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QUALITY CHARACTERISTICS OF SOME WINTER WHEAT VARIETIES IN 2014/2015

KVALITETA SORTI OZIME PŠENICE U 2014./2015.

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ABSTRACT

The Agricultural Institute Osijek in their has wheat breeding program few criteria that every new wheat variety must meet: good agronomic and quality performance, stability, resistance to diseases, resistance to low temperatures or drought, pre-harvest sprouting and lodging resistance. Specific end-use qualities are critical considerations in the development of new wheat varieties. It is important in the national wheat program of Croatia to create high yielding wheat varieties with optimal gluten proteins composition and amount, where wheat varieties are examined for protein and wet gluten contents as well as gluten index and dough rheological parameters as measure of gluten quality. Also gluten content and its composition are measured, such as HMW-GS, which are important indicators of wheat bread-making quality. The aim of this research was to present technological and baking characteristics of six Croatian winter wheat varieties. End product test varied for all of Croatian wheat varieties in 2014/2015, however, the variety 'Kraljica' demonstrated the superiority of the Croatian wheats for this product type.

Keywords*:* wheat, variety, quality, gluten

SAŽETAK

Oplemenjivački program pšenice Poljoprivrednog instituta Osijek stvara sorte s dobrim agronomskim svojstvima, te poboljšanom kvalitetom i stabilnosti, kao i povećanom otpornosti na bolesti, niske temperature, sušu, osipanje zrna i polijeganje. Također, jedan od značajnih oplemenjivačkih ciljeva je i kreiranje visokoprinosnog materijala koji bi imao optimalan sastav i količinu rezervnih bjelančevina glutena. Standardno se svake godine utvrđuju udio bjelančevina i vlažnog glutena, te gluten indeks i reološka svojstva tijesta

kao dobri pokazatelji kvalitete glutena. U ovom istraživanju utvrđeni su gluten i njegov sastav, te HMW-GS podjedinice koji su glavni pokazatelji kvalitete kruha. U ovom radu prikazana je kemijska i reološka kvaliteta nekih sorti pšenice Poljoprivrednog instituta Osijek. Sorte su u 2014./2015. godini varirale u parametrima kvalitete, međutim sorta 'Kraljica' je pokazala superiornost u 'kvaliteti' u odnosu na ostale ispitivane materijale.

Ključne riječi: pšenica, sorta, kvaliteta, gluten

INTRODUCTION

After maize, wheat is the most important cereal in Croatia (Annual Statistical Yearbook RH, 2015). In the last 100 years more than 150 wheat varieties have been released by Agricultural Institute Osijek in Croatia. A maximum of three varieties accounts for more than 50% of the crop, and one variety cover, 34% of the area ('Srpanjka'). The region in Croatia, where wheat is grown, is a part of Panonic region, and is suitable for growing high quality wheat. Millers and bakers expect certain quality properties in bread wheat. Specific end-use qualities are critical considerations in the development of new wheat varieties. The end-use quality of wheat varieties is dependent on the genetic background, but also on environmental conditions (Grausgruber et al., 2000., Lasztity, 2003., Horvat et al., 2012., Rozbicki et al., 2015.), such as rainfall, temperatures in vegetation period and soil type. Especially high temperature heat shock during grain filling can affect protein deposition (Nuttall et al., 2016.). Nitrogen fertility is also one of the key factors affecting wheat yield and quality (Bayoumi and El- Demardash, 2008.). Also, proper storage after harvest can protect grain quality (system with cooling and drying).

To meet the needs of the baking and milling industry, wheat varieties must have the quality required by the market. Varieties which do not meet the expected standard can be rejected. These standards are not the same for individual companies and tests undertaken may vary in different places. End-users apply a range of wheat quality assessment which is determined by physical properties (test weight, 1000 kernel weight, size, shape and color of grain), smell criteria, health and chemical composition of grain, technological properties of flour (through actual amount of gluten in flour to the assessment of viscoelastic properties of dough), pasta and bread. Depending on the quality, wheat grain has 10-17% of protein content, test weight can vary from 60 to 85 kg hl^{-1} and 1000 kernel weight from 25 to 55 g. It is known that protein

content and grain yield are negatively correlated (Frey, 1977, Costa and Kronstad, 1994, Spanic et al., 2013). In general, higher protein content can indicate flours with higher water absorption, stronger and more extensible dough properties and better baking performance. Contrary to that, lower protein content can indicate lower water absorption, reduced ability to retain gas during fermentation and at the end reduced loaf volume can occur. Moisture content is also an important parameter to measure at grain reception points. It can happen that grain moisture exceeds 15% and then the risk of infestation and mycotoxin accumulation can occur. Sprouting can occur if there is low Hagberg falling number, which is an indicator of high enzyme activity. Acceptable level of falling number is ≥250 seconds. Test weight can be a rough estimator of grain quality. Bad growing conditions (soil type and weed pressure) and disease attack can lower test weight.

