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

Nora SMATANOVÁ - Magdaléna LACKO-BARTOŠOVÁ

Faculty of Agrobiology and Food Resources, Slovak Agricultural University in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic
E-mail: smatanova.nora@zoznam.sk

Abstract: *Winter wheat (Triticum aestivum L.) direct baking quality was evaluated in the year 2009. 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 are 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 aim of this work was to evaluate parameters of baked bread loaves obtained after baking test in laboratory which gives possibility to the most comprehensive assesment of technological properties and flour quality. Baking test was realised according to ICC Standard No. 131 from white wheat flour. Qualitative parameters of baked loaves included: bread volume and height/width ratio, specific volume and bulk productivity, product yield and baking loss. Evaluated paramateres of baked loaves from one-year research were statistically significant affected by crop nutrition. Application of manure had positive effect on each evaluated paramater, except bread yield and baking loss. Fertilizing in ecological system increased bread volume and bulk productivity about 3 – 3.3 %. In ecological unfertilised variant was found improvement of height/width ratio, specific volume, bread yield and baking loss about 0.6 – 3.9 %. Manure plus synthetic fertilizers in IS caused improvement of baking parameters equal to 9.4 – 12.5 %. Ecological farming system had in the 2009 possitive effect on direct baking quality of winter wheat. Reached results from direct baking test confirmed that quality of winter wheat white flour from ecological farming system was not statistically different from integrated one.*

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

INTRODUCTION

Wheat and consecutively flour quality depends on a range of factors, as wheat variety, crop year, agrotechnical treatment and final processing (ŠVEC et al., 2004). Organic farming is a farming system characterized by a limited nutrient content (easily soluble nitrogen) and the absence of the separate and gradual application of nitrogen (KÖPKE, 2005) what generally leads to different – often inferior – bread-making potential (MASON et al., 2007).

The definitions of baking quality vary from country to country and from person to person. Sometimes a high specific volume or an elastic crumb are not accepted as a sign of good quality. However, the volume measured at a defined form ratio (height/width) is an international criterion for quality on the wheat market (KIEFFER et al., 1998).

The baking test is the most useful test available for determining the practical value of a particular flour sample. Traditionally, loaf volume has been considered as the most important criterion for the bread-making quality (KOPPEL, INGVER, 2010). Both protein content and protein quality have major influence on the baking potential of wheat flours. The protein

content is determined mainly by nitrogen fertilization, whereas the protein quality depends primarily on the wheat genotype. Climatic conditions during maturation can affect both the content and the quality of wheat proteins (UHLEN et al., 2004). An important requirement for obtaining of grain with good technological quality is also a correct agrotechnics: inclusion of wheat into crop rotation, soil preparation, basic fertilisation, sowing term, treatment during the vegetation and harvesting conditions (ŠOTTNÍKOVÁ, 2007).

The aim of this work was to evaluate the baking quality parameters of bread loaves prepared from white winter wheat flour cultivated from ecological and integrated farming system with two variants of fertilization during the year 2009 and to determine the effect of farming system, forecrop and fertilization on baking quality parameters.

MATERIAL AND METHODS

Field experiments were conducted at the Research Experimental Station Dolná Malanta, Western Slovakia in year 2009 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 a direct 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). Experiment 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

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

The work presents the results of evaluating the baked bread loaves obtained after baking test in laboratory which gives possibility to the most comprehensive assesment of technological properties and flour quality. Baking test was realised according to ICC Standard No. 131 from white wheat flour. Qualitative parameters of baked loaves included: bread volume (cm^3) – measured by OBK instrument, principle of measurement consists in determination of the changes in volume refill with millet seeds, which indicates the volume of the bread; ratio height/width; specific volume ($cm^3.100g^{-1}$ of flour) – expression of the ratio between bread volume and 100 g of flour; bulk productivity ($cm^3.100g^{-1}$ of loaf) – the ratio of the bread volume and weight of bread; product yield (%) – express the relation between weight of bread loaf and used amount of flour for its production; and baking loss (%) which is characterized as the bread weight reduction after baking. 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

Direct baking quality of winter wheat was evaluated after direct baking of loaves from white flour wheat samples. Baking test is generally used term for laboratory baking which

gives possibility to the most comprehensive assessment of technological properties and flour quality.

On evaluated paramateres of baked loaves from one-year research had farming system no significant effect (table 2). Ecological farming system had in the 2009 possitive effect on direct baking quality of winter wheat, namely on bread volume (+ 16.6 cm^3 than in IS), bulk productivity (+ 7.4 $cm^3.100g^{-1}$), h/w ratio (+ 0.01) and specific volume (+ 4.6 $cm^3.100g^{-1}$). In IS was found higher product yield of 138.7 % and the lowest baking loss of 11.5 %. The greatest differences between farming systems were found by baking loss (0.3 %), the lowest differences showed h/w ratio (0.01).

