BAKING QUALITY AND PROTEIN COMPOSITION OF EMMER WHEAT LANDRACES

Petr Konvalina, Jan Moudrý, Jan Moudrý jr.
University of South Bohemia in České Budějovice, Faculty of Agriculture
E-mail: konvalina@zf.jcu.cz

Abstract

Emmer wheat, *Triticum dicoccum* SCHRANK (SCHUEBL), is an old species of cereal which has been traditionally grown in aride areas. The renewed interest in this variety has its origin in favourable quality parametres of emmer wheat grain and a beneficial effect on human organism. This article deals with a study of quality parametres and storage protein composition of 6 varieties of emmer wheat (which have been chosen from the collection of gene bank at the Research institute of Crop Production in Prague-Ruzyně and in České Budějovice). High crude protein content in grain was proved during the trials. Nevertheless, such a characteristic is not suitable for the classical bakery processing (production of leavened products). The analysed genotypes contain more than 10% of high molecular weight glutenins (HMW glutenins), approximately 70% of low molecular weight glutenins + gliadins (LMW glutenins + gliadins), and almost 20% of residual albumins and globulins. Thanks to high share of albumins and globulins, emmer wheat grain is very valuable raw material for the production of healthy diet. The level of stability of storage proteins composition destine the suitability of emmer wheat for organic and low input farming in Less Favoured Areas.

Key words: emmer wheat, quality, storage protein composition.

Introduction

Emmer wheat (*Triticum dicoccum* SCHRANK (SCHUEBL), tetraploid species 2n=28, AABB genom), which is divided into 99 botanic varieties (Michalová *et al*., 2002), belongs to glumeous varieties of wheat that have a long tradition of growing and use as human diet (Marconi and Cubadda, 2005). Considering increasing requirements for richness, diversity and good-quality of foodstuff products, the interest in this species of wheat has been still increasing (Hammer and Perinno, 1995; Olsen, 1998; Nielsen and Mortensen, 1998). Such a renewed interest in emmer wheat varieties has its origin in countries with well-developed intensive agriculture. On the other hand, the surface of areas of emmer wheat has been decreasing in countries with less developped farming sector (Marconi and Cubadda, 2005).

Wheat storage (gluten) proteins create up to 80% from a total amount of wheat grain (Shewry *et al*., 2000). Technologically, glutenins and gliadins are the most important wheat storage proteins. Their proportion and amount in wheat grain is variable and changes with the total protein content, growing conditions, genetic disposition of variety, and process of grain maturing (Branlard *et al*., 2000; Shewry *et al*., 2000). The gluten quality for the specific final utilization is determined especially by the optimal storage proteins combination. Each of them affects rheology in a unique way dough viscosity and tensibility are affected by gliadins, elasticity – by glutenins (Bushuk and Bekes, 2002).

Gliadins create heterogeneous mixture of onechain polypeptides; they are proteins with the lowest nutritional value in the way of amino-acid composition. Glutenins are divided into two groups: the HMW and LMW (High and Low Molecular Weight) (Thompson *et al*., 1994; Shewry *et al*., 2000). Most studies of bread-making wheat focus on HMW glutenins, performing as key factors in the bread-making process, and they are easily identifiable by the electrophoresis (Krejčířová *et al*., 2007). Albumins and globulins are usually ranged to the so-called protoplasmatic proteins. As to the amino-acid composition, these proteins have the highest nutritional quality. Generally, albumins and globulins are not considered as proteins critical for the flour quality, even though a small significance was noticed (Schofield and Booth, 1983). According

to some autors, they decrease the quality of gluten (Paine *et al*., 1987; Bushuk, 1989).

Several authors state the favourable quality indicators for the human diet. They mention the high crude protein content in the first place; nevertheless, it is not suitable for the bakery processing. The literature may contain the results of the quality analysis contrary to each other. Therefore, this study is focused on the quality parametres of the varieties of emmer wheat which are part of the collection of the gene bank at Research institute in Prague-Ruzyně (RI). The second part evaluates protein composition and determines the nutrition value of emmer wheat grain.