Testing in early generations provides only partial knowledge on wheat quality due to the relatively small amount of grain developed in small plots. The quality of wheat lines in early generations can be found out based on the external appearance of grain, using micro-tests to examine protein content, sedimentation value and measurement of the water absorption into flour. In preliminary field experiments of wheat lines where we get enough amounts of seed, we get a complete picture of the rheological properties of dough. To prepare flour for testing, milling should be done. Quality of the flour is examined by the rheological properties of dough by two most common laboratory tools for recording dough properties (farinograph and extensograph). Farinograph is an instrument for measurement of the plasticity and mobility of the dough through traits such as arrival time, departure time, water absorption, development time, dough stability, and resistance to dough softening and thereby determines quality number of the flour (A1-A2, B1-B2, C1-C2). A2-A1 indicates the type of wheat that can be used as "improver" of the quality, the groups B1-B2 give good wheat bread, and the group C1-C2 will contain wheat genotypes with bad quality properties (Fig. 1.).

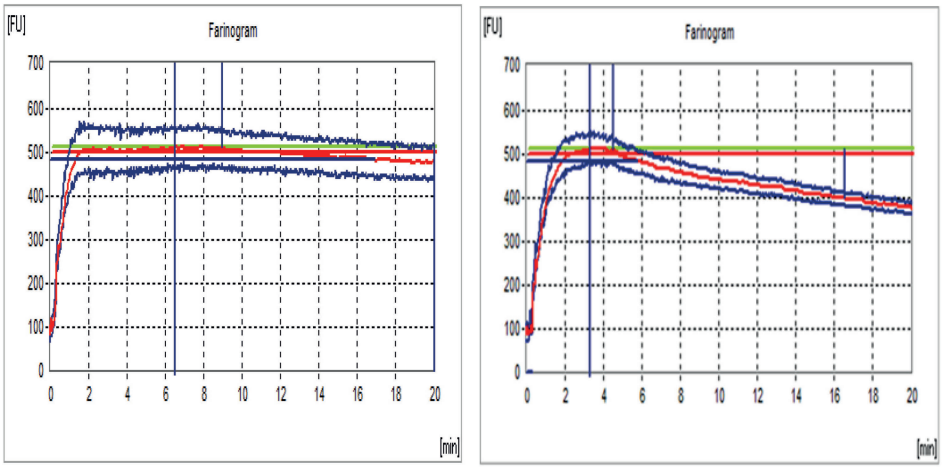

Fig 1. The Farinograph curves with a strong and a weak dough

Slika 1. Farinografske krivulje sa snažnim i slabim tijestom

Extensogram extensibility is a measure of how dough will stretch before breaking. The maximum resistance is the maximum height of the curve. Using extensograph we can determine gluten characteristics such as energy, resistance, flexibility and maximum resistance of dough (Fig. 2.).

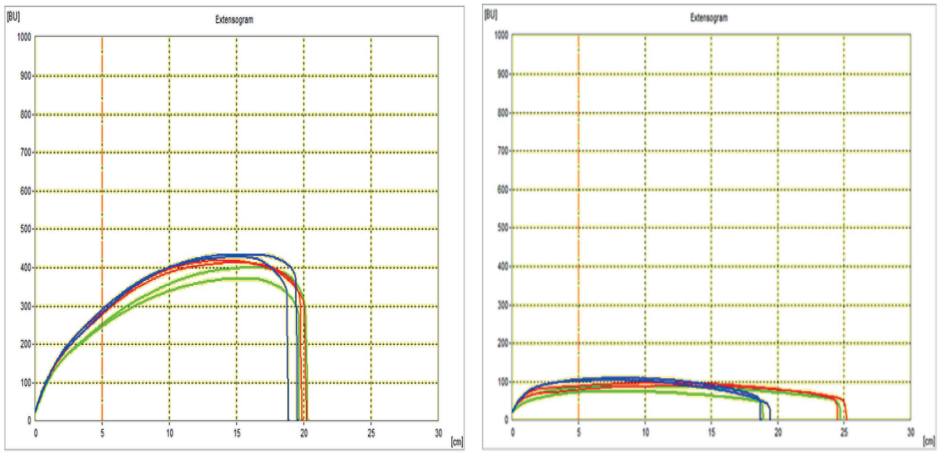

Fig 2. The Extensograph curves with a strong and weak dough

Slika 2. Ekstenzografske krivulje sa snažnim i slabim tijestom

Rheological analysis is followed by trial baking bread, which determines the yield of bread, bread volume and value number generated scoring organoleptic properties such as color, size and number of pores, elasticity of bread crumb, thickness and crispiness of the crust.

