB design with three repetitions in 2005/2006 year. Cultivars were planted in eight row plots of 7 m long 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 milling grains 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 water absorption of flours and the mixing behaviour of dough were determined by Brabender Farinograph (Brabender, Duisburg, Germany) in accordance with ICC No 115/1. Farinogram evaluation was performed using software Brabender Farinograph for Windows ver. 2.3.7. The stretching and elasticity characteristics of dough were measured by Brabender Extensograph (Brabender, Duisburg, Germany) according to ICC No 114/1 and extensogram evaluation was automatically performed using software Brabender Extensograph for Windows ver. 2.1.5.

Composition of HMW-GS was analyzed by SDS-PAGE using Phast System (Pharmacia LKB). HMW-GS bands were previosly identifed according to the nomenclature of Payne and Lawrence (1983) and Glu-1 quality scores were calculated.

Glutenin proteins were analyzed by RP-HPLC system (Integral 4000, Perkin Elmer), following the quantitative extraction and HPLC procedure of Wieser et al. (1998). The peak area under chromatogram was used as a direct measure for content of glutenin proteins.

The bread recipe (based on flour weight) was: water according to the farinographic absorption, 2% salt and 2% fresh yeast. An oxidizing improver Ekstrapan Plus (DATEM 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. The volume and the shape (H/D ratio) of the loaf were measured.

Image analysis of the sliced loaves was done using GlobalLab Image/2 software. A crumb structure evaluation was done by calculating average cell area as measure of crumb cells size and total cell area as measure of crumb porosity.

RESULTS AND DISCUSSION

The pedigree and flour quality traits of analyzed cultivars are shown in Table 1. Advance line Osk. 266/03 and Golubica had the highest value of protein and wet gluten content. The highest gluten index was found in advanced line Osk. 266/03 and Soissons, while Golubica and Soissons had the best flour yield.

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 (Tanács, 2007), while in the USA the mixograph is more preferred. The impact of bread improver on farinographic parameters was most pronounced on degree of softening, which resulted in a lower quality group (Table 3). Addition of an oxidizing improver generally increased dough energy and disturbed R/EXT ratio as result of increasing dough resistance and decreasing extensibility. Improver addition increased loaves volume up to 14%, but it didn't have significant influence on H/D ratio. Regarding bread crumb structure, a significant influence of improver on cells size was noticed, while the crumb porosity was on the same level as in the control group.

Table 1. Pedigree and flour quality parameters of wheat genotypes

CULTIVAR	YEAR OF RELEASE	PEDIGREE	P[a]	WG	GI	Y
ŽITARKA	1985	Osk 6.30-20 / Slavonka /3/ Ephart M68 / Osk 154-19 // Kavkaz	10.3	25.3	91	70
GOLUBICA	1998	Slavonija / Gemini	12.9	33.7	77	75
JANICA	2003	Osk. 5.36-9-91 / Srpanjka	11.4	25.5	97	71
SRPANJKA	1989	Osk 4.50-1 / ZG 2696	12.0	28.0	97	70
OSK. 266/03	2003	Soissons / Osk. 6.362-2-88	13.4	28.6	99	73
SOISSONS	1987	Iena (Champlein / Courtot) / HN (Hybride Naturel) 35	12.4	27.6	99	75
MEAN			12.1	28.1	93	72

[a]P=flour protein content (%); WG=wet gluten (%); GI=gluten index; Y= flour yield (%)

Table 2. HMW-GS composition and glutenin proteins content

CULTIVAR	HMW-GS			GLU-1 SCORE	T GLUT[a]	T HMW-GS[b]
	GLU-A1	GLU-B1	GLU-D1			
ŽITARKA	N	7+8	2+12	5	681[c]	181
GOLUBICA	N	7+9	2+12	4	714	195
JANICA	N	7+9	2+12	4	739	189
SRPANJKA	N	7+8	2+12	5	892	224
OSK. 266/03	2*	7+8	5+10	10	775	236
SOISSONS	2*	7+8	5+10	10	839	241
MEAN					773	211

[a]T GLUT= content of total glutenins (AU); [b]T HMW-GS=content of total high-molecular-weight glutenin subunits (AU)
[c]AU= the area under the glutenin peaks expressed in arbitrary units

