THE UTILISATION OF GRAIN SORGHUM (*SORGHUM BICOLOR* L. MOENCH) AND SWEET SORGHUM (*SORGHUM SACCHARATUM* L. MOENCH, VAR. *SACCHARATUM*) FOR GLUTEN-FREE DIET IN COELIAC DISEASE*

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The authors study the collection of crops that should expand resources of plant products for the diet at the coeliac disease. Within this collection they studied ten grain sorghum (*Sorghum bicolor* L. Moench) and sugar sorghum (*Sorghum saccharatum* L. Moench, var. *saccharatum*) varieties. The total nitrogen was analysed with an average nitrogen 1.72% and protein nitrogen with average content 1.55%. Crude protein at N x 5.7 was 9.83%, at N x 6.25 10.78%, where pure proteins form 91% of the total content of crude protein. The percentage of gliadins was found to be 32.33–44.82% and glutelins 14.22–16.72% in these samples in analysis of fractions of reserve proteins obtained by extraction with ethanol at 65 °C. The hybrid GK Zsófia F_1 from Hungary had the lowest content of gliadins, while on the contrary the highest percentage of gliadins show the sweet sorghum 150 cm tall Seva Flora. Evaluation of electrophoretic analysis of reserve proteins by the method SDS-PAGE confirmed the presence of monomer and aggregated prolamines. Regarding the possibility of the use of sorghum for gluten-free diet, immunological examination by the ELISA test is a decisive criterion, where it had been confirmed that the values found for gliadin content are deep below the limit value 10 mg.100 g^{-1}. These results allow recommending sorghum for the use in the diet at coeliac disease. It was proved that cultivation of very early hybrids would be possible in warm sugar beet- and maize-growing region of Bohemia and Moravia in sites where grain maize is cultivated.

sorghum; total and protein nitrogen content; protein fractions; gluten-free diet; coeliac disease

INTRODUCTION

Sorghum belongs to old cultural plants and was used for human nutrition for time immemorial. Now its cultivation is expanding, so it is the fifth most spread cereal crop with a seeding area 1.5 million hectares in the world and 220,000 hectares in Europe. It belongs to the group of thermophile cereals that are cultivated in southern regions of the world. The greatest growers of sorghum in Europe are France with 63 thousand of hectares, Italy with 34.5 thousand hectares and Spain with area of 8.1 thousand hectares. Maize and sorghum belong to the most productive cereals with the type of photosynthesis C 4. Sorghum is a crop the most resistant to drought and tolerant to stress factors, such as salinisation. The yields of sorghum are growing owing to the progress in breeding of hybrid varieties. It can also be seen that like it is with maize, the alteration of its cultivation in more northern-situated regions, due to higher cold tolerance and earliness of new hybrids. It also offers a greater possibility of its utilisation in Europe for food purposes what has not been allowed till now. The assortment of food preparations is very rich in regions of greater spread of sorghum.

The possibility of use of sorghum for diet at coeliac disease was derived from the ordinary utilisation of maize and rice from the same group of cereals. However, its suitability should be tested for the structure of protein complex and immunology for elimination of the coeliac disease (gluten-sensitive enteropathy).

The genus sorghum includes several species and a lot of possibilities for utilisation. The greatest share of grain sorghum is in Africa and Asia for human nutrition. The grain is peeled into grouts, it is ground to meal for bread and baking and many meals of special names are prepared from them in different countries. The varieties with light grains are used for these purposes predominantly. The preparation of paste from different ground meal or grouts in combination with meat or vegetable is widely used. The use of sorghum for alcohol and beer production, where grains of coloured varieties are used, is rather widespread. In the developed countries grain sorghum is used as a main component for feed mixtures. The plants of sweet sorghum are processed for sugar syrups or are

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fed, silaged or dried for hay. Except sweet sorghum Sudan sorghum (*Sorghum sudanense* L.) or hybrids of sorghum and Sudan sorghum are widely used in this context.

Grains of grain sorghum or sweet sorghum are smaller than those of wheat. The thousand kernel weight (TKW) is 20–30 g. The percentage of endosperm is 82.3%, of germ 9.8% and husk 7.9% (Zeller, 2000; Anonym, 1995).