By dissolving proteins in water they form wet gluten. According to the chemical and physical properties, gluten proteins are divided into two groups: gliadins (soluble in 70-90% ethanol, but not in water) and glutenins (soluble in dilute acids and bases, but insoluble in neutral solutions and alcoholic solutions of salts). Water-soluble albumins and salt-soluble globulins constitute from 10 to 22% of total flour protein (Singh and MacRitchie, 2001.). These two groups are of minor importance in bread-making quality. According to Barak et al. (2013.) gliadins are equally important as glutenins in asserting the bread making performance of wheat varieties.

Glutenins, group of polymeric gluten proteins, are components that determine the elasticity of the dough together with gliadins which act as plasticizers and allow extensibility of dough. According to molecular weight glutenin subunits are divided into high molecular weight subunits (HMW) and low molecular weight subunits (LMW). Total glutenins contain 25-35% of HMW glutenin subunits, and the rest are LMW subunits. HMW subunits can be different in different varieties and have different structures and properties of the subunits. Horvat et al. (2008) already had shown that the distribution of the HMW-GS composition in Croatian varieties did not widely range in comparison with other HMW-GS units of winter wheat varieties across Europe.

MATERIAL AND METHODS

The survey was conducted during 2014/15 using six winter wheat varieties originating from Agricultural Institute Osijek, Croatia (‘Srpanjka’, ‘Katarina’, ‘Golubica’, ‘Kraljica’, ‘Olimpija’ and ‘Vulkan’). The experiment was set up as completely randomized block in two replications at location Osijek, 45°27’N, 18°48’E where soil was eutric cambisol. The climate conditions during growing season were: amount of rainfall and average temperatures = 513.0 mm, 11.3°C). Area of one experimental plot was 7.56 m^2. After the harvest the following traits were analyzed: test weight, 1000 kernel weight, protein content, wet gluten content, sedimentation value, gluten index and falling number. Few dough rheological parameters were obtained: water absorption, stability, degree of softening, quality group, energy, resistance to extension, extensibility. The

wheat proteins extraction from 100 mg of flour sample was done stepwise according to the procedure of Wieser et al. (1998.). Proteins separation was carried out using Perkin Elmer LC 200 chromatograph controlled by Total-Chrom software (Perkin Elmer Instruments, USA).

RESULTS AND DISCUSSION

Varieties 'Olimpija' and 'Golubica' had the highest protein content and wet gluten content (15.5% and 33.7%; 14.2% and 36.3%), while the smallest protein content and wet gluten content was found in variety 'Katarina' (12.3% and 28.7%, respectively) (Table 1.). Wheat proteins contribute to dough properties, bread loaf volume, and crumb structure and strong elastic gluten indicates good bread-making quality (Magdić et al., 2006.). Variety 'Kraljica' had highest the sedimentation value (51 cm^3) which can determine the good quality of wheat. Falling number in all varieties was higher than 250 s as acceptable levels. Varieties 'Olimpija' and 'Vulkan' (Table 1) had the highest test weight (82.9 and 82.8 kg hl^{-1}, respectively) and 1000 kernel weight (37.3 and 34.6 g, respectively). In previous research it was concluded that with regard to Gluten Index (GI) cultivars with GI between 75 and 90 had optimal baking characteristics (Simic et al., 2006.). In our investigation only variety 'Srpanjka' had gluten index lower than 90 (Table 1.). Meanwhile, due to changes in the genetic parent components in the wheat breeding process and significant climate change, the value of gluten index is shifted to values above 90.

In the experiment 2014/2015 farinograph dough water absorption was lowest for the variety 'Vulkan' (55.5%) followed by the varieties (in rank order) 'Katarina', 'Kraljica', 'Srpanjka', 'Olimpija' and 'Golubica' (Table 2). Stability scores were ranging from 0.4 for 'Katarina' to 3.7 for 'Srpanjka'. The largest degree of softening (73 and 72 BU, respectively) was produced by 'Katarina' and 'Vulkan', but the degree of softening above 100 imply a poorer gluten strength properties. These varieties in spite of lower glutenin proportion (29.4 and 27.8%, respectively) and higher GLI/GLU ratio (1.8 and 2.3, respectively) (Table 3) showed a very good dough elasticity and stretching properties evaluated by extensograph (Table 2). The best farinograph quality group was for 'Kraljica' (A1) followed by 'Srpanjka', 'Golubica', 'Olimpija' and 'Vulkan' (A2), and one variety was in B1 group ('Katarina'). Extensograph energy was the highest for 'Kraljica' (157 cm^2), as well as resistance to extension (413 BU), R_{MAX} (744 BU), R/Ext (2.4) and R/R_{MAX} (4.4) and the highest proportion of

