

The evaluation of grain and flour quality of spring durum wheat (*Triticum durum* Desf.)

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Abstract. The quality of grain and baking properties of the flour from spring durum wheat (*Triticum durum* Desf.) were evaluated (one breeding line and three cultivars of the durum wheat along with a common wheat (*Triticum aestivum* L.) used as a benchmark). The research material for the investigation came from the field experiments conducted in soil and climate conditions of Lublin voivodship. The scope of the investigation included the evaluation of the physical and chemical indicators of the grain and flour quality: 1000 grain weight, test weight (kg hl⁻¹), the percentage of grain fractions, falling number, content and weakening of the gluten and Zeleny test for the sedimentation rate. The baking properties of the flour on the basis of the analysis of the selected rheological characteristics were also identified. The flour water absorption, resistance and softening of the dough and the calorimetric value of the flour were estimated. Durum spring wheat, exceeded common spring wheat in terms of 1000 grain weight, grain accuracy, the quantity of gluten and water consumption of the flour. By contrast, the falling number and the sedimentation test were higher in the common wheat. The rheological properties (water absorption of the flour, resistance and softening of the dough, the calorimetric value) indicate a good or at least sufficient technological quality of the flour obtained from milling the grain of spring durum wheat. Within the comparison of the durum wheat genotypes, Chado cultivar was distinguished by favourable physical parameters of grain, low weakening of gluten and good results of the farinographic assessment.

key words: spring durum wheat, grain quality, flour quality, rheological properties of dough

INTRODUCTION

All over the world there is a tendency to increase the consumption of products from durum wheat, which are considered as healthy, wholesome and nutritious. The most popular articles with a grain of this species are pasta and

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couscous (Elias, 1995). Some parts of this grain are milled to wheat flour destined for the bread production. Hence, of interest is not only the pasta value but also the baking value of the grain (Gąsiorowski, Obuchowski, 1978). Bread from durum wheat is produced in the Middle East and North Africa on a grand scale, where almost half of the grain of durum wheat is used to produce different types of bread. Moreover, in Europe, especially in Italy, regional bakery wares are made from that wheat (Boggini et al., 1995; Elias, 1995). The demand for this type of bread is increasing due to its specific characteristics (Palumbo et al., 2000). The bread produced from durum wheat compared to common wheat bread is usually characterized by a slower staling, and thus a longer shelf life, taste and pleasant aroma and a more aesthetic peel and yellow crumb (Golik, 2000; Raffo et al., 2003). However, that cereal also shows undesirable technological characteristics in the raw material destined for the bakery, which can be largely attributed to the specificities of the grain gluten proteins (Elias, 1995; Pasqualone et al., 2004). The differences in the share of each protein fraction contributes to the fact that the dough of durum wheat has different rheological properties from the dough of common wheat (Gąsiorowski, Obuchowski, 1978), which is closely connected with the smaller volume of durum wheat bread (Hareland, Puhr, 1998; Szumilo et al., 2009). However, with certain genotypes of wheat with strong gluten, showing a good balance between flexibility and elongation of dough you can still get the correct volume and appearance of the bread, so in this respect they are similar to high-quality bread wheat (Edwards et al., 2007). Thus, it is advisable to increase knowledge of the baking quality of durum wheat, which may increase the commercial value of this species and open alternative markets (Boggini et al., 1995).

The aim of this study was the evaluation of the grain quality and flour baking properties of selected genotypes of spring durum wheat in comparison with spring common wheat.

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MATERIAL AND METHODS

The experimental material consisted of spring wheat grains derived from one of the field experiments conducted from 2007 to 2008 by the Department of Plant Cultivation in the Felin Experimental Farm (51°22' N, 22°64' E), belonging to the University of Life Sciences in Lublin. The field experiment was conducted on a soil classified into good wheat complex, on the stand after the winter rape. The soil tillage was typical for the plough system. Nitrogen, phosphorus and potassium fertilization amounted to: P – 26, K – 66 and N – 40 kg ha⁻¹ and was applied before sowing. The second dose of nitrogen was applied as a top-dressing at the rate of 40 kg ha⁻¹. Weed control was achieved by the use of herbicides Puma Uniwersal 069 EW and Chwastox Trio 540 SL. Stabilan 750 SL was used to prevent lodging in cereals. Fungal diseases and pests were combated by using the formulas: Alert 375 SC and Decis 2.5 EC respectively.