Materials and methods

On the basis of the previous screening, 6 genotypes of emmer (Table 1), 4 landraces (Kundan, Jara, Praga, Rosamova česká přesívka), and 2 modern (M6 - Vanek, M10 – SW Kadrij) controlling cultivars of bread wheat were choosen. In the experimental year 2007, small plot trials with two replications were performed in two locations (Research institute in Prague-Ruzyně = RI, and University of South Bohemia in České Budějovice = USB). The characteristics of the trial stations: RI – altitude of 364 m; mean air temperature of 7.9 °C; total precipitation of 525.9 mm; sunshine duration of 1668.3 hours, pH ($CaCl_2$) of 7.3; P 78 $mg.kg^{-1}$; K 210 $mg.kg^{-1}$; Mg 148 $mg.kg^{-1}$; and Ca 4360 $mg.kg^{-1}$. USB – altitude of 388 m; mean air temperature of 8.2 °C; total precipitation of 620 mm; sunshine duration of 1564.3 hours; pH ($CaCl_2$) of 6.3; P 138 $mg.kg^{-1}$; K 155 $mg.kg^{-1}$; Mg 163 $mg.kg^{-1}$; and Ca - 1557 $mg.kg^{-1}$. The climatic and soil conditions were favorable for emmer growing et both locations. The experiments were carried out in low input growing system (practically not certificied organic farming system), without mineral fertilizers and pesticides at both locations. For seeding we used trial seed machine and for harvesting the Wintersteiger machine. The trials were weeded after tillering.

The quality analyse were carried out in the laboratories of the Czech Agricultural University in Prague. The following methods were used to carry out the laboratory analysis: crude protein content - (Kjeldahl - ICC No. 105); wet gluten content and gluten index ČSN ISO 5531, Glutomatic 2200, Zeleny sedimentation – value - ICC No. 116/1, enzyme (α-amylase) activity – Falling number ICC No. 107; and starch content (according Ewers, ČSN ISO 56 0512-16, Polamat A).

For the classification of wheat grain storage protein composition, the polyacrylamide gel electrophoresis in sodium dodecyl sulphate (SDS-PAGE) was used, according to the method of Wrigley (1992). Percentage of individual protein subunits HMW, LMW glutenins a gliadins, and residual albumins and globulins was calculated on the basis of denzitometric evaluation of electreograms using the Bio 1D software from Vilber-Lourmat firm.

Table 1

List of varieties

Code of variety	ECN[1]	BCHAR[2]	Name	SP[3]	*Triticum dicoccum* (SCHRANK) SCHUEBL:
D1	01C0200117	412064	Horny Tisovnik	CZ	var. *rufum* SCHUEBL
D2	01C0200947	412048	Ruzyne	-	var. *rufum* SCHUEBL
D3	01C0201262	412051	Tapioszele 1	-	var. *serbicum* A. SCHULZ
D4	01C0201282	412017	Tapioszele 2	-	var. *rufum* SCHUEBL.
D7	01C0203989	412013	Kahler Emmer	D	var. *dicoccum*
D10	01C0204501	412013	No. 8909	-	var. *dicoccum*
Note: [1] ECN = identificator ; [2] BCHAR = taxonomical code ; [3] SP = origin					

Results and discussion

The obtained results document crude protein content, wet gluten content, gluten index, sedimentation value, starch content, starch content and grain storage proteins composition of emmer landraces in comparison with landraces and modern cultivars of bread wheat.

Evaluated varieties provide higher crude protein content than controlling ones. At location RI is difference 3.5% and CB 2.6% on behalf emmer (Table 2). The higher protein content provide D4 (Tapioszele 2) – 20.1%. According to standartd ČSN 46 1100-2 is possible to include all emmer varieties in quality group elite. Coeficient of variation (CV) is 8.9% (RI) and 12.4% (USB). The higher protein content of emmer with comparison of soft wheat grown in the same conditions acknowledges e.g. (Marconi *et al*., 2005; Michalová *et al*., 2002).

At the location RI emmer provide the higher wet gluten content than controlling varieties about 9%, at USB was the same. CV attained 20%, relativelly stable at both location. Crude protein content, quality and content of gluten provide negative relation. Varieties with high gluten content but its low quality aren´t usefull for making proofing dought from backery point of view (Zimolka *et al*., 2006).

Gluten index have possitive corelation with quality of gluten. High value of gluten index showed strong gluten which is very difficult working. Low value is characterised by weak gluten which isn´t suitable for backery processing. In case of RI location provide 30 (CV 85.1%) at CB it is 36 (CV 37.9) (Table 2). This trait is very unstable. Gluten index provide double value in case of controlling varieties. Gluten of emmer is weak and isn´t good for backery processing.

