INDIRECT BAKING QUALITY AND RHEOLOGICAL PROPERTIES OF SPELT WHEAT (*TRITICUM SPELTA* L.)

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Abstract: *Spelt (Triticum spelta L.) has undergone a renaissance as a niche product. This may be due to the perception that it is a "healthier", more "natural", or less "over-bred" grain than modern wheat. For a couple of years, the breeders have again taken an interest in spelt because of its better resistance to the influence of the environment. A field stationary experiment was carried out at the Research Experimental Station of the Slovak University of Agriculture in Dolná Malanta near Nitra. Eight spelt wheat cultivars (Altgold, Bauländer Spelz, Franckenkorn, Holstenkorn, Ostro, Rouquin, Rubiota, Schwabenkorn) were cultivated in ecological farming system without fertilization and any chemical treatment. The work reports on the results from studying the indirect baking quality indicators (wet gluten content, gluten index (ICC 155,158; AACC38-12), swelling of gluten (STN 461011-9), exstensibility of gluten (STN 461011-9, AACC 54-24), falling number (ICC 107/1; AACC56-81B), Zeleny test (ICC 116/1) and dough parameters (water absorption, dough development time, dough stability and softening, quality number) during a four-year research (from 2005 to 2008). Farinogram test was conducted using ICC standard method No 115/1. All evaluated indirect baking quality parameters were depended on the variety and weather conditions. Spelt wheat was rich in the content of wet gluten. More than 45% was found in Altgold, Ostro and Rubiota. Very tensile gluten of spelt wheat was of standard quality. GI higher than 50% was determined in Altgold, Franckenkorn, Holstenkorn and Rouquin. Rheological properties of wheat flour dough are essential for the successful manufacturing of bakery products because they determine its behaviour during mechanical handling, thereby affecting the quality of the finished products. Statistical analysis showed significant influence of the variety and year also on dough properties. Dough of spelt wheat was developed in short time period, characterized with low stability and weak resistance to over mixing. On the basic of all parameters of rheological analysis the best results was obtained in Franckenkorn. The normal air temperatures and sufficient precipitation of 2008 reflected into the best dough properties of spelt wheat when compared with other years of growing. Further it was found that dough prepared from spelt flour were very soft and sticky during kneading. This fact can be explained thereby that rheological properties of spelt gluten are predominated by gliadins as a very sticky monomeric plasticizer. Currently, there is considerable interest in the use of spelt for food destined for health, its distinctive taste attributes and organic food markers.*

Key words**:** *spelt, rheological properties, indirect baking quality indicators*

INTRODUCTION

In the past few decades spelt (*Triticum spelta* L.) has undergone a renaissance as a niche product. This may be due to the perception that it is a "healthier", more "natural", or less "over-bred" grain than modern wheat. For a couple of years, the breeders have again taken an interest in spelt because of its better resistance to the influence of the environment. Because of protection provided by the hulls, chemical treatment of hulled seeds used for sowing may not be required. Consequently, there are an increasing number of international publications on spelt food quality, rheology of spelt dough or gluten. Recently emerging in the market as a speciality food, this cereal has received increasing interest from wheat breeders and food technologists due to its genetic potential for improving common wheat cultivars resistance to plant diseases and the potential technological and nutritional value of the species itself (SCHOBER, 2006).

Agronomically, spelt may be more resistant to disease, and do better under less advantageous growing conditions, such as wet, cold soils and high altitudes. Because spelt contains gluten, it is not suitable for people with celiac disease (WIESER, 2010). Many people with an allergy or intolerance to common wheat can tolerate spelt (MARQUES, 2007). Its grain is distinguished by higher total protein contents as well as by the different composition of prolamine proteins. This is probably why some people suffering from the food allergy tolerate products originating from spelt.

Rheological properties of wheat flour dough are essential for the successful manufacturing of bakery products because they determine its behaviour during mechanical handling, thereby affecting the quality of the finished products (SARKER, 2008). The technological quality of wheat includes many attributes of kernel and flour, which are all important in the production of several kinds of baked products (OSELLA, 2008). Bread baking quality is determined by the physical properties of dough, its oxidative potential, flour water absorption, bread volume, and colour of crumb and crust (KOPPEL, 2010). Currently, there is considerable interest in the use of spelt for food destined for health, its distinctive taste attributes and organic food markers. The common way of consuming spelt is as bread and baking products because it is a hexaploid wheat (42 chromosomes) with rheological and technological properties close to those of soft wheat (MARCONI, 2002; ABDEL-AAL, 2008).