Table 2

Bread loaves evaluation 2009

		Bread volume (cm^3)	Specific volume ($cm^3.100g^{-1}$)	Height/width ratio	Bulk productivity ($cm^3.100g^{-1}$)	Bread yield (%)	Baking loss (%)
Farming system	**ES**	820.8 a	406.7 a	0.77 a	297.3 a	138.3 a	11.8 a
	IS	804.2 a	402.1 a	0.76 a	289.9 a	138.7 a	11.5 a
Forecrop	**Alfalfa**	820.8 a	406.7 a	0.77 a	297.3 a	138.3 a	11.8 a
	Barley	775.0 a	387.0 a	0.74 a	277.7 a	139.2 a	11.3 a
	Pea	833.3 a	417.3 a	0.78 a	302.1 a	138.2 a	11.6 a
Crop nutrition	**F**	847.2 b	419.7 a	0.79 b	306.9 b	138.1 a	11.9 a
	N	772.2 a	387.6 a	0.74 a	277.8 a	139.0 a	11.3 a

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

The best results of baking test parameters were found after forecrop pea, namely bread volume with value of 833.3 cm^3, bulk productivity of 302.1 $cm^3.100g^{-1}$, h/w ratio with 0.78 and specific volume with 417.3 $cm^3.100g^{-1}$. Despite of highest values the majority of baking parameters after pea was showed the lowest bread yield (138.2 %). The lowest results were reached after spring barley, especially bread volume of 775 cm^3, bulk productivity of 277.7 $cm^3.100g^{-1}$, h/w ratio with 0.74, specific volume of 387 $cm^3.100g^{-1}$. Despite of this bread yield after forecrop spring barley had the highest value of 139.2 % and the lowest baking loss of 11.3 %. Bread loaves values after alfalfa were intermediate. According to Hřivna, Richter (2000) the leguminous after incorporation into the soil slowly release nitrogen which is well used during the period of grain development. This period determines about overall quality of wheat grain. Leguminous positively affect physico-chemical soil properties and have positive effect on redistribution of phosphorus, potassium and the other nutrients from the deeper soil layers to plow layer. Cultivation of wheat after cereals in terms of yields and grain quality is less appropriate. Cereals deteriorate soil characteristics, create risk of higher weed infestation and higher attack of diseases and pests (ZIMOLKA, 2005).

Direct baking parameters were statistically significant affected by crop nutrition. Application of manure had positive effect on most of the evaluated paramaters, except bread yield and baking loss. Fertilising in ecological system increased bread volume and bulk productivity about 3 – 3.3 %. In ecological unfertilised variant was found improvement of camber, specific volume, bread yield and baking loss about 0.6 – 3.9 % in comparison with ES fertilised variant. Manure plus synthetic fertilisers in IS caused improvement of baking parameters at about 9.4 – 12.5 %. In integrated unfertilised variant was found improvement of product yield and baking losses about 0.7 – 4.7 %. The highest statistical significance between variants of fertilizing was showed by bread volume with the difference of 75 cm^3. On the specific volume had fertilizing the lowest effect with the difference between the variants of 32.1 $cm^3.100g^{-1}$.

According to MUCHOVÁ et al. (2008) reached results of winter wheat bread evaluation

with values of bulk productivity 277.7 – 306.9 $cm^3.100g^{-1}$ (min. 211 – 310 $cm^3.100g^{-1}$) and specific volume 387 – 419.7 $cm^3.100g^{-1}$ (min. 351 – 450 $cm^3.100g^{-1}$) could be wheat flours classified as „weak" flours. Flours with values of h/w ratio 0.74 – 0.79 (min. 0.7) could be classified as „very good" flours.

CONCLUSIONS

Evaluated parameters of baked loaves from one-year research were statistically significant affected by crop nutrition. Application of manure had positive effect on each of evaluated paramater, except bread yield and baking losses. Most affected by fertilisation was bread volume. Baking test parameters reached the highest values after forecrop pea, the lowest values were found after spring barley. Ecological farming system had in the 2009 possitive effect on direct baking quality of winter wheat. Higher bread yields and baking loss were found in integrated system.

Overall, the quality of wheat flours from which were prepared bread loaves could be assessed as „weak" flours. Reached results from direct baking test confirmed that quality of winter wheat white flour from ecological farming system was not statistically different from integrated one.

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