EFFECT OF ENVIRONMENT AND GENOTYPE ON RHEOLOGICAL PROPERTIES OF FLOUR AND DOUGH OF WINTER WHEAT

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ABSTRACT – Effect of environment and genotype on rheological properties of flour and dough of winter wheat
Five winter wheat cultivars created in Small Grains Research Centre of Kragujevac (Ana Morava, Toplica, Vizija, Takovčanka and Lazarica) were grown at the macro field trial in three locations (Kragujevac, Sombor and Bačka Topola) during three years (2004-2006). Influence of environment (location and growing season) and genotype on rheological properties of flour and dough (water absorption, dough development time, dough stability time, dough weakness, and mixing tolerance index) were investigated. Analysis of variance showed highly significant differences among investigated cultivars (G), years (Y) and among their interactions (G x Y, G x L, Y x L, G x Y x L) for water absorption of flour. The strongest individual influence for water absorption had location ($F=56.032^{**}$) and G x Y x L interaction ($F=55.712^{**}$), and then year ($F=45.069^{**}$). Farinograph properties have shown that wheat flour on average belonged to A_2 and B_1 quality group, what means that investigated cultivars had high technological quality

Key words: wheat, quality, genotype-environment interaction, flour, rheology

INTRODUCTION

Rheology investigates the elasticity and viscosity of the dough. The viscoelastic properties of dough affect the processing of dough and the texture properties of bread. Dough must have both the properties of a viscous fluid and those of an elastic solid, and must have viscoelastic texture (WALKER - HAZELTON, 1996).
Rheological characteristics such as water absorption, stability, mixing tolerance, elasticity, viscosity and extensibility are important for the milling and bakery industries in view of the prediction of the processing parameters of dough and the quality of the final products. These rheological characteristics change during the bread making process and are difficult to measure in definitive terms. To predict the quality of flour and the dough of it, a number of physical, chemical, and rheological characteristics must be known. This information can be obtained from analysis of flour and test devices, such as farinograph, extensograph and alveograph.
Wheat breeders can improve overall end-use quality of cultivars through evaluation and selection. However, genetic improvement in processing quality may not translate into improved 'consistency' in the marketplace due to inherent variation caused by production environments (PETERSON et al., 1998). On the one hand, information about the microscopic rheology of wheat-flour dough is required by the plant breeder if improved varieties of wheat are to result in enhanced export income.
Grain quality of winter wheat varies depending on genotype and growing conditions. The successful process of wheat breeding is based on the knowledge of characteristics of the genotypes as well as on the interaction of genotype and location. Understanding the cause

of genotype by environment interaction can be used to establish breeding objectives, identify ideal test conditions and formulate recommendations for areas of optimal cultivar adaptation (WEIKAI - HUNT, 2001). The presence of genotype-environment interaction complicates the selection of superior genotypes and the understanding of environmental and genotypic causes of significant genotype-environment interaction is important in all stages of plant breeding (DHUNGANA et al., 2007). Environmental factors play a main role in the expression of genotype characteristics. The ideal cultivar for high grain yield and technological quality need to express genetic potential in different environmental factors of growing (ZECEVIC et al., 2007; 2009; 2010).
There is inverse relationship between grain yield and protein content. Since bread making quality is influenced by both protein quantity and quality, breeders must apply breeding strategies to increase one without affecting the other to achieve specific wheat quality classes. The basic principles to quality improvement are understanding effects of G x E interactions on the expression of quality traits and understanding genetic control and diversity associated with quality traits (ABUGALIEVA - PEÑA, 2010).
The aim of this work was to study the effect of genotype and environment on the rheological flour and dough properties of winter wheat cultivars.

MATERIAL AND METHOD

Five winter wheat cultivars created in Small Grains Research Centre of Kragujevac (Ana Morava, Toplica, Vizija, Takovčanka and Lazarica) were grown at the macro trial at experimental field in three locations (Bačka Topola, Kragujevac and Sombor) during three years (2004-2006). Influence of genetic and agro-ecological conditions of locations and growing seasons on rheological properties of flour and dough (water absorption, dough development time, dough stability time, dough weakness, and mixing tolerance index) were investigated. Based on the results of these properties, we determined the quality number and quality of flour group. Grain samples were milled using a Brabender Quadrumat Junior laboratory mill. The rheological properties were determined by using Farinograph "Brabender" according to ICC standard method No. 115/1 (1972, 1992).
The analysis of variance was calculated according to randomize complete block design with three factors: genotype (G), year (Y) and location (L) using ANOVA (MSTAT-C program, 1989). The significant differences among the means were grouped according to least significant difference (LSD).