Table 3. The mean values of quality parameters under experimental treatments

PARAMETER		WA[a]	DDT	DS	E	R_{MAX}	R/EXT	V	H/D	TCA	ACA
TREATMENT	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=loaf volume (cm^3); H/D=height/diameter ratio; TCA=total cell area (%); ACA=average cell area (pixells)
[b]1=control; 2=improver

The analyzed cultivars were divided into two groups, in accordance with their gluten characteristics obtained by dough rheological analysis. Žitarka, Golubica and Janica with higher exstensibility, lower resistance and good elasticity belonged to the first group with gluten characterized as medium strong (Table 4). The improver addition had positive impact in Žitarka, increasing loaf volume up to 10%, significantly increasing the H/D ratio and improving bread crumb structure. In Golubica, by addition of the improver the R/EXT ratio had optimal value. Loaf volume of this cultivar was increased by 10%, accompanied by H/D ratio increase and crumb structure parameters decrease. Improver addition also had positive effect on bread properties of Janica, increasing loaf volume by 15% and H/D ratio, without destroying the crumb structure (Table 4).

Table 4. Quality parameters grouped by genotypes and treatments

PARAMETER			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=loaf volume (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=advanced line Osk. 266/03; SOI=Soissons
[c]1=control; 2=improver

The mixing properties and baking performance of wheat flours are closely related with composition of HMW-GS and glutenin proteins content. In particular, HMW-GS 5+10 and 2+12 at the Glu-D1 locus have a major effect on dough strength (Lasztity, 2003; Goesaert et al., 2005; Horvat et al., 2006). Cultivar Soissons and advanced line Osk. 266/03 with HMW-GS 2*, 7+8, 5+10 and the highest Glu-1 quality score, were the best concerning values of gluten index and extensographic parameters as direct measure of gluten strength (Table 1 and 4). Cultivars Srpanjka (N, 7+8, 2+12), in spite of presence GS 2+12 at the Glu-D1 locus, which are related with poor quality, showed very good technological characteristics what is in agreement with our previous investigations (Horvat et al., 2006). Regarding glutenin proteins content, genotypes Srpanjka, Osk. 266/03 and Soissons had the highest contents of HMW-GS as well as total glutenins (Table 2). These genotypes with lower extensibility, high resistance and reduced elasticity belonged to the second group characterized with strong gluten. The improver had negative effect on Srpanjka significantly increasing of R/EXT, and loaf volume by 12% without changing H/D ratio, but totally destroying bread crust and significantly increasing of crumb cells size without changing crumb porosity (Table 4). The advanced line Osk 266/03 had the second biggest loaf volume in control group with satisfactory crumb cells characteristics. However, in combination with the oxidizing improver there was no significant distortion of R/EXT. Addition of improver increased loaf volume by 16% in this cultivar but significantly decreased the H/D ratio as well as crumb porosity. Addition of improver also had negative effect on bread properties of Soissons by increasing R/EXT. This cultivar showed the largest increase in loaf volume (23%) but decrease of H/D ratio. Improver addition significantly increased the crumb cells size in this cultivar, without significantly changing crumb porosity. We also noticed (Figure 1) appearance of several very large cells on slice's area, a well known characteristic of flours with disturbed viscoelastic properties (Magdić et al., 2002; Scanlon et al., 2000; Zghal et al., 2001).