The content of starch is similar to that of maize and wheat – about 70%, the content of amylose is ranging from 21 to 34%, and amylopectin 65–80%. From analyses of more than 160 genotypes of the world collection ICRISH the content of starch is 69.5%, the percentage of amylose is 26.9%. The content of proteins is ranging between 8 and 16%, in the above mentioned analyses it was 11.4%, the fat content 3.3%, ashes content 1.9 %, crude protein 1.9% (Jambunathan, Subramanian, 1988). The tannin content (proanthocyanidine) is given as negative and some other anti-nutritional substances that have negative impacts on digestibility. This is more bound to varieties of sweet sorghum or varieties with coloured grains.

The contents of different substances are usually much different according to the site of cultivation and cultivation practice. For example, the content of proteins is strongly affected by nitrogen fertilization, it mainly increases prolamin fractions, called kefirine at sorghum (Sawhney, Naik, 1969). Just the task of the content of different protein fractions to be used for the diets at the coeliac disease seems to be one of most important questions. From the results of analyses of sorghum grain from main regions of its cultivation Jambunathan et al. (1981) indicate a low content of prolamines 25.2% of the total protein, 17.4% of albumin and globulin and 39.7% of glutelin, the rest was 10.6%. The content of lysine, arginine, histidine and tryptophan is valued in albumin and globulin fraction. On the other side, prolamin fraction is poor in lysine, arginine, histidine and tryptophan. This fraction contains much proline, glutamine acid and leucine (Abuja et al., 1970).

The results of analyses mentioned above on the content of nutritive substances testify the suitability of the use of sorghum for traditional human nutrition, what is proved by its use to solve the problem of starvation in developing countries. Consuming experiments conducted with children and adults were very good, however when the principles of suitable preparation of meals were kept, when the content of prolamins and eventual content of anti-nutritional substances is reduced. These results indicate the possibility of its use for the diet for patients with coeliac disease.

The coeliac disease (coeliac sprue, gluten-sensitive enteropathy) is defined as a permanent intestinal intolerance of gluten and related proteins comprised in cereals. The disease is different by its pathogenic symptoms from food allergy. The coeliac disease is most frequently manifested in one year-old child, i.e. several months after transition from milk to normal food; it may be manifested even in older children or in adulthood, then occurrence reaches the peak in 40 years old people. By using sensitive serological tests for population screening it was recently shown that the prevalence in Europe is high – 1 : 200, or even greater (Tlaskalová et al., 1999). The eating of food containing gluten results in damage to intestinal mucous membrane, what leads to malabsorption.

Gluten is a basic component causing the development of coeliac sprue. The finding of gluten peptides responsible for its toxicity and immunogeneity is very difficult, because gluten as reserve protein of cereals is a mixture of closely related molecules. Gliadins belongs to prolamines, i.e. cereal proteins soluble in alcohol (glutenins are alcohol-insoluble). Wheat gliadins, responsible for coeliac disease, show a marked sequential homology with related prolamines from rye (secalines), barley (hordeines) and oats (avenins). All these molecules have a linear structure, containing repeating sequences, a high occurrence of amino acids, glutamin and prolines is typical in primary structure. The full removal of gluten from food leads during several months to renewal of architecture and function of intestinal tissue and clinical condition of patients is markedly improved (Tlaskalová et al., 1999).

For the intention of this research, studying just its use for the diet of the patients with the coeliac disease, it was necessary to verify whether in cultivation under Czech conditions the content of nutritional and hazardous substances is suitable for these purposes. A strong effect of cultivation conditions, weather and cultural practices is known, particularly as affected the content of proteins and their composition. Therefore, the authors focused their research on the detailed study of chemical composition including immunological tests for suitability of sorghum for diets at coeliac disease.

