Protein composition of winter wheat from organic and conventional growing systems

Lucie Krejčířová, Ivana Capouchová, Jiří Petr, Eva Bicanová, Radomír Kvapil

Original scientific paper

Czech University of Agriculture in Prague, Kamýcká 129, 165 21 Prague 6 – Suchdol, Czech Republic, (e-mail: krejcirova@af.czu.cz)

Abstract

Technological quality and the wheat grain protein composition are influenced by the growing system, variety, locality, year conditions and growing technology significantly. During two-year experiments we evaluated grain protein composition by SDS-PAGE method and selected winter wheat quality parameters in a set of varieties from different quality groups based on their baking quality (E – elite, the most suitable for baking utilization, A – high-quality, B – additional, suitable for use in mixture, C – others, unsuitable for baking utilization) from conventional and organic farming. Our results indicate influence of organic and conventional growing on grain storage proteins composition. Varieties from conventional farming system reached up to two times higher content of high molecular weight (HMW) glutenins. Varieties from organic farming were mainly characterized by higher content of low molecular weight (LMW) glutenins and gliadins and much higher content of nutritional valuable albumins and globulins. At the same time was noticed the highest content of HMW glutenins in varieties from quality group E. Varieties from quality group C were characterized by higher content of nutritional valuable albumins and globulins. This trend was noticed at wheat varieties from both systems of growing. The aim of our research was to find out information about protein composition and technological quality of tested wheat varieties from conventional and organic farming.

Key words: winter wheat protein composition, winter wheat quality, organic farming, conventional farming

Introduction

The wheat has a lot of differences in technological quality from organic farming compared with technological wheat quality from conventional growing. The most significant differences between qualitative wheat parameters from organic and conventional growing are crude protein content in a dry matter of grain and in parameters characterizing the wheat protein complex quality. Higher nitrogen needs vegetation phase mainly in late, when the grain is forming and maturing. It is in organic farming with absence of industrial fertilizers with fast effect frequently cause nitrogen deficit with a lower accumulation of wheat storage proteins – gliadins and glutenins (Prugar, 1999). This deteriorates food possibilities, mainly baking utilization (total crude protein content correlates significantly with a lot of other qualitative wheat parameters) (Branlard et al., 1991).

Although present studies indicate, that genetically determined differences, e.g. in bakery wheat quality from conventional farming observance also at organic farming. Some high-quality varieties from quality groups "E" (elite) and "A" (high-quality) may give good bakery utilization possibilities. Organic farming due to favourable quality gluten thereby and satisfactory rheology dough quality (Prugar, 1999; Capouchová, 2003).

Wheat flour ability to create viscoelastic properties of dough depends on wheat protein character, especially by optimal storage protein combination – gliadins and glutenins. Each of them affects rheology by the unique way – viscosity is affected by gliadins and elasticity by glutenins (Bushuk, Bekes, 2002).

Materials and methods

During two-year experiments (harvest year 2004 a 2005) were evaluated relations between grain protein composition, flour-milling parameters and baker quality in a set of winter wheat varieties from different quality groups based on their baking quality (E – elite, the most suitable for baking utilization, A – high-quality, B – additional, suitable for use in mixture, C – others, unsuitable for baking utilization) from conventional farming at the Breeding Station Stupice and organic farming at the Experimental Station of Plant production Department, Faculty of Agrobiology, Food and Natural Resources, Czech University of Agriculture in Prague – Uhříněves. Experimental places of Breeding Station Stupice and Experimental Station Uhříněves lies in nearly same soil-climatic conditions in sugar-beet growing region. Experiments were founded according to methods valid for leading of State Varietal Trials in the Czech Republic – by method accidental blocks, in 4 repetition, size of experimental plot approx 15 m^2. Experiments at the Breeding Station Stupice were established with using total N fertiliser rate 130 kg N.ha-1, herbicide, fungicide, insecticide, morphoregulator. At the Experimental Station in Prague-Uhříněves were experiments led in organic growing system according to principles of IFOAM (International Federation of Organic Agriculture Movements) and Methodical instruction for organic farming of Ministry of Agriculture of the Czech Republic. Field experiments were led in the same way as at Breeding Station Stupice, but there were not used industrial nor organic fertilizers and pesticides.