The breeding line LGR_{896/23} of the hard wheat (*Triticum durum* Desf.) was used for analysis (selected at the Institute of Genetics, Plant Breeding and Biotechnology, UP Lublin, Poland) and Lloyd cultivar (American one), and Chado and Kharkivska 27 (Ukrainian cultivars). The grains of common wheat (*Triticum aestivum* L.) cultivar Torca were used as a benchmark. The scope of investigation included the evaluation of the physical and chemical indicators of the grain and the flour quality and baking properties of the flour on the basis of analysis of selected rheological characteristics of the dough. The evaluation of the physical characteristics of the grain was made according to the standard methods (Jakubczyk, Haber, 1983). After prior purification of the raw material and bringing the material up to the optimum moisture a few traits were determined: 1000 grain weight (TGW), test weight (kg hl⁻¹), and share of grain thickness fractions. Test weight was measured by a densitometer, using the measuring container with a volume of 1000 cm³. The grain was separated by Vogel sieves into four thickness fractions: >2.8 mm, 2.5–2.8 mm, 2.2–2.5 mm and <2.2 mm. The flour were obtained by milling the grain in the laboratory mill (type QC-109). The following traits were determined: the falling number – by Hagberg-Perten method (apparatus type SWD-83), the gluten content – by method of the leaching of the gluten from the dough by sodium chloride (by the mechanical device for measuring gluten concentration type SŽ), then the following traits were evaluated: weakening of the gluten and Zeleny test for the sedimentation rate. Furthermore, analyses of flour and dough were led by farinograph, on the basis of the generally accepted methods (Jakubczyk, Haber, 1983): flour water absorption, the dough resistance and the valormetric value of the flour – with a template (valorimeter).

The course of weather conditions in years of study (2007 and 2008) was much diversified. In 2007, April was distinguished by the deficiency of rainfall, which adversely

affected the germination of wheat. However, in the period from May to July a high temperature and rainfall in excess of the long-term average were recorded (1951–2000). These conditions favoured the intense growth and development of the plants. April in 2008 was warm, with rainfall surpassing long-term norm, thus promoting germination of cereals. May was characterized by moderate temperatures and a large excess of rainfall, whereas in June shortages of rainfall occurred. However, the temperature and the precipitation in July were similar to long-term normal.

The significance of differences between mean values of quality indicators were evaluated by analysis of variance at the significance level $\alpha = 0.05$ and the least significant difference was determined using Tukey's test.

RESULTS

The grain of all durum wheat entries (the cultivars and the line) stood out significantly with the greater weight of 1000 grain (an average of 31.3%) than that of cultivar Torca (Table 1). Similarly, test weight of grain varied significantly with the genetic factor. It was observed that the values of this index of the grain quality were at a high level, both in the case of the durum wheat (802–815 kg m⁻³), and the common wheat, which indirectly allows to forecast a good technological quality of the grain. In cereals harvested in 2008, a higher test weight and bigger TGW were found in comparison to 2007. By comparing the percentages of the individual fractions in the grain of the durum wheat and the common wheat it was found that the common wheat was characterized by a greater participation of small grains (the fractions less than 2.5 mm) and medium-sized grain (2.5–2.8 mm). Among the durum wheat genotypes, a large share of the average grain fractions was recorded in line LGR_{896/23} and Lloyd cultivar, and the most plump grain (fraction above 2.8 mm) was found in Ukrainian cultivars, especially in Chado cultivar.

The falling number of flour from grain of durum wheat cultivars and lines was low (Table 2), indicating a high activity of amylolytic enzymes. The flour obtained from common wheat was characterized by nearly twice as high value of the falling number (low activity of alpha-amylase), and smaller quantities of gluten (on average less by 8.0 percentage points) than the durum wheat flour. The significant variation of gluten amount in flour among the cultivars and lines of durum wheat was found. Line LGR_{896/23} and Lloyd cultivar were characterized by a greater gluten yield than the Chado and Kharkivska 27 cultivars. However, the gluten weakening ranged from 0.8 to 2.9 mm depending on the genotype of durum wheat and was significantly higher in the Kharkivska 27 and Lloyd cultivars than LGR_{896/23} line and Chado cultivar. The sedimentation index determined for durum wheat genotypes was on average 14.0 cm³, thus indicating insufficient baking quality of the flour. A significantly higher value of the sedimentation test

Table 1. Physical traits of spring wheat grain.