MATERIAL AND METHODS

A field stationary experiment was carried out at the Research Experimental Station of the Slovak University of Agriculture in Dolná Malanta near Nitra. The long-term average annual temperature of the site is 9.7°C and 16.6°C during the vegetation period. The average rainfall is 561 mm, including 323 mm during the vegetation period. Eight spelt wheat cultivars (Altgold, Bauländer Spelz, Franckenkorn, Holstenkorn, Ostro, Rouquin, Rubiota, Schwabenkorn) were cultivated in ecological farming system without fertilization and any chemical treatment. The field trial was ordered into randomized blocks (the average plot size was $30m^2$) in three repetitions.

The work reports on the results from studying the indirect baking quality indicators (wet gluten content, gluten index (ICC 155,158; AACC38-12), swelling of gluten (STN 461011-9), exstensibility of gluten (STN 461011-9, AACC 54-24), falling number (ICC 107/1; AACC56-81B), Zeleny test (ICC 116/1) and dough parameters (water absorption, dough development time, dough stability and softening, quality number) during a four-year research (from 2005 to 2008). The farinograph Brabender (Germany) is an instrument which is used to measure the rheological properties of spelt flour doughs, to test the quality and strength of bread flours, using a simple-flour-water dough system. Farinogram test was conducted using ICC standard method No 115/1. Indicators were evaluated in three replicates and the results presented are means of the three realized measurement, according to Slovak technical norms, ICC standards and AACC methods. All data were statistically analysed by analysis of variance (ANOVA) and Fischer test. The least significant difference at the 5% probability level (P value<0.05) was calculated for each parameter.

RESULTS AND DISCUSSIONS

Spelt usually observed a higher yield of wet gluten and higher gluten spread ability, i.e. weaker gluten structure (SCHOBER, 2006). The amount of wet gluten is closely connected with the baking quality of bread grain. The demand for food wheat is minimum 25%. The average wet gluten content in eight spelt wheat cultivars was 42.9% and ranged from 37.4% (Rouquin) to 49.8% (Rubiota). The differences between varieties were significant, average wet gluten content lower than 40% was determined in Rouquin and Hostenkorn, varieties Rubiota,

Altgold, Ostro exceed 45% of wet gluten content. Franckenkorn, Schwabenkorn and Bauländer Spelz were intermediate. Wet gluten content was significantly influenced also by the year of growing, that means by the weather conditions during vegetative period (Tab.1). The highest wet gluten was found in 2007 and 2008, when the weather conditions with higher temperatures and insufficient (2007) or normal distribution of rainfalls (in 2008) caused the highest gluten formation.

The gluten index (GI) was in average 48.9%. Statistical analysis showed high influence of the variety and year of growing on this quality indicator. GI ranged from 41.1% (Ostro) to 56.7% (Rouquin). GI higher than 50% was determined in Altgold, Franckenkorn, Holstenkorn and Rouquin. Concerning the weather conditions, the highest GI was observed in 2007, when higher air temperature in combination with drought caused higher formation of storage proteins. In 2008, lowest GI, indicating worst gluten quality, was caused by wet July, when excessive rainfalls before harvest caused lodging of spelt varieties (except Franckenkorn).

Table 1

The indicators of indirect baking quality of spelt wheat (*Triticum spelta* L.), average values for 2005-2008

VARIETY	WET GLUTEN (%)	GLUTEN INDEX (%)	FALLING NUMBER (s)	SWELLING (cm^3)	EXSTENSIBILITY (cm)	ZELENY TEST (ml)
Altgold	46,4 e	54,1 f	299,9 b	2,9 a	19,6 d	24,1 a
Bauländer Spelz	40,8 c	48,7 d	321,9 e	6,6 d	15,0 ab	31,1 e
Franckenkorn	42,5 d	50,7 e	303,8 c	6,0 c	14,8 ab	29,0 d
Holstenkorn	38,1 b	53,5 f	303,3 bc	6,6 d	14,5 a	25,0 b
Ostro	47,7 f	41,1 a	278,4 a	4,3 b	20,3 d	26,8 c
Rouquin	37,4 a	56,7 g	313,5 d	7,7 e	16,2 c	29,5 d
Rubiota	49,8 g	42,6 b	282,0 a	6,0 c	15,8 bc	32,2 f
Schwabenkorn	40,7 c	43,9 c	327,8 f	6,7 d	16,5 c	33,8 g
YEAR						
2005	36,7 a	49,7 b	375,0 c	8,1 d	14,5 a	31,4 d
2006	39,1 b	56,7 c	292,9 b	6,7 c	15,9 b	26,4 a
2007	44,8 c	60,0 d	423,1 d	5,5 b	17,1 c	30,5 c
2008	46,8 d	30,7 a	157,0 a	4,5 a	17,4 d	28,8 b
Average	**42,9**	**48,9**	**304,0**	**5,8**	**16,6**	**29,1**
Standard error	±5,88	±14,54	±110,67	±1,94	±2,83	±4,48