After harvest were collected approx. 3kg of grain samples for laboratory quality analysis. By grain samples were analyzed total crude protein content in dry matter of grain ČSN ISO 1871, wet gluten content in dry matter of grain ČSN ISO 5531 and sedimentation index by Zeleny ČSN ISO 5529. Left over part of grain was milled on laboratory mill Bühler (type MLU-202). After it were individual passages mixure so, reply for common baker smooth flour T 550. That was used for analyzing of rheology quality on pharinograph (ČSN ISO 5530-1) and for baker test (methodics by VÚ MPP Prague). For classification wheat grain protein composition was using electrophoresis analysis of storage proteins – method SDS-PAGE.

Results and discussion

Achieved results document influence of organic and conventional way of growing on the wheat grain storage proteins composition and technological quality characteristics, predicative partly about protein quantity (total crude protein content and wet gluten content in dry matter of grain), partly about protein complex quality (sedimentation index by Zeleny, rheology characteristics determination on pharinograph and yield of bread).

In content of LMW glutenins and gliadins we unlisted considerable differences between organic and conventional growing. At organic growing wheat was even their content a little bit higher compared with conventional wheat. In case of HMW glutenins was found considerably higher content at conventionally growed wheat; in case of organic wheat we recorded on the other hand considerably higher content of nutritional the most high-quality albumins and globulins. These results are in accordance with conclusions of Prugar (1980) and Graveland (1996), according to that nitrogen application generally increases part of protein fractions typical for gluten – glutenins and gliadins. Increasing amount of these fractions in total protein content lead to improvement of technological, especially baking wheat quality, but to decrease biological and nutritional value of proteins, due to reducing of essential amino-acids content.

Table1. Electrophoretic analysis of storage proteins and selected qualitative parameters of wheat from conventional and organic farming – harvest 2004 and 2005

Year	Locality	Qu. gr.	HMW glu. (%)	LMW glu. + gli. (%)	Alb. + Glob. (%)	Crude protein content in grain DM (%)	Wet gluten content in grain DM (%)	Sedi index by Zeleny (ml)	Water absorption (%)	Dough development time (min)	Dough stability time (min)	Degree of dough softening (FU)	Yield of bread (ml/100g of dough)
2004	Conventional farming	E	28.74	67.19	4.06	9.52	23.32	33	55.25	1.50	3.75	95	342
		A	25.85	66.59	8.10	11.01	27.64	34	52.83	1.25	3.67	107	344
		B	25.82	69.07	5.11	11.65	27.75	25	52.93	1.75	4.33	87	331
		C	24.77	59.88	15.35	9.94	18.20	22	48.35	0.88	2.13	100	300
	Organic farming	E	15.40	71.16	13.44	8.58	16.21	22	52.30	1.00	2.00	180	271
		A	10.66	69.86	18.81	8.27	16.81	20	51.90	1.00	2.33	147	290
		B	10.92	68.76	20.28	8.28	12.79	16	53.15	0.88	1.75	165	225
		C	7.73	67.71	24.50	7.61	10.84	12	50.84	0.85	1.65	174	238
2005	Conventional farming	E	34.90	62.34	2.75	11.95	22.64	30	63.50	1.25	3.75	100	358
		A	30.05	64.22	5.67	12.24	26.46	33	54.90	1.25	3.00	120	317
		B	23.60	70.51	5.53	11.42	24.39	29	32.66	1.00	3.25	150	265
		C	20.13	70.65	8.43	11.78	23.34	23	52.10	1.50	1.75	163	242
	Organic farming	E	17.52	70.56	11.92	11.59	23.27	29	54.70	1.50	3.08	100	314
		A	14.78	69.90	14.02	10.94	22.91	35	35.85	1.17	3.58	120	292
		B	14.20	70.98	14.87	10.61	21.04	32	51.10	1.17	2.83	140	269
		C	10.88	70.78	18.40	10.10	19.28	18	50.90	1.13	2.33	147	251

Values in table are statistical means.

