TECHNOLOGICAL QUALITY OF *TRITICUM AESTIVUM* L. CULTIVATED IN SUSTAINABLE FARMING SYSTEMS – INDIRECT BAKING QUALITY

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Abstract: *Indirect baking quality of winter wheat (Triticum aestivum L.) was evaluated in the year 2009 and 2010. Winter wheat was cultivated in ecological (ES) and integrated (IS) farming system with two levels of fertilizing. Farming systems were established at Research Base Dolná Malanta in Western Slovakia region on brown clay-loamy soil. The experimental field altitude was 178 m, average precipitations is 561 mm and average temperature 19.7 °C in July and - 1.7 °C in January. The ecological system was composed of a six course crop rotation: beans + alfalfa – alfalfa – winter wheat – peas – maize – spring barley. The integrated system consisted of the crop rotation: winter wheat – peas – winter wheat – maize – spring barley – lucerne (3 years at the same plot). Subplots were fertilized (F) and unfertilized (N). The F variant in ES was based on 40 t of manure, the IS also recieved 40 t of manure plus synthetic fertilizers. The work presents results of evaluating the indirect baking quality parameters (wet gluten content, gluten index – ICC 155, 158; AACC 38-12; Zeleny test – ICC 116/1) and dough rheological properties (water absorption, dough stability, softening time – ICC No. 115/1). Each evaluated baking quality parameter was affected by forecrop, weather conditions and fertilizing. Winter wheat had high content of wet gluten. More than 31 % was found in fertilized variant, after forecrop alfalfa, in the year 2010. The highest gluten index over 45 % was found after forecrop spring barley. The Zeleny sedimentation which characterises the viscoelastic features and quality of proteins reached 27 – 32 ml. The farinograph determines dough and gluten properties of a flour sample by measuring the resistance of dough against the mixing action of paddles. Rheological dough properties significantly affect production operations – kneading, forming; and the quality of the finished product. Rheological properties were statistically affected by forecrop, weather conditons and fertilizing. Winter wheat dough had high water absorption (58.8 – 61 %), very good dough stability (5.2 – 7.5 min.) and medium softening of dough (67.1 – 44.3 BU). Fertilizing and weather conditions in 2010 had positive effect on rheological properties. System of farming had no effect on rheological properties. Better indirect baking quality parameters were found in integrated system and better rheological properties were found in ecological system.*

Key words**:** *winter wheat, ecological system, baking quality*

INTRODUCTION

Sustainable agriculture is an important part of sustainable development of society and includes the management of the natural resources in a way that will ensure their availability in the future. Ecological farming system is a sustainable system which aims to landscape protection and production of high quality food (MACÁK, 2006).

Wheat technological quality depends on the genetic factors, environmental conditions, growth locations; agronomic practices prevailing during different wheat growth stages greatly alter the wheat quality attributes. Generally wheat quality refers to its suitability for a particular end-use based on physical, chemical and nutritional properties of wheat grain. Protein content is a key quality factor that determines the suitability of wheat for a particular type of product as it affects other factors including mixing tolerance, loaf volume and water absorption capacity (SHAH et al., 2008). The gluten quality depends on the optimal storage protein combination – gliadins and glutenins. Each of them affects rheology in a unique way – viscosity is affected by

gliadins, elasticity by glutenins (BUSHUK, BEKES, 2002). L-BAECKSTROM et al. (2004) found clear differences in baking quality between organically and non-organically grown wheat, with higher baking quality in the non-organic system.

The aim of this work was to evaluate an indirect baking quality parameters and rheological properties of winter wheat cultivated in ecological and integrated farming system with two variants of fertilizing during the years 2009 and 2010, and to determine effect of farming system, forecrop, weather conditions and fertilization on indirect baking quality parameters and rheological properties.

MATERIAL AND METHODS

Field experiments were conducted at the Research Experimental Station Dolná Malanta, Western Slovakia during 2009 and 2010 on a Haplic Luvisol developed at proluvial sediments mixed with loess. The altitude of the experimental field was 178 m. The location has a continental climate with an average temperature 19.7 °C in July and – 1.7 °C in January, an average annual precipitations are 561 mm. The aim of this work was to evaluate an indirect baking quality of winter wheat (*Triticum aestivum* L.). A split - plot design was used with two main treatments, ecological (ES) and integrated (IS) cropping systems. The ecological system was composed of a six course crop rotation: beans + alfalfa – alfalfa – winter wheat – peas – maize – spring barley. The integrated system consisted of the crop rotation: winter wheat – peas – winter wheat – maize – spring barley – alfalfa (3 years at the same plot). Subplots were fertilized (F) and unfertilized (N). The fertilized variant in ES was based on 40 t of manure while the IS also received 40 t of manure plus synthetic fertilizers (Table 1). Fertilizing was replicated four times. Sowing and harvesting dates, rainfall and average temperature calculated for vegetative period of the crop, synthetic fertilizer inputs ($kg.ha^{-1}$) applied in the IS are shown in *Table 1*. Nitrogen fertilizers were applied in three split applications.