MATERIAL AND METHODS

The seed of grain sorghum (*Sorghum bicolor* L. Moench) and sweet sorghum (*Sorghum saccharatum* L. Moench, var. *saccharatum*) was obtained from the Cereal Research Institute Szeged (Hungary), from the company Seva Flora Valtice (Czech Republic) and from the Gene Bank of the Research Institute of Crop Production (VÚRV, Prague-Ruzyně):

1. White-seed grain sorghum (Hungary)
2. Grain sorghum GK Zsófia (Hungary)
3. Grain sorghum without tannin (Hungary)
4. Grain sorghum GK Zsófia, hybrid F1 (Hungary)
5. Low red grain sorghum (VÚRV Prague-Ruzyně)
6. Low black sweet sorghum BAZ (VÚRV Prague-Ruzyně)
7. Spike sweet sorghum, 150 cm tall, black (Seva Flora Valtice)
8. High black sweet sorghum (Seva Flora Valtice)
9. Low sweet sorghum (Seva Flora Valtice)
10. High sweet sorghum (Seva Flora Valtice)

The seed of the above-mentioned varieties was sown in the last decade of April 2001, on two experimental sites of Central Bohemia (The Experimental Station of the Czech University of Agriculture in Prague-Uhříněves and The Experimental Station of the Czech University of Agriculture in Prague-Suchdol), in sugar beet-growing region with production potential of soils about 80 points.The plot size was 30 m^2 in two replication. The plants were harvested in the middle of September and hot-air dried out in panicles and then flailed. The hybrid GK Zsófia F1 was the earliest variety. Sorghum hybrids No. 1, 5, 8 and 10 did not ripen and due to they were not included in further evaluation.

The seed samples were prepared for analysis after harvest, where the following substances were determined:

1. total nitrogen (determined by the method after Kjeldahl).
2. protein nitrogen (determined by the method after Berstein).
3. composition of protein fractions (discontinued fractionation after Osborn, modification by Michalík et al., 1994, and Michalík, 2002).
4. electrophoretic composition of storage proteins (SDS-PAGE ISTA after Wrigley, 1992).
5. immunological determination of gliadin amount (ELISA-enzyme immunoassay, the kit Reidel).
6. each samples was analysed twice – all results are averages of two analyses.

ELISA for quantitative determination of gliadin

The method consists in interaction of specific antibodies against gliadin with gliadin comprised in a food sample. In our experiments we used commercial kit RIEDEL-de Haen). In brief: 1 g of food is extracted in 10 ml of 50% ethanol, diluted supernatant after centrifugation is applied to a microplate with a bound antibody. In further stage after appropriate incubation and washing, antibody conjugated with peroxidase is applied and this is followed by reaction with substrate and chromogene, after its finishing, the values of optical density are read. As prescribed by the present valid Codex alimentarius the food that contains less than 10 mg of gliadin per 100 g is considered as suitable for gluten-free diet.

RESULTS AND DISCUSSION

The results of determination of the total nitrogen and protein nitrogen (average for three determinations) are given in Table 1 for the studied varieties.

Average content of proteins of studied sorghum varieties cultivated in the sugar beet-growing region of Bohemia with average annual temperature 8.3 °C and sum of precipitation 575 mm is 9.8% (N x 5.7), at (N x 6.25) 10.78%. The FAO publication Sorghum and millets in human nutrition (1995) reports the content of protein 12.3% at (N x 6.25) from analyses of Hubbard et al. (1950) who did analyses from the regions of main cultivation in the USA. Among cultivation conditions of Hungary in grain sorghum hybrids the content of proteins is 10.0–10.7% (Rajki-Siklósi, 1993). Zeller (2000) reports the range 8–16% (Jambunathan, Subramanian, 1988).

Different variety structure, different agro-ecological conditions and technology of cultivation cause the variability in the content of proteins. The level of nitrogen nutrition in a decisive degree particularly affects the production of protein complex (Michalík, 2002). 91.36% on average falls to "pure" proteins of the total crude protein content.

For the objectives of this study, however, the percentage of protein fractions plays a decisive role. In an analysed collection of varieties cultivated under the conditions of Central Bohemia the percentage of albumins and globulins amounted to 17.9% of the total nitrogen, prolamines 5.8%, glutelins 18.3%, the residue 57% (Table 2). As reported Naik (1968) the percentage of albumins and globulins should be 15–25%, of gliadins 27–43% and glutelins 26–39%.