Except differences in wheat grain storage proteins composition from organic and conventional growing we however recorded certain differences in protein composition among single varieties groups of quality. In conventional and organic way of growing was found the highest content of HMW glutenins and at the same time the lowest content of albumins and globulins in varieties from quality group E – elite and A – high-quality and the lowest in varieties from quality group C – others, unsuitable for baking utilization. It acknowledges results of Michalík (1992), according to which are changes in ratio of single protein fractions affected. Not only by total proteins content in wheat grain, but also by genotype and results of Prugar (1999) and Capouchová (2003), who show, that varieties from quality groups E and A itself observance, its genetically contingent differences in characters of baking quality and act like technologically better, superior, also during ecological way of growing .

Varieties with higher content of HMW glutenins reached higher values of pharinographic water absorption, longer dough development time, longer dough stability time, lower values of softening degree and higher yield of bread. Varieties with higher content of albumins and globulins reached worse values of rheology characteristics and yield of bread.

Conclusions

From our results it is noticeable influence of organic and conventional way of growing on wheat grain storage proteins composition and technological quality characteristics, predicative partly about protein quantity (total crude protein content and wet gluten content in dry matter of grain), partly about protein complex quality (sedimentation index by Zeleny, rheology characteristics determination on pharinograph and yield of bread).

Varieties from conventional farming system reached up to two times higher content of high molecular weight (HMW) glutenins. Varieties from organic farming were mainly characterized by higher content of low molecular weight (LMW) glutenins and gliadins and much higher content of nutritional valuable albumins and globulins.

At the same time was noticed the highest content of HMW glutenins in varieties from quality group E and

A. Varieties from quality group C were characterized by higher content of nutritional valuable albumins and globulins. This trend was noticed at wheat varieties from both systems of growing.
Varieties with higher content of HMW glutenins (conventionally growed varieties and varieties from quality group E and A), which are the most suitable for baking utilization – for making products from proofing dough, reached higher values of pharinographic water absorption, longer dough development time, longer dough stability time and lower values of softening degree.
Varieties from organic growing system and varieties from quality group C (unsuitable for baking utilization) reached worse values of rheology characteristics and these varieties were mainly characterized by higher content of LMW glutenins + gliadins and with higher content of nutritional valuable albumins and globulins.
This trend was noticed at wheat varieties from both systems of growing – organic and conventional way of growing, when varieties from quality groups E and A retain their better baking quality even in conditions of organic growing and as well as varieties from quality group C reached worse baking quality and higher nutritional quality in both ways of growing.

Financial support by the research project of CUA 6046070901, grant GA FAPPZ 21160/1312/3116 and grant NAZV QG 50034

References

Branlard, G., Rousset, M., Loisel, W., Autran, J.C. (1991): Comparsion of 46 technological parameters used in breeding for bread wheat quality evaluation. J. of Agronomy, 6(3-4):145-154.

Bushuk, W., Bekes, F. (2002): Contribution of protein to flour quality. Proceedings of the ICC Conference „Novel Row Materials, Technologies and Products - new Callange for the Quality Control“ Budapešť, pp. 14-19.

Capouchová,I. (2003): Vliv odrůdy a agroekologických faktorů na škrobárenskou a pečivárenskou jakost ozimé pšenice. Habilitační práce, ČZU Praha, 198 s.

Graveland, A., Henderson, M.H., Paques, M., Zandbelt, P.A. (1996): Composition and functional properties of gluten proteins. Sb. „Gluten ´96“, Proceedings of the Sith International Gluten Workshop, held in Sydney, 2-4.9.1996, in association with the 46th Australian Cereal Chemistry Conference,p. 218-223.

Michalík, I. (1992): Rostlinná výroba, 38, 8, s. 643-649.

Prugar, J. (1980): Otázky vlivu hnojenia na jakosť pšeničného zrna vo svetovej literature. III. časť, Agrochémia, 20, 1, s. 105-107.

Prugar,J. (1999): Kvalita rostlinných produktů z ekologického zemědělství. Stud. informace ÚZPI, 5/1999 (rostlinná výroba), 79 s.