glutenins (35.6%) and well balanced GLI/GLU ratio (1.52) (Table 2 and 3). Variety 'Srpanjka' also showed a good baking quality due to the highest proportion of HMW subunits (10.2) and well-balanced GLI/GLU ratio (1.48), which is similar to previous findings (Horvat et al., 2012a). Baric et al. (2004.) and Horvat et al. (2012b.) associated above mentioned traits with protein quality.

Table 1 Technological and agronomical properties of six Croatian winter wheat varieties grown in vegetation period 2014/2015

Tablica 1. Tehnološka i agronomska svojstva šest hrvatskih ozimih pšenica u vegetacijskoj sezoni 2014./2015.

Variety	P (%)	SED (cm^3)	WG (%)	GI	FN (s)	TW ($kg\ hl^{-1}$)	TKW (g)
SRPANJKA	13.4	40	30.3	88	401	74.3	32.3
KATARINA	12.3	42	28.7	98	362	73.6	28.0
GOLUBICA	14.2	49	36.3	95	350	77.4	27.9
KRALJICA	13.5	51	29.7	99	398	79.8	28.7
OLIMPIJA	15.5	46	33.7	98	423	82.9	37.3
VULKAN	13.2	47	30.3	98	267	82.8	34.6

P-protein content, SED-sedimentation value, WG-wet gluten content, GI-gluten index, FN-falling number, TW-test weight, TKW-1000 kernel weight

Flavor and other baking characteristics are important to potential buyers, so it is best to consult with them about their preferences. In this research end product varied for all Croatian wheat varieties in 2014/2015 with protein content of 12.3–15.45% however variety ‘Kraljica’ demonstrated the superiority in quality among the Croatian wheats of this type. Characterization of HMW and LMW glutenins and gliadins allows breeders to combine protein content and quality more effectively. In conclusion, Agricultural Institute Osijek can offer winter wheat varieties with good bread-making quality.

Table 2 Dough rheological parameters in six Croatian winter wheat varieties grown in vegetation period 2014/2015

Tablica 2. Reološka svojstva tijesta šest hrvatski ozimih sorti pšenice uroda 2014./2015.

Variety	Farinograph parameters				Extensograph parameters				
	WA (%)	STAB (min)	DS (BU)	QG	E (cm^2)	R (BU)	Ext (mm)	R_{MAX} (BU)	R/Ext
SRPANJKA	57.6	3.7	55	A2	107	302	172	470	1.8
KATARINA	56.2	0.4	73	B1	96	292	164	438	1.8
GOLUBICA	60.5	1.7	62	A2	116	286	193	430	1.5
KRALJICA	56.3	2.5	12	A1	157	413	170	744	2.4
OLIMPIJA	59.5	0.9	62	A2	96	268	178	392	1.5
VULKAN	55.5	1.7	72	A2	95	304	160	440	1.9

WA-water absorption; STAB-stability; DS-degree of softening; QG-quality group; E-energy; R-resistance to extension; EXT-extensibility; R_{MAX}-maximal R

Table 3 Proportion (%) of albumins-globulins, gliadins and glutenins in six Croatian winter wheat varieties

Tablica 3. Udio (%) albumina-globulina, glijadina i glutenina u šest hrvatski ozimih sorti pšenice

Variety	AG	GLI	ω-	α-	γ-	GLU	HMW	LMW	GLI/GLU
SRPANJKA	15.5	50.5	3.1	27.8	19.5	34.0	10.2	23.8	1.5
KATARINA	19.1	51.5	3.5	25.0	23.0	29.4	8.6	20.8	1.8
GOLUBICA	13.8	54.9	4.1	30.0	20.8	31.3	8.0	23.4	1.8
KRALJICA	10.5	53.9	5.1	27.4	21.5	35.6	9.2	26.4	1.5
OLIMPIJA	8.6	58.3	4.3	32.0	22.1	33.1	8.1	25.0	1.8
VULKAN	8.4	63.8	5.1	32.7	26.1	27.8	6.7	21.1	2.3

AG- albumins-globulins; GLI- gliadins (ω- omega, α- alfa, γ- gama);
GLU- glutenins (HMW-high molecular weight glutenin subunits,
LMW-low molecular weight glutenin subunits)

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