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REGULAR ARTICLE

BREAD TEXTURE ANALYSIS IN ECOLOGICAL AND INTEGRATED FARMING SYSTEM

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ABSTRACT

The aim of this study was to evaluate texture of winter wheat bread. 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 on a Haplic Luvisol. The experimental field altitude is 178 m, average annual precipitations 586 mm, average year temperature 10.4 °C. Subplots were fertilized (F) and unfertilized (N) variants. The F variant in ES was based on 40 t of manure, the IS also recieved 40 t of manure plus synthetic fertilizers. The effect of farming systems and two levels of fertilization on qualitative parameters of winter wheat was observed in the year 2009 and 2010. Farming system had no statistically significant effect on the bread crumb texture. Weather conditions, forecrop and fertilizing had significant influence on bread crumb texture. Year had the significant effect on every texture parameter, better values was reached in 2010. Forecrop had significant effect on crumb firmness and stiffness. After alfalfa as forecrop was found the best bread texture, the worst after forecrop pea. Fertilizing positively affected all texture parameters of bread.

Keywords: texture, bread, winter wheat, ecological and integrated system

INTRODUCTION

Bread, in its many varieties, has been a staple in the diets in many parts of the world throughout thousands of years. Although a general consensus has been reached regarding the classification of breads according to the degree of hydration of their dough, the presence or absence of fats or their volume, there is as yet no standard method with which to carry out a texture evaluation of bread (**Callejo, 2011**). The bread production process starts with the mixing of the pre-product dough with the main components flour, water, yeast, sodium chloride, and other quality enhancing ingredients. After water binding, the gluten proteins form a viscoelastic continous phase. This interconnected spatial network has a dominant rheological impact on the dough **(Georgopoulos et al., 2004**). As the dough proofs, the rheological attributes influence gas bubble growth and gas retention properties. In the final baking process, these dough characteristics determine the crumb appearance and the final product quality (**Schirmer et al., 2011**). With the temperature increase the viscosity of the dough rapidly changes due to starch gelatinizatuon and protein denaturation. Thus, the bread crumb is characterized as a complicated viscoelastic foam material (**Gray and Bemiller, 2003; Choi et al., 2008**). Structure properties of bread and other cereal products depend on the quality of ingredients, their combination and use. In bread there is wheat protein called "gluten" which creates a typical structure (**Cauvian, 2004**).

The textural properties of food have been described as "the group of physical characteristics that are sensed by the feeling of touch, are related to the deformation, disintegration, an flow of the food under the application of a force and are measured objectively by functions of force, time and distance" (**Bourne, 1982**). Bread texture is defined by the sensory properties (sensory analysis) as well as the methods of objective assessment (instrumental analysis) (**Hansen and Setser, 1990**). Texture is the major criterion in assesing the eating quality of bread because of its close association with the consumer´s perception of freshness (**Cauvian and Young, 2007**). Primary texture property of bread is crumb firmness. From the physical point of view it is the power that is needed to reach a given deformation (**Kopec and Horčin, 1997; Yeatman, 1972)**). To the key characteristics related to freshness belong crumb softness and its ability to recover its shape after exposition to deformation power (**Krkošková, 1986**).

The quickest way to evaluate softness is the pressing of the crumb between fingers. Consumer experiences lead to rejection of bread which is hard when touched or which remains compressed when the pressing is over (**Cauvian, 2004**). The most of instrumental methods of texture analysis is based on mechanical tests including measuring the resistance of food to forces which are greater than gravity. The necessary is a "calibration" for a correlation with sensory evaluation and for a definition of limit values of acceptability (**Štetina, 2007**).

The objective of our study was to evaluate the crumb texture of bread prepared from white flour obtained from winter wheat cultivated in ecological and integrated farming system during two growing seasons with two variants of fertilizing.

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 a texture of bread made from 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 (Tab. 1). Treatments 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 the 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 the results of baked bread loaves evaluation 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, yeast, salt and water according to binding capacity of each flour sample.

Texture analyser TA-XTPlus by company STABLE MICRO SYSTEMS LTD measures texture characteristic of foodstuffs and material properties of non-food products. Texture analyser continually records strenght, lenght and time at the current deformation of material in tension or pressure. The work presents results of evaluating the texture properties of wheat bread: crumb firmness (N), crumb stiffness ($N.mm^{-1}$) and relative elasticity (%). Texture of the wheat breadcrumb was evaluated using probe SMS P/100 and tensometer with load of 25 kg. Duration of the force compresion was 40 seconds. Speed of analyser was as follows: before start of measuring 5 $mm.s^{-1}$, during the measuring and after - 10 $mm.s^{-1}$. The samples of the breadcrumb were prepared for the measurement after setup. After samples measuring the following parameters were evaluated: F_{max} (the crumb firmness expressed as maximal force in N), F_{end} (force measured 20 seconds after the F_{max} reaching in N), ST (crumb stiffnes in N/mm) and relative elasticity (F_{end}/F_{max} in %). All tests were carried out in six replications. 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

Instrumental evaluation of the texture is fast, objective and well replicable method. Deformation in pressure was used for bread samples.