Line and cultivars	1000 grain weight (TGW) [g]			Test weight [kg m ⁻³]			Fractions of grains [%]			
	2007	2008	mean	2007	2008	mean	<2.2 mm	2.2–2.5 mm	2.5–2.8 mm	>2.8 mm
LGR _{896/23}	37.5	46.2	41.9	779	825	802	3.8	10.7	23.5	62.0
Lloyd	44.5	46.7	45.6	809	813	811	3.6	10.7	22.3	63.4
Chado	42.9	51.4	47.1	791	839	815	1.0	3.9	12.3	82.8
Kharkivska 27	44.2	48.4	46.3	796	821	809	2.2	7.4	20.1	70.3
Torka	31.4	37.5	34.5	765	818	792	5.6	19.3	40.5	34.6
Mean	40.1	46.0	–	788	823	–				
	a	1.41			8.4					
LSD _{0.05}	b	0.62			3.7					
	a×b	2.00			11.9					

a – for line and cultivars

b – for years

a×b – for interaction: line and cultivars × years

ns – not significant

Table 2. Flour quality parameters of spring wheat.

Line and cultivars	Falling number [s]			Gluten content [%]			Gluten weakening [mm]			Zeleny test [cm ³]		
	2007	2008	mean	2007	2008	mean	2007	2008	mean	2007	2008	mean
LGR _{896/23}	102	201	152	31.5	34.1	32.8	1.1	1.7	1.4	14.5	11.4	12.9
Lloyd	101	226	164	31.9	35.7	33.8	1.8	4.0	2.9	14.8	12.1	13.4
Chado	111	181	146	25.8	36.6	31.2	0.4	1.2	0.8	13.5	15.5	14.5
Kharkivska 27	116	172	144	26.3	36.0	31.2	1.6	3.0	2.3	15.2	14.9	15.1
Torka	336	254	295	26.2	22.3	24.3	0.3	0.5	0.4	45.4	31.1	38.3
Mean	153	207	–	28.4	33.0	–	1.0	2.1	–	20.7	17.0	–
	a	20.1			1.45			0.36			2.34	
LSD _{0.05}	b	8.8			0.64			0.16			1.03	
	a×b	28.5			2.05			0.51			3.31	

Explanations in Table 1

Table 3. Physical properties of the flour and the dough from spring wheat.

Line and cultivars	Water absorption [%]			Dough resistance [min]			Dough weakening [B.U.]			Valorimeter value [j.u.]		
	2007	2008	mean	2007	2008	mean	2007	2008	mean	2007	2008	mean
LGR _{896/23}	70.0	68.8	69.4	6.94	7.67	7.31	23	17	20	66	69	68
Lloyd	72.7	70.8	71.7	5.28	5.14	5.21	50	50	50	56	56	56
Chado	67.9	68.7	68.3	3.35	12.22	7.79	23	3	13	56	83	70
Kharkivska 27	67.2	69.4	68.3	5.25	4.58	4.92	58	73	66	56	52	54
Torka	65.1	61.7	63.4	9.47	2.45	5.96	14	43	29	75	49	62
Mean	68.6	67.9	–	6.06	6.41	–	34	37	–	62	62	–
	a	2.44			0.629			8.3			2.4	
LSD _{0.05}	b	ns			0.276			ns			ns	
	a×b	ns			0.890			11.7			3.5	

Explanations in Table 1

was found in the common wheat which is closely connected with the good quality of gluten. The flour with a greater falling number along with the quantities and weakening of the gluten was obtained from the grain of the cultivars and lines of the durum wheat harvested in 2008.

The quality of flour obtained by milling of the durum wheat grain was determined by the farinograph, based on the examination of the physical characteristics of the dough at the time of its creation – Table 3. Evaluated genotypes significantly affected the rheological properties such as water absorption of the flour, resistance and softening of the dough. The common wheat flour showed the lowest water absorption, whereas the flour of Lloyd cultivar was characterized by increased water absorption compared to the Ukrainian cultivars. The dough of Chado cultivar and LGR_{896/23} line stood out with a good resistance and small weakening among the compared genotypes of durum wheat. A resistance and softening of the dough from common wheat flour in comparison with durum wheat genotypes had intermediate values. The average valorimeter value of the flour from durum wheat was 62 u. The flour from LGR_{896/23} line, Chado durum wheat cultivar and Torka common wheat cultivar were characterized by a good valorimeter value, whereas the valorimeter value of the flour from grain of Kharkivska 27 and Lloyd cultivars was assessed as satisfactory. In 2008, Chado cultivar showed a greater resistance of the dough and a valorimeter value than in 2007, but smaller weakening of the dough value.