It is known from the literature that prolamines of sorghum grain are hard-soluble in 70% ethanol under laboratory temperature, what is indicated by several authors (Jones, Beckwith, 1970; Haikerwall, Mathieson, 1971 and others). Low solubility of re-

Table 1. The content of total and protein nitrogen (%) and crude protein

Sorghum variety	% of total N	Crude protein (N x 5.7) (%)	% of protein N	% of pure proteins
6. +Low black sweet sorghum BAZ (VÚRV Prague-Ruzyně)	1.68	9.59	1.50	89.60
7. +Spike sweet sorghum, 150 cm tall, black (Seva Flora Valtice)	1.79	10.23	1.64	91.37
9. +Low sweet sorghum (Seva Flora Valtice)	1.71	9.75	1.50	88.13
4. +Grain sorghum GK Zsófia, hybrid F1 (Hungary)	1.72	9.83	1.54	89.45
2. +Grain sorghum GK Zsófia (Hungary)	1.71	9.75	1.59	93.45
3. +Grain sorghum without tannin (Hungary)	1.69	9.67	1.51	89.27
4. ++Grain sorghum GK Zsófia, hybrid F1 (Hungary)	1.75	9.99	1.57	89.96
Average	1.72	9.83	1.55	91.36

+ Provenance the Experimental Station Prague-Uhříněves
++ Provenance the Experimental Station Prague-Suchdol

Table 2. Protein fractions in sorghum varieties after prolamine extraction at 20 °C

Variety		Albumins + globulins	Prolamines	Glutelins	Rest
6. +Low black sweet sorghum BAZ (VÚRV Prague-Ruzyně)	content (% N)	0.12	0.14	0.53	1.06
	percentage	7.49	8.32	20.02	63.34
4. +Grain sorghum GK Zsófia, hybrid F1 (Hungary)	content (% N)	0.34	0.08	0.33	0.95
	percentage	20.00	4.87	19.54	55.30
2. +Grain sorghum GK Zsófia (Hungary)	content (% N)	0.36	0.08	0.30	0.92
	percentage	21.33	4.91	18.06	54.12
3. +Grain sorghum without tannin (Hungary)	content (% N)	0.37	0.11	0.25	0.93
	percentage	22.33	6.60	15.20	55.04
4. ++Grain sorghum GK Zsófia, hybrid F1 (Hungary)	content (% N)	0.32	0.07	0.33	1.01
	percentage	18.42	4.50	18.87	57.58
7. +Spike sweet sorghum, 150 cm tall, black (Seva Flora Valtice)	content (% N)	0.14	0.12	0.36	1.14
	percentage	7.80	7.02	20.32	63.57
9. +Low sweet sorghum (Seva Flora Valtice)	content (% N)	0.14	0.11	0.33	1.10
	percentage	8.18	6.90	19.52	64.76
Average	content (% N)	0.25	0.10	0.35	1.02
	percentage	15.07	66.16	18.79	55.27

+ Provenance the Experimental Station Prague-Uhříněves
++ Provenance the Experimental Station Prague-Suchdol

Table 3. Protein fractions in sorghum varieties after prolamine extraction at 65 °C

Variety		Albumins + globulins	Prolamines	Glutelins	Rest
6. +Low black sweet sorghum BAZ (VÚRV Prague-Ruzyně)	content (% N)	0.12	0.74	0.28	0.52
	percentage	7.49	44.06	16.70	31.31
4. +Grain sorghum GK Zsófia, hybrid F1 (Hungary)	content (% N)	0.34	0.60	0.23	0.54
	percentage	20.00	35.13	13.33	31.54
2. +Grain sorghum GK Zsófia (Hungary)	content (% N)	0.36	0.63	0.19	0.51
	percentage	21.33	36.88	11.46	29.98
3. +Grain sorghum without tannin (Hungary)	content (% N)	0.37	0.61	0.17	0.50
	percentage	22.33	36.36	10.25	29.76
4. ++Grain sorghum GK Zsófia, hybrid F1 (Hungary)	content (% N)	0.32	0.56	0.25	0.60
	percentage	18.42	32.33	14.71	34.28
7. +Spike sweet sorghum, 150 cm tall, black (Seva Flora Valtice)	content (% N)	0.14	0.80	0.29	0.55
	percentage	7.80	44.82	16.42	30.62
9. +Low sweet sorghum (Seva Flora Valtice)	content (% N)	0.14	0.75	0.28	0.52
	percentage	8.18	44.30	16.72	30.68
Average	content (% N)	0.25	0.67	0.24	0.53
	percentage	15.07	39.12	14.22	31.16

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++ Provenance the Experimental Station Prague-Suchdol

serve proteins is caused probably by production of the complex of proteins with saccharides, what follows from the results of Beckwith (1972), who proved that solubility of prolamine and glutelin proteins was increased after enzymatic hydrolysis of starch.