Table 1

Crop management data for winter wheat 2009 – 2010

Year	Sowing date	Harvest date	Rainfall (mm)	Average temperature (°C)	Nitrogen ($kg.ha^{-1}$)	Phosphorus ($kg.ha^{-1}$)	Potassium ($kg.ha^{-1}$)
2009	13/10/08	15/07/09	426	9,6	82,5	37,5	20,0
2010	7/10/09	28/07/10	610	8,8	62,5	7,5	40,0

The work presents results of evaluating the indirect baking quality parameters: wet gluten, gluten index according to ICC Standard 155, 158; AACC Standard 38-12; Zeleny test values were determined according to ICC Standard 116/1; and dough rheological properties: water absorption, dough stability, dough softening were determined according to ICC Standard No. 115/1. All tests were carried out in triplicate. Obtained data were statistically evaluated by analysis of variance (ANOVA) and the significant differences were calculated by LSD test. Significance was indicated at $P \leq 0.05$.

RESULTS AND DISCUSSION

Indirect baking quality parameters of winter wheat were statistically significant influenced by every experimental factor: farming system, forecrop, year (weather conditions) and crop nutrition. The quantity and quality of gluten are considered the most important quality parameters of wheat flour. Wet gluten content is determined by washing the dough obtained from flour or wheat meal, with water or other solutions (e.g. NaCl solution), in certain conditions, to remove the starch and other soluble compounds of the sample. Wet gluten content (WG) was significantly affected by forecrop, farming year and crop nutrition. Factor forecrop showed the highest statistical significance. The highest value of WG (31.2 %) was reached after alfalfa and the lowest WG (26.3 %) after spring barley. This difference was

statistically significant. Pea with value 27.2 % was intermediate (Table 2). Value of WG in 2010 was higher about 4.7 % in comparison with 2009, what could be caused by higher temperatures during vegetative period and by higher supply of precipitations in 2010. Fertilization had positive effect on WG content. According to STN 43 1100-2 (2003) the content of WG over 25 % includes wheat samples into quality class "A" (standard) and over 27 % into quality class "E" (elite).

Table 2

Indirect baking quality of winter wheat 2009 - 2010

		Wet gluten (%)	Gluten index (%)	Zeleny test (ml)
Farming system	**ES**	30.0 a	29.4 a	29.3 a
	IS	28.4 a	41.4 b	29.9 a
Forecrop	**Alfalfa**	31.2 b	31.0 a	31.3 b
	Barley	26.3 a	45.8 b	27.7 a
	Pea	27.2 ab	39.5 ab	29.0 ab
Year	**2009**	26.5 a	43.0 b	27.6 a
	2010	31.3 b	31.8 a	31.8 b
Crop nutrition	**F**	31.3 b	35.6 a	32.1 b
	N	26.5 a	39.2 a	27.3 a

Legend: ES = ecological system; IS = integrated system; F = fertilized variant; N = non-fertilized variant.

Gluten index (GI) represented gluten quality, was statistically affected by system of farming. Very low value of GI 29.4 % observed in ecological system was influenced by higher values of WG (29 % and more) in this system. Gluten was weaker, therefore GI values were lower (45.8 % and less). Weather conditions in 2009 had on GI with value 43 % statistically significant positive effect. The highest GI was observed after forecrop spring barley (45.8 %), pea was intermediate (39.5 %) and the lowest GI was reached after alfalfa (31 %). It is generally accepted the values of the gluten index in the range 60 – 90 % in trade for bread-making. If its value is high, its strength is high as well (ELGÜN, 2002). Gluten in our wheat samples was of weak quality (29.4 – 45.8 %).