The falling number which is the indicator of enzymatic activity (alpha-amylase) was influenced mainly by the variety and year of growing. Average value of the falling number was 304s and ranged from 278s (Ostro) to 328s (Schwabenkorn). Based on this, we can confirm that average enzymatic activity of all evaluated varieties was satisfactory, even values above 300s are considered as too high. A shortage of activity can be solved technologically by addition of amylolytic enzymes. Regarding the weather conditions, in all evaluated years there were significant differences between the values of this qualitative indicator. The lowest enzymatic activity was detected in 2007 (x=423s), caused by higher air temperature and

drought during grain maturing. Very high enzymatic activity (x=157s) was determined in 2008, when wet weather conditions influenced negatively this quality indicator.

Gluten extensibility is an important factor for dough processing. It could be used for prediction of flour utilization in baking process. Gluten with an extensibility over 15cm is more difficult to process, the dough is sticky, and mainly suitable for biscuits preparation. For baking industry recommended values ranged between 5-15cm. Extensibility of gluten was significantly influenced by variety and year of growing. Max. 15cm extensibility was found in varieties Holstenkorn, Franckenkorn and Bauländer Spelz. The most tensile gluten was determined in Ostro and Altgold. The best gluten extensibility was determined in 2005, with normal air temperature as well as precipitation in May. The worst extensibility was found in 2008.

The quality of bread wheat gluten depends on its swelling. For elite flour this value should be more than 13ml, in standard flour gluten swelling ranged from 9-11ml. In samples of spelt varieties the swelling varied between 2.9-7.7ml, which are lower values than the requirement for baking. The highest swelling was recorded in 2005, when also satisfactory extensibility was achieved. Because of the low swelling ability of spelt gluten, this wheat would be more suitable for pasta production than for bakery industry.

Zeleny test is based on the use of break flour. The composition of flour depends strongly on the moisture content of grain when being ground. Swelling of the gluten fraction of flour in lactic acid solution affects the rate of sedimentation of flour suspension in the lactic acid medium. High gluten content and better gluten quality both give rise to slower sedimentation rates, and thus higher sedimentation values. The average sedimentation value according to Zeleny test was 29.1ml. Significantly the lowest values were observed in Altgold (24.1ml) and Holstenkorn (25.0ml). More than 30ml sedimentation volume had Schwabenkorn Bauländer Spelz and Rubiota. According to weather conditions, the highest sedimentation values were found in 2005 and 2007. As in both years was June characterized with deficit of precipitation, water deficit could influence the properties of grain proteins.

The Brabender farinograph is used to access the rheological properties of wheat flours as they are mixed and developed into dough. The farinograph test is one of the most commonly used flour quality tests in the world. The results are used as parameters in formulation to estimate the amount of water required to make a dough, to evaluate the effects of ingredients on mixing properties, to evaluate flour blending requirements, and to check flour uniformity. The results are also used to predict processing effects, including mixing requirements for dough development, tolerance to over-mixing, and dough consistency during production. Farinograph results are also useful for predicting finished product texture characteristics. For example, strong dough mixing properties are related to firm product texture.

Water absorption is an important quality factor to the baker as it related to the amount of bread what can be produced from a given weight of flour. It also has a profound influence on crumb softness and breed keeping characteristics. High absorption values are desirable in bread baking as added moisture slows staling. Higher water absorption also means that less flour is needed to make a loaf of bread (Koppel, 2010). Water absorption ranged from 56.7% (Schwabenkorn) to 59.2% (Franckenkorn) what corresponded to European level. Significantly the lowest WA was in 2008 (56.3%) and highest in 2006 (59.5%). According to Marconi (2002) for yeast bread 55-65% absorption is appropriate. Flour containing high amounts of gluten, showed high water absorption values.