Statistical analysis showed that farming system had not statistically significant effect on the crumb firmness, stiffnes and relative elasticity (Tab. 2). But ES showed slightly better values of crumb firmness and stiffnes.

Bread texture was achieved statistically high significant affected by year of farming. Better texture was showed in 2010: for the crumb deformation lower force was needed (4.84 N), what corresponds with higher relative elasticity (95.31 %). In the 2009 we found about 0.62 $N.mm^{-1}$ lower crumb stiffness in comparison with 2010.

Table 2 Evaluation of winter wheat bread texture in the years 2009 - 2010

		Crumb firmness (N)	Crumb stiffnes ($N.mm^{-1}$)	Relative elasticity (%)
System	**E**	8.87 a	0.50 a	94.62 a
	I	9.88 a	0.56 a	94.74 a
Year	**2009**	14.24 b	0.85 b	94.09 a
	2010	4.84 a	0.23 a	95.31 b
Forecrop	**Alfalfa**	7.42 a	0.41 a	94.90 b
	Barley	11.40 b	0.65 b	94.58 ab
	Pea	12.20 b	0.74 b	94.32 a
Variant	**F**	8.62 a	0.49 a	95.11 b
	N	10.46 b	0.59 b	94.28 a

Legend: E – ecological system, I – integrated system, F – fertilized variant, N – non-fertilized variant

In terms of forecrop the highest statistical difference was showed between forecrop alfalfa and pea, in case of crumb firmness and stiffnes. Between pea and barley was not significant difference. The softest bread crumb with 7.42 N and crumb stiffnes with only 0.41 $N.mm^{-1}$ was found after alfalfa. The highest crumb firmness (12.20 N) and also the most stiffest crumb (0.74 $N.mm^{-1}$) was found after pea. The best ability of bread to restore its shape after deformation was found after alfalfa (94.9 %).

Aplication of fertilizers showed high statistical significance on relative elasticity. Fertilized variant had positively higher relative elasticity with the value of 95.11 %. Positively significant effect of fertilization was determined on crumb firmness and stiffnes. In non-fertilized variant the force used was about 1.84 N and about 0.09 $N.mm^{-1}$ higher for crumb firmness and stiffnes respectively in comparison with fertilized variant.

Texture analysis of bread crumb showed that evaluated bread loaves had soft and fine crumb and the related higher relative elasticity.

The bread crumb texture can be affected by the quality of wheat proteins and by their ability to retain gas in bread dough. The flour samples from which breads were prepared contain the gluten in average amounts of 31.34 % in the 2010 and 26.54 % in 2009. Higher values of gluten in 2010 could increase the loaf volume and with consequently better – the softer and finer crumb texture. The finding that bread loaf is softer and the volume greater, the more protein flour consists, confirms also **Cauvian (2004)**. Gluten forms and keeps in the dough a net of air bubbles which are expanded by gas which is produced by the yeast fermentation. Gas retention and thus volume and texture improve with increasing protein content in the flour. The other properties of bread crumb can be related to enzymatic activity of wheat flour (alpha-amylase). **Naito *et al.* (2005)** have reported that gelatinized starch granules can sustain gas pressure during expansion at the early stage of baking, which results in uniform gas cells under the crust, resulting in bread with a sticky texture and good expansion characteristics. Nevertheless, several researchers claimed that bread firming is more complex and not synonymous with starch retrogradation (**Piazza and Masi, 1995; Beck et al., 2012**). Crumb firmness might be a result of starch-gluten interactions or rather cross-linking between gluten and gelatinized starch (**Martin and Hoseney, 1991; Martin et al., 1991**), however, other studies have revealed that influence of gluten on firmness is not essential (**Morgan et al., 1997**).

CONCLUSION

Evaluated parameters of wheat bread texture from two-year research showed that farming system had no statistical effect. On the other side, texture analysis was statistically affected by weather conditions, forecrop and by fertilization.

In the 2010 was found positively lower crumb firmness (4.84 N) and crumb stiffnes (0.23 $N.mm^{-1}$) and positively higher relative elasticity (95.31 %). The best bread texture was showed after forecrop alfalfa, the worst one after forecrop pea. Fertilized variant showed better bread texture properties.

Bread texture from ecological system is comparable to bread texture in integrated system.

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