The Zeleny sedimentation value which characterizes the viscoelastic features and quality of proteins, and indicates the potential for the fermentation process in dough was influenced by year of cultivation and crop nutrition. Average value of the Zeleny test was 29.6 ml, what indicated high quality of proteins and possibility for good bread-making quality. High values of sedimentation indicate good protein quality and other traits necessary for production of high quality bread (MLADENOV et al., 2005). Sedimentation index values of winter wheat samples vary between 27 – 32 ml what represents flour quality of class A (min. 25 ml) and class E (min. 30 ml) (STN 43 1100-2, 2003).

Indirect baking quality parameters reached higher values in integrated system, namely gluten index (41.4 %). Wet gluten content and Zeleny test did not differ within evaluated farming systems. Flour quality class, according to STN 46 1100-2 (2003) in both farming systems falls into class quality of "A" (standard) and "E" (elite).

Rheological properties of wheat dough determined by farinograph better express an internal structure of flours, substructures of their components, especially with a focus on the protein composition (MANU, PRASADA RAO, 2008). Physical properties like consistency, stability, elasticity and tensibility, significantly affect production operations – kneading, forming; and the quality of the finished product (ŽITNÝ et al., 2010). Rheological flour and dough parameters of winter wheat as dough stability, dough softening and water absorption (WA) were determined by Brabender Farinograph.

Table 3

Rheological parameters of winter wheat 2009 - 2010

		Dough stability (min.)	Dough softening (BU)	Water absorption (%)
Farming system	**ES**	6.2 a	53.9 a	60.3 a
	IS	6.5 a	55.9 a	59.9 a
Forecrop	**Alfalfa**	6.8 a	48.8 a	60.6 b
	Barley	5.5 a	67.1 a	59.7 ab
	Pea	6.7 a	50.8 a	58.8 a
Year	**2009**	5.2 a	66.2 b	59.0 a
	2010	7.5 b	44.3 a	61.0 b
Crop nutrition	**F**	7.2 b	50.9 a	60.5 b
	N	5.5 a	59.6 a	59.5 a

Legend: ES = ecological system; IS = integrated system; F = fertilised variant; N = non-fertilised variant.

Water absorption was affected by every observed factor, except farming system (table 3). Higher WA was found in 2010 (61 %) with high amount of precipitations and average year temperatures. Fertilisation had possitive effect on the WA, it increased its value about 1 % in comparison with non-fertilised variant. Forecrop alfalfa the most possitivly affected WA (60.6 %), in comparison with forecrop pea after which was found the lowest WA (58.8 %). WA after spring barley with value 59.7 % was intermediate.

Dough stability (min.) was statistically affected by weather conditions and fertilization. Higher dough stability was found in 2010 (7.5 min.) what was about 2.3 min. longer time in comparison with 2009. Fertilized variant showed similar higher value of DS (7.2 min.), higher than in variant without fertilizers.

Dough softening was affected only by growing season, better value was achieved in 2010 (44.3 BU). According to KLINGLER (1995) reached results confirmed that high water absorption over 57 % and dough stability with values of 5.2 – 7.5 min. (minimum 2.5 min.) in both farming systems represent flours with strong baking quality; values of dough softening between 44.3 and 67.1 BU express medium flour quality (min. 40 – 130 BU).

Farinographic properties of wheat flour are strongly affected by content and quality of proteins what corresponds with SKENDI et al. (2009). Rheological parameters of winter wheat were not influenced by farming system, but were significantly affected by fertilization and weather conditions. Different forecrops for winter wheat affected water absorption of flour determined by the farinograph.

CONCLUSIONS

Evaluated indirect baking quality parameters were affected by year, fertilization and forecrop. Farming system affected only gluten index. Winter wheat had high content of wet gluten. More than 31 % was found in fertilized variant, after forecrop alfalfa, in the year 2010 and was of elite quality (E). The highest gluten index over 45 % was found after forecrop spring barley. The Zeleny sedimentation which characterises the viscoelastic features and quality of proteins reached 27 – 32 ml and standard quality (A).

Rheological properties of winter wheat were also statistically influenced by factor year, fertilization and forecrop (water absorption). Farming system had no effect on evaluated parameters. Winter wheat dough had high water absorption (58.8 – 61 %), very good dough stability (5.2 – 7.5 min.) and medium softening time (67.1 – 44.3 BU). Fertilizing and weather conditions in 2010 had positive effect on rheological properties.

On the basis of reached results of evaluated parameters we can note that better indirect baking quality parameters were found in integrated system and better rheological properties were found in ecological system.

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