DISCUSSION

The results of investigation show a significantly greater weight of 1000 grains of durum wheat than TGW of common wheat. The smaller plumpness of common wheat grain as compared to hard wheat was also observed in other studies (Ciołek, Makarska, 2004; Rachoń, Szumiło, 2002). The better filling of the durum wheat grain causes its dimensional weight, to be about 10 kg m⁻³ higher than other wheat (Gąsiorowski, Obuchowski, 1978). A similar regularity is indicated by the results of this study. According to Cacak-Pietrzak et al. (2005b) in the spring wheat (*Triticum aestivum*) yield, percentage fraction of grains with a thickness greater than 2.8 mm is lower than the fraction 2,5–2,8 mm. It was confirmed by the researchers' investigations. However, in the case of *Triticum durum* grains the situation is reversed.

In determining the grain quality attention is paid to the enzymatic properties, especially to the amylolytic activity, which is characterized by the falling number. It defines the usefulness of the tested grains for further usage (Knapowski, Ralcewicz, 2004). This ratio depends on the genetic properties of the cultivar and the weather conditions during ripening and harvesting of the grain (Cacak-Pietrzak et al., 2005a). Relatively low values of the falling number were obtained for the flour from the cultivars and

lines of durum wheat, which indicates the high activity of amylolytic enzymes and reduces the usefulness of the tested grain for bread production. The higher amount of gluten and its enhanced quality demonstrates the suitability of the flour for baking the bread (Podleśna, Cacak-Pietrzak, 2006). Under the experimental conditions durum wheat was characterized by higher amount of wet gluten than common wheat. This is confirmed in other studies (Ciołek, Makarska, 2004; Rachoń, Kulpa, 2004; Rachoń, Szumiło, 2002; Woźniak, 2006). One of the features which indicates the quality of gluten is the weakening. Gluten characterized by good quality should have a low weakening value – less than 10 mm (Podolska, 2007). The results show that in terms of quantity of wet gluten and its weakening, all genotypes of durum wheat meet the requirements for raw materials for baking. By contrast, the low sedimentation rate of the wheat (Zeleny test) noted in this research tends to the opposite conclusion. The higher values of this parameter in durum wheat were noted by other authors (Woźniak, 2006; Woźniak, Staniszewski, 2007).

According to Gąsiorowski and Obuchowski (1978) stresses occurring during the milling of grains of *T. durum* often affect the starch granules which are very sensitive to the mechanical action, so that they are substantially damaged. In turn, the degree of starch damage in wheat flour has a significant impact on its water absorption, which implies the damaged starch granules absorb much more water (Laskowski, Różyło, 2004; Sapirstein et al., 2007). As it was expected, the flour made from the grain of the compared genotypes of the durum wheat absorbed more water than the common wheat flour. The physical properties of the dough from *Triticum durum* are similar to properties of the dough of “average” to “very weak” common wheat. The dough of durum wheat compared to the dough of the common wheat is not so strong. The reason is that the gluten from durum wheat flour is weaker than the common wheat gluten (Gąsiorowski, Obuchowski, 1978). In the authors' research, the dough made of flour from durum wheat cultivars (Chado) and line (LGR_{896/23}) was characterized by good resistance and low softening, which is due to the weakening of the structure of dough, mainly gluten (Rachoń, Kulpa, 2004). However, the flour from grain of these genotypes was distinguished by high valorimeter value, which demonstrates the usefulness of the studied raw materials for bread baking. Nevertheless, to fully assess the baking usefulness of durum wheat grown under soil and climatic conditions of Poland, further studies are needed.

CONCLUSIONS

1. Spring durum wheat, exceeded spring common wheat in terms of thousand grain weight, grain accuracy, the quantity of gluten and water absorption of the flour. However, the common wheat was characterized by far higher values of falling number and rate of sedimentation.

2. The rheological properties (water absorption of the flour, resistance and softening of the dough) indicate a good technological quality of flour from the milling of the grain of spring durum wheat.

3. Within the compared genotypes of durum wheat cultivars, Chado cultivar was distinguished by favourable physical parameters of the grain, low gluten weakening and good results of the farinographic assessment.

4. Preliminary results indicate the usefulness of durum wheat grain for bread making, but further research should be done related to baking process.