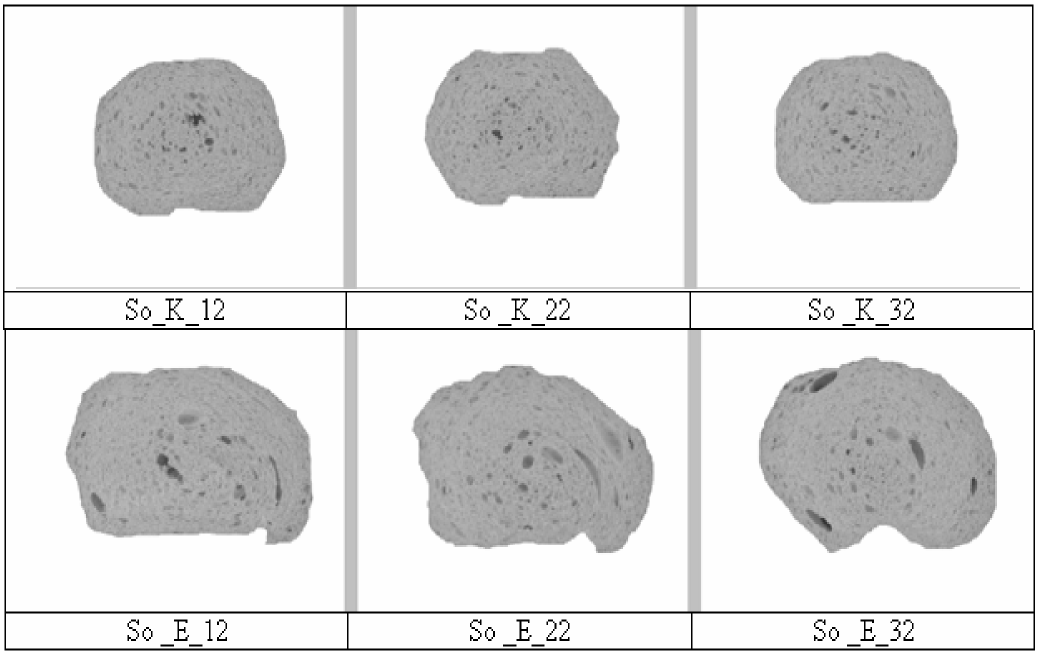

Figure 1. Negative effect of an oxidizing bread improver addition on bread crumb properties (cv. Soissons)

CONCLUSIONS

The gluten strength characteristics of genotypes should be taken into consideration before the decision about baking conditions and recepies is made. Addition of an oxidizing improver had possitive effect on flours with medium gluten strength, through improvment of loaf volume and shape with satisfactory 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 improvers in the bakery industry, the cultivars with stronger gluten should be used in combination with flours of weaker 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: 357-360.

Goesaert, H., Brijs, K., Veraverbeke, W.S., Courtin, C.M., Gebruers, K., Delcour, J.A., 2005. Wheat flour constituents: how they impact bread quality, and how to impact their functionality. Trends in Food Science & Technology, 16: 12-30.

Grausgruber, H., Miesenberger S., Schoenlechner, R., Vollmann, J., 2008. Influence of dough improvers on whole–grain bread quality of einkorn wheat. Acta Alimentaria, 37: 379-390.

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 Communications, 34: 1177-1184.

Hrušková, M. and Novotná, D., 2003. Effect of Ascorbic Acid on the Rheological Properties of Wheat Fermented Dough. Czech Journal of Food Sciences, 2: 137–144.

Lagrain, B., Brijs, K., Delcour, J.A., 2006. Impact of redox agents on the physico-chemistry of wheat gluten proteins during hydrothermal treatment. Journal of Cereal Science, 44: 49-53.

Larré, C., Denery-Papini, S., Popineau, Y., Deshayes, G., Desserme, C., Lefebvre, J., 2000. Biochemical analysis and rheological properties of gluten modifide by transglutaminase. Cereal Chemistry, 47: 121-127.

Lasztity, R., 2003. Prediction of Wheat Quality - Succes and Doubts. Periodica polytechnica Chemical Engineering, 46: 39-49.

Magdić, D., Horvat, D., Jurković, Z., Sudar, R., Kurtanjek, Ž., 2002. Chemometric Analysis of High Molecular Weight Glutenin Proportions and Image Data of Bread Crumb Structure from Croatian Wheat Cultivars. Food Technology and Biotechnology, 40: 331-341.

Morita, N.K., Nakata, Z.H. and Toyosawa, L., 1996. Effect of α - Glucosyl Rutin as Improvers for Wheat Dough and Breadmaking. Cereal Chemistry, 73: 99-104.

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: 137-143.

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

Scanlon, M.G., Sapirstein, H.D. and Fahloul, D., 2000. Mechanical properties of bread crumb prepared from flours of different dough strength. Journal of Cereal Science, 32: 235-243.

Stanciu, G. and Neacşu, A., 2008. Effects of genotype, nitrogen fertilizer and water stress on mixing parameters in wheat (*Triticum aestivum L.*). Romanian Agricultural Research, 25: 29-35.

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

Zghal, M.C., Scanlon, M.G. and Sapirstein, H.D., 2001. Effects of flour strength, baking absorption, and processing conditions on the structure and mechanical properties of bread crumb. Cereal Chemistry, 78: 1-7.

Wieser, H., Antes, S., Selmeier, W., 1998. Quantitative determination of gluten protein types in wheat flour by reverse-phase high-performance liquid chromatography. Cereal Chemistry, 75: 644-650.