Sedimentation value determine viscosoelastic character of gluten albumines and theire quality which provide fermentative processes in dought (proofing) for. With crude protein content and bread volume corelate in positivelly way. The value are low at both locations. Varieties aren´t able to surmount value (ČSN 46 1100-2) as minimum for submission into quality category B (bread). Controlling varieties provide high value (RI – 63 ml, USB – 54 ml) (Table 3). According to (Stehno, 2001) are sedimentation value at half with comparison of modern varieties.

Table 2

Quality parametres I

Variety	Crude protein content (%)			Wet gluten content (%)			Gluten index		
	location		mean	location		mean	location		mean
	RI	CB		RI	CB		RI	CB	
D1	18.0	15.6	16.8	44.5	30.0	37.3	4	43	24
D2	20.4	18.6	19.5	55.8	42.9	49.4	51	43	47
D3	15.9	14.4	15.2	34.9	33.0	34.0	5	15	10
D4	20.2	20.0	20.1	53.4	45.2	49.3	11	17	14
D7	19.6	19.2	19.4	40.2	49.7	45.0	55	24	40
D10	19.0	18.3	18.7	57.2	44.5	50.9	53	43	48
mean	**18.9**	**17.7**	**-**	**47.7**	**40.9**	**-**	**30**	**36**	**-**
SD	**1.7**	**2.2**	-	9.2	7.7	-	25.5	13.7	-
CV	**8.9**	**12.4**	**-**	**19.2**	**18.8**	**-**	**85.1**	**37.9**	**-**
M6	1.8	14.8	15.3	38.2	41.1	39.7	83	90	87
M10	15.0	15.3	15.2	39.2	41.8	40.5	79	55	67

Starch content is the same in case of all varieties and is very fixed. The lower starch content provide varieties D2 (Ruzyně) a D4 (Tapioszele2) at both location. The higher content provide variety D3 (Tapioszele 1) (65.9% RI and 64.8% CB) at both locations. (Galterio *et al*., 1994) features the lower value of starch content (52.7-56.8%).

Falling number detect damage of storage matter of grain wheat endosperm by hydrolytic enzymes, which are syntetised in consequence of start germination before harvest in grain. For insertion into quality group elita is minimum value 240 s according to ČSN 46 1100-2. This value didn´t get only one variety D3 (Tapioszele 1) at RI location

(Table 3). At the same location is higher level of CV 20%. This fact could be explained by later harvest some of varieties (came after rainy time), it is conformed by (Zimolka *et al*., 2006). This author note that falling number is very sensitive to rainy time during harvest. At CB location there was harvested in time and varieties provide the high value with low variability.

Table 3

Quality parametres II

Variety	Zeleny test (ml)			Starch content (%)			Falling number (s)		
	location		mean	location		mean	location		mean
	RI	CB		RI	CB		RI	CB	
D1	10	15	13	62.7	64.6	63.7	399	380	390
D2	12	17	15	59.1	61.8	60.5	367	369	368
D3	12	14	13	65.9	64.8	65.4	221	387	304
D4	14	17	16	58.6	60.3	59.5	363	352	358
D7	10	16	13	60.5	61.4	61.0	426	359	393
D10	14	15	15	60.4	62.4	61.4	355	403	379
mean	**12**	**16**	**-**	**61.2**	**62.6**	**-**	**355**	**375**	**-**
SD	1.8	1.2	-	2.7	1.8	-	70.9	18.8	-
CV	**14.9**	**7.6**	**-**	**4.4**	**2.9**	**-**	**20.0**	**5.0**	-
M6	59	50	55	62.7	61.7	62.2	339	269	304
M10	66	57	62	62.7	60.4	61.6	329	289	309
mean	**63**	**54**	**-**	**62.7**	**61.1**	**-**	**334**	**279**	**-**

In accordance with the results stated in Table 4, storage proteins composition of emmer wheat does not differ too much from storage proteins composition of bread wheat in low input farming system. Therefore, the statement of Marconi and Cubadda (2005) may not be confirmed. They state that emmer wheat grain is not so toxic for people suffering from digestive allergies as bread wheat grain (because of storage proteins composition). On the other hand, a comparison of the proportion of valuable albumine and globuline fractions could be very interesting aspect. The fractions of emmer wheat genotypes, grown on more fertile station (RI), achieve lower level (16.9%) than the fractions of bread wheat ones (17.5%). The proportion of these fractions in emmer wheat grain is higher (17.2%) in case of less fertile station (USB).