REFERENCES

- Boggini G., Tusa P., Pognal N.E., 1995.** Bread making quality of durum wheat genotypes with some novel glutenin subunit compositions. *J. Cereal Sci.*, 22: 105-113.
- Cacak-Pietrzak G., Ceglińska A., Sulek A., 2005a.** Effect of nitrogen fertilization and retardants on yield and quality of winter wheat grain. *Pam. Puł.*, 140: 25-33. (in Polish)
- Cacak-Pietrzak G., Ceglińska A., Torba J., 2005b.** The milling value some wheat cultivars from Breeding „Nasiona Kobierzyc”. *Pam. Puł.*, 139: 27-38. (in Polish)
- Ciolek A., Makarska E., 2004.** The effect of differentiated nitrogen fertilization and chemical protection levels on grain quality traits of durum wheat (*Triticum durum* Desf.). *Ann. UMCS, Agricultura*, 59(2): 777-784. (in Polish)
- Edwards N.M., Preston K.R., Paulley F.G., Gianibelli M.C., McCaig T.N., Clarke J.M., Ames N.P., Dexter J.E., 2007.** Hearth bread baking quality of durum wheat varying in protein composition and physical dough properties. *J. Sci. Food Agric.*, 87: 2000-2011.
- Elias E.M., 1995.** Durum wheat products. 23-31. Seminar on „Durum Wheat Quality in the Mediterranean Region”. Zaragoza, Spain, November 17–19, 1993.
- Gąsiorowski H., Obuchowski W., 1978.** Pasta's wheat durum (*Triticum durum*). *Post. Nauk Rol.*, 1/78: 35-52. (in Polish)
- Golik V.S., 2000.** Breeding spring *Triticum turgidum* L. var. *durum* on bread-making quality in Yurjev Plant Production Institute. 511-513. Seminar on „Durum Wheat Improvement in the Mediterranean Region: New Challenges”. Zaragoza, Spain, April 12–14.
- Hareland G.A., Puhr D.P., 1998.** Baking performance of durum and soft wheat flour in a sponge-dough breadmaking procedure. *Cereal Chem.*, 75(6): 830-835.
- Jakubczyk T., Haber T., 1983.** Analysis of cereals and cereale products. 339 pp. Publisher SGGW, Warsaw. (in Polish)
- Knapowski T., Ralcewicz M., 2004.** Estimation of the quality features of winter wheat corn and flour in the relation to diversified nitrogen fertilization. *Ann. UMCS, Agricultura*, 59(2): 959-968. (in Polish)
- Laskowski J., Różyło R., 2004.** Influence of starch damage extent in wheat flour on rheological (alveograph) properties of dough. *Acta Agrophys.*, 4(2): 373-380. (in Polish)
- Palumbo M., Spina A., Boggini G., 2000.** Agronomic and bread-making characteristics of durum wheat genotypes deriving from interspecific hybridisation with bread wheat. 515-518. Seminar on „Durum Wheat Improvement in the Mediterranean Region: New Challenges”. Zaragoza, Spain, April 12–14.
- Pasqualone A., Caponio F., Simeone R., 2004.** Quality evaluation of re-milled durum wheat semolinas used for bread-making in Southern Italy. *Europ. Food Res. Technol.*, 219: 630-634.
- Podleśna A., Cacak-Pietrzak G., 2006.** Formation of the spring wheat yield as well as its milling and baking parameters by nitrogen and sulphur fertilization. *Pam. Puł.*, 142: 381-392. (in Polish)
- Podolska G., 2007.** Formation of grain quality of wheat through production technology. *Stud. Rap. IUNG-PIB*, 9: 55-64. (in Polish)
- Rachoń L., Kulpa D., 2004.** Evaluation of durum wheat grain (*Triticum durum* Desf.) usefulness for bread production. *Ann. UMCS, Agricultura*, 59(2): 995-1000. (in Polish)
- Rachoń L., Szumiło G., 2002.** Yield and grain quality of some Polish and foreign varieties and lines of hard wheat (*Triticum durum* Desf.). *Pam. Puł.*, 130: 619-624. (in Polish)
- Raffo A., Pasqualone A., Sinesio F., Paoletti F., Quaglia G., Simeone R., 2003.** Influence of durum wheat cultivar on the sensory profile and staling rate of Altamura bread. *Europ. Food Res. Technol.*, 218: 49-55.
- Sapirstein H.D., David P., Preston K.R., Dexter J.E., 2007.** Durum wheat breadmaking quality: Effects of gluten strength, protein composition, semolina particle size and fermentation time. *J. Cereal Sci.*, 45: 150-161.
- Szumiło G., Kulpa D., Rachoń L., 2009.** Evaluation of the usefulness of selected winter wheat species grain for bread production. *Ann. UMCS, Agricultura*, 64(4): 1-8. (in Polish)
- Woźniak A., 2006.** The yield and quality of grain of spring wheat (*Triticum aestivum* L.) and hard wheat (*Triticum durum* Desf.) in dependence on agrotechnical level. *Acta Agrophys.*, 8(3): 755-763. (in Polish)
- Woźniak A., Staniszewski M., 2007.** Yield and grain quality of hard wheat (*Triticum durum* Desf.) depending on crop rotation. *Acta Agrophys.*, 9(3): 809-816. (in Polish)