RESULTS AND DISCUSSION

Absorption measures the amount of water that can be absorbed by a given quantity of flour. In bread making, it is usually preferable to have flour that can absorb a large amount of water. Optimum absorption represents the maximum amount of water, as a percent of the flour weight, that will produce a high yield of bread during the baking process.
In general, high water absorption means good baking performance. It is considered that high protein quantity provides both high water absorption and good baking performance (BLOKSMA, 1990; BASARAN - GÖÇMEN, 2003). The high molecular weight glutenin subunits play an important role in governing the functional properties of wheat dough. Weak gluten flour has a lower water absorption and shorter stability time than strong

gluten flour. Water absorption and dough stability time are in significant positive correlations with protein concentration and gluten content (SELEIMAN et al., 2011).
In this investigation, the water absorption varied in accordance with genotype, locations and years (*Table 1*). Average absorption value ($\bar{x}$**G**) ranged from 62.5% (Ana Morava) to 65.0% (Takovčanka). Genotypes reacted differently on investigated locations. According to location means, the highest water absorption for all cultivars was achieved in Sombor (64.8%), while the lowest in Bačka Topola (62.8%). The highest value of all investigated cultivars and localities for water absorption established in Kragujevac locality by cultivar Takovčanka (67.1%), while the lowest in Bačka Topola locality by cultivar Lazarica (60.8%).

Table 1. Mean values for water absorption of wheat flour (%)

Genotype (G)	Location (L)			$\bar{x}$G
	Kragujevac	Sombor	Bačka Topola	
Ana Morava	61.1	63.5	62.9	62.5
Toplica	63.1	66.7	65.0	64.9
Vizija	61.7	64.9	61.3	62.6
Takovčanka	67.1	63.7	64.1	65.0
Lazarica	65.0	65.3	60.8	63.7
$\bar{x}$L	63.6	64.8	62.8	63.7

Analysis of variance showed highly significant differences among investigated cultivars (G), years (Y) and among their interactions (G x Y, G x L, Y x L, G x Y x L) for water absorption of flour (*Table 2*). The strongest individual influence for water absorption had location (F=56.032**) and G x Y x L interaction (F=55.712**), and then year (F=45.069**). In our previous results, sedimentation value and gluten content also significantly depended on environment, cultivar, year and their interactions (ZECEVIC et al., 2009).

Table 2. Analysis of variance for water absorption of wheat flour

Source	DF	MS	F	LSD	
				0.05	0.01
Genotype (G)	4	27.146	34.410**	0.698	4.157
Year (Y)	2	35.555	45.069**	0.806	1.859
G x Y	8	14.026	17.779**	0.966	1.405
Location (L)	2	44.203	56.032**	0.806	1.859
G x L	8	27.856	35.310**	0.966	1.405
Y x L	4	5.511	6.985**	0.900	1.493
G x Y x L	16	43.950	55.712**	1.537	2.118

The dough properties, in average for all cultivars and years, are presented in *table 3.* Rheological properties of dough (dough development time, dough stability time, dough weakness, and mixing tolerance index) were similar in Kragujevac and Sombor, but the best results obtained in Bačka Topola locality. According to CAMPOS et al. (1997), dough development was influenced by composition and quality of flour, moisture and dough temperature.

Table 3. Farinograph characteristics of the dough

Dough properties	Location		
	Kragujevac	Sombor	Bačka Topola
Water absorption (%)	63.6	64.8	62.8
Dough development time (min)	2.0	1.5	2.0
Dough stability time (min)	2.0	1.0	5.0
Dough weakness (BU)	60	70	40
Mixing tolerance index (BU)	40	40	30

The rheological properties were influenced by production environment, years and cultivars. Farinograph properties have shown that wheat flour on average belonged to A_2 and B_1 quality group, what means that investigated cultivars had high technological quality (*Table 4*). Quality number, in average, varied from 55.7 (Vizija) to 73.9 (Toplica). According to locations means, the highest quality number was measured in Bačka Topola (70.9) while the lowest was at location Sombor (59.6).

Table 4. Quality number and quality group of wheat flour

Genotype (G)	Location (L)			$\bar{x}$G
	Kragujevac	Sombor	Bačka Topola	
Ana Morava	65.0/B_1	60.8/B_1	80.8/A_2	68.9/B_1
Toplica	72.8/A_2	71.0/A_2	78.0/A_2	73.9/A_2
Vizija	51.1/B_2	50.8/B_2	65.2/B_1	55.7/B_1
Takovčanka	61.7/B_1	60.8/B_1	67.0/B_1	63.2/B_1
Lazarica	69.3/B_1	54.6/B_2	63.5/B_1	62.5/B_1
$\bar{x}$L	64.0/B_1	59.6/B_1	70.9/A_1	64.8/B_1

Previous results indicated that the quality number of the wheat flour dough was closely correlated with the strong gluten flour, which had high dough stability, high dough breakdown time, a high farinograph quality number, and low dough mixing tolerance index (LEI et al., 2008). In their investigations correlation analysis showed that the farinograph quality number was highly positively correlated with dough breakdown time, dough stability, and dough development time (r = 1.000, 0.958, 0.894, respectively), and highly negatively correlated with the mixing tolerance index (r = -0.890).
Environment was the major source of variation for most of the chemical and rheological properties of flours extracted from both soft and hard wheat (MIKHAYLENKO et al., 2000), as reported previously (HAZEN - WARD 1997).

CONCLUSIONS

Rheological properties of flour and dough were influenced by environmental factors, cultivar, and their interactions. Growing location had significant effect on water absorption of flour. The quality of the investigated cultivars was high and belonged to A_2 and B_1 quality group. The highest quality had cultivar Toplica, which belonged to A_2 quality group. According to location means, the highest quality number was measured in Bačka Topola, while the lowest was in Sombor.

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