The average dough development time was 2.8 minutes (Table 2). The best was detected in Schwabenkorn, Bauländer Spelz and Roquin (from 3.1 to 3.2 min). Significantly longer dough development time was observed in 2008 (3.6 min).

Table 2

Farinograph analysis (Farinographic properties) of spelt wheat flour, average values for 2006-2008

VARIETY	Water absorption (%)	Dough development time (min)	Dough stability (min)	Dough softening (FU)	Quality number
Altgold	58,4 e	2,1 a	1,5 a	115,3 cd	32,2 a
Bauländer Spelz	57,4 c	3,2 e	2,3 de	97,5 ab	46,5 de
Franckenkorn	59,2 f	2,9 d	2,3 de	87,7 a	47,2 de
Holstenkorn	58,2 d	2,6 c	2,1 c	118,7 d	41,3 c
Ostro	58,5 e	2,3 b	2,0 b	96,7 ab	39,8 b
Rouquin	56,9 b	3,2 e	2,3 de	104,2 bc	49,8 e
Rubiota	59,7 g	2,7 c	2,2 cd	93,3 ab	43,2 cd
Schwabenkorn	56,7 a	3,1 de	2,4 e	99,2 ab	46,7 de
YEAR					
2006	59,5 c	2,5 b	1,9 b	105,8 b	33,5 a
2007	58,6 b	2,2 a	1,4 a	103,0 ab	45,2 b
2008	56,3 a	3,6 c	3,1 c	95,9 a	51,3 c
average	**58,1**	**2,8**	**2,1**	**101,6**	**43,3**
standard error	±1,80	±0,84	±0,90	±15,39	±10,69

Stability is an indicator of the flours tolerance of mixing. Dough stability is measure that is expected by baking industry for producing yeast bread. All spelt wheat varieties were characterized with short stability, in average 2.1 minutes so it indicated standard flour quality. Significantly the highest stability was found in Schwabenkorn (2.4 min). It was detected significant influence of variety and weather conditions on this parameter.

According to dough softening was spelt wheat flour of standard quality. Significantly the lowest softening was in Franckenkorn (87.7FU). The highest softening was in Holstenkorn (118.7FU). More stabile dough was in the year 2008 (95.9FU).

The quality number is a non-dimensional value indicating the flour quality. Statistical analysis confirmed significant influence of the variety and weather conditions on the quality number. Significantly the highest quality number was found in Roquin, Schwabenkorn and Franckenkorn, the lowest in Altgold and Ostro (Table 2). Overall evaluation of quality number indicated standard to weak flours. On the basic of all parameters of rheological analysis the best results was obtained in Franckenkorn.

The lower monthly average temperature of the years 2006 and 2007 during anthesis and maturing decreases the value of stability and increases the degree of softening. More rainfall during maturing in 2006 and 2007 decreases the dough development time and stability, but increases the degree of softening. The normal air temperatures and sufficient precipitation of 2008 reflected into the best dough properties of spelt wheat when compared with other years of growing. Further it was found that dough prepared from spelt flour were very soft and sticky during kneading. This fact can be explained thereby that rheological properties of spelt gluten are predominated by gliadins as a very sticky monomeric plasticizer.

CONCLUSIONS

All evaluated indirect baking quality parameters were depended on the variety and weather conditions. Spelt wheat was rich in the content of wet gluten. More than 45% was found in Altgold, Ostro and Rubiota. Very tensile gluten of spelt wheat was of standard quality. GI higher than 50% was determined in Altgold, Franckenkorn, Holstenkorn and Rouquin. In samples of spelt varieties the swelling varied between 2.9-7.7ml, which are lower values than the requirement for baking. High gluten content and better gluten quality both give rise to slower sedimentation rates, and thus higher sedimentation values.

Statistical analysis showed significant influence of the variety and year also on dough properties. Flour containing high amounts of gluten, showed high water absorption values. Dough of spelt wheat was developed in short time period, characterized with low stability and weak resistance to over mixing. On the basic of all parameters of rheological analysis the best results was obtained in Franckenkorn. The normal air temperatures and sufficient precipitation of 2008 reflected into the best dough properties of spelt wheat when compared with other years of growing (significantly the highest values of dough development, dough stability and quality number and the lowest dough softening).

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