When comparing the stability of storage proteins composition from the point of view of the coefficient variability, we may generalize the results of the studies for the analysed groups of the varieties. HMW glutenins are the most fluctuating group CV = 7.3 – 36.2, the percentage of LMW albumins and glubulins is more stable feature CV = 0.2 – 4.6. The percentage of HMW glutenins is very versatile factor in case of emmer wheat and bread wheat too; it is supposed to be influenced by land and climatic conditions of the station (Krejčířová *et al*., 2006, 2007). The diversity of albumins and glubulins in emmer wheat genotypes is also very interesting characteristics CV = 15.6% - RI and 21% - USB; the proportion of these two types of elements is fixed in bread wheat genotypes CV = 3.1% - RI and 2.8% - USB.

Table 4

Storage proteins composition

Genotype	Parametre	Location					
		RI			USB		
		HMW[1]	LMW[2]	A+G[3]	HMW[1]	LMW[2]	A+G[3]
Emmer	**Mean (%)**	**10.2**	**72.9**	**16.9**	**13.6**	**69.2**	**17.2**
	SD	2.2	1.5	2.6	2.0	2.6	3.6
	CV (%)	**21.5**	**2.0**	**15.6**	**14.5**	**3.7**	**21.0**
Bread wheat (landraces)	Mean (%)	**9.6**	**72.4**	**18.0**	**14.3**	**70.6**	**15.1**
	SD	3.45	3.3	1.3	1.0	1.4	1.6
	CV (%)	**36.2**	**4.6**	**7.0**	**7.3**	**2.0**	**10.3**

Genotype	Parametre	Location					
		RI			USB		
		HMW[1]	LMW[2]	A+G[3]	HMW[1]	LMW[2]	A+G[3]
Bread wheat (modern varieties)	Mean (%)	**10.1**	**72.5**	**17.5**	**11.6**	**71.6**	**16.8**
	SD	1.4	0.9	0.5	0.6	0.2	0.5
	CV(%)	**14**	**1.2**	**3.1**	**18.4**	**0.2**	**2.8**
Notes: [1]HMW glutenins; [2]LMW glutenins + gliadins; [3]albumins + globulins							

According to Table 5, the effect of the species (emmer wheat, bread wheat) on the composition of storage proteins has not been confirmed by statistics. On the contrary, the effect of the station (intensity of the farming) has been registered in both cases (HMW glutenins and LMW glutenins and gliadins). Krejčířová *et al*. (2006, 2007) confirms these statements in her paper works; she points out the fact that the availability of nitrogen during the growing season is a limiting factor of the dislocation of the assimilated nutrients into each protein fraction. The proportion of albumins and globulins was not influenced by the station.

Table 5

ANOVA, values of the test criterion *F* for storage proteins composition

Factor	Quality parameter		
	HMW glutenins	LMW glutenins + gliadins	Albumins + globulins
Genotype	0.16^{n}	0.60^{n}	0.10^{n}
Location	15.80^{*}	9.85^{*}	0.82^{n}
Notes: *statistically significant α = 0.01; n – statistically insignificant			

Conclusions

High proportion of crude protein in grain was affirmed by the quality analysis (in several cases, it exceeded 20% in small-parcel trials). Its quality (from the point of view of its use in bakery sector) seems to be quite problematic factor. It proves negative values of gluten index and Zeleny test. In case of emmer wheat, it is better not to use it in the bakery sector, but in the other sectors and branches. Bread made of emmer wheat is flat but it has perfect sensoric qualities and features.

Emmer wheat, grown in low-input farming system, does contain similar storage proteins to bread wheat; the fact that emmer wheat grain is suitable for people suffering from celicalia cannot be approved. The evaluated genotypes contain more than 10% of HMW glutenins, about 70 % of LMW glutenins and gliadins and almost 20% of albumins and globulins in grain. The high percentage of the last group mentioned above causes the valuability of emmer wheat as a raw material for the production of healthy diet. The stability of storage proteins composition predestines the suitability of emmer wheat for organic and low-input farming systems in Less Favoured Areas. Emmer is not able to compete with modern varieties from the point of view of the level of yield, nevertheless it provides very good-quality grains.

Acknowledgements

Supported by the project MSM 6007665806

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