Based on it, analysed samples were repeatedly fractionated with the difference that 70% ethanol at the temperature 65 °C was used for extraction of prolamines. The results given in Table 3 and their comparison with the results presented in Table 2 are an evident proof of the effect of temperature on solubility of prolamine proteins. The percentage of prolamines represent 32–45% and solubility of extracted fractions reaches about 70%.

The fraction of prolamine proteins shows higher percentage (44.82%) in the sample 7 spike sweet sorghum. Differences in representation of prolamines among analysed varieties amount up to 72%.

Generally speaking the sorghum varieties, above all of Indian provenance, differ from African varieties by higher share of prolamine proteins in relation to glu-

Table 4. Quantitative evaluation SDS-PAGE of electrophoretic analysis of reserve (gluten) proteins

Variety	HMW	LMW + prolamines	Residual albumins + globulins	HMW	LMW + prolamines	Residual albumins + globulins
	(PI)[a]	(PI)[a]	(PI)[a]	(%)[b]	(%)[b]	(%)[b]
6. +Low black sweet sorghum BAZ (VÚRV Prague-Ruzyně)	51.54 (3)[c]	262.78 (12–15)[c]	166.90 (3–4)[c]	4.51	39.39	56.10
7. +Spike sweet sorghum, 150 cm tall, black (Seva Flora Valtice)	45.88 (2)[c]	307.97 (14–17)[c]	139.42 (7–11)[c]	5.57	53.68	40.75
9. +Low sweet sorghum (Seva Flora Valtice)	53.47 (3)[c]	328.02 (16–18)[c]	214.79 (7–8)[c]	4.52	40.67	54.81
4. +Grain sorghum GK Zsófia, hybrid F1 (Hungary)	64.22 (3)[c]	299.25 (13)[c]	241.71 (12)[c]	4.67	44.49	50.84
2. +Grain sorghum GK Zsófia (Hungary)	3.44 (0–1)[c]	146.21 (13)[c]	124.93 (8)[c]	0.90	42.73	56.37
3. +Grain sorghum without tannin (Hungary)	0.00 (0)[c]	125.43 (7–12)[c]	97.90 (7–8)[c]	0.00	49.32	50.68
4. ++Grain sorghum GK Zsófia, hybrid F1 (Hungary)	0.00 (0)[c]	195.46 (15–16)[c]	174.58 (8–9)[c]	0.00	26.10	73.90

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[a] pixel intensity
[b] relative percentage
[c] number of bands

tenins. Based on the results obtained, it can be said that analysed varieties belong to the group of Indian varieties. The results presented in Table 3 are identical with the results of other authors (Virupakscha, Sastry, 1968; Haikerwall, Mathieson, 1971).

The dominant position of prolamine proteins follows partially also from the results given in Table 4. On the other hand, the percentage of high-molecular glutenin subunits (HMW), except the samples 3 and 4, is ranging between 4.5 and 5.6%, what is on the level of values that are presented for wheat grain.

Compared with wheat gliadins, prolamines of sorghum grain differ by the structure of amino acid (Rjadčikov, 1978), what conditions their secondary structure and reactivity. The differences consist in the content of aspartic and glutamic acids, glycine, alanine, cyteine, leucine and tryptophan. The occurrence of different polypeptide fragments is also presupposed. Despite of the presence of prolamine proteins, whose content is comparable with prolamines of wheat grains, their sequential domains are not compatible with the gliadin fragments, what has been confirmed by the results of immunochemical analyses. Applied monoclonal antibodies prepared on the basis of wheat celiac-active prolamines are not immunologically identical prolamines to the sorghum fractions. Prolamines of sorghum grains are represented by the components of α-caphirine, soluble in 95% ethanol analogously like α-zeins of maize grain (Sastry, Virupakscha, 1969). Sorghum glutenins are hard-soluble and an increase of their solubility can be reached by enzymatic hydrolysis of starch and reduction of disulfide bonds (Beckwith, 1972).

The results obtained confirmed that the presence of prolamine proteins in food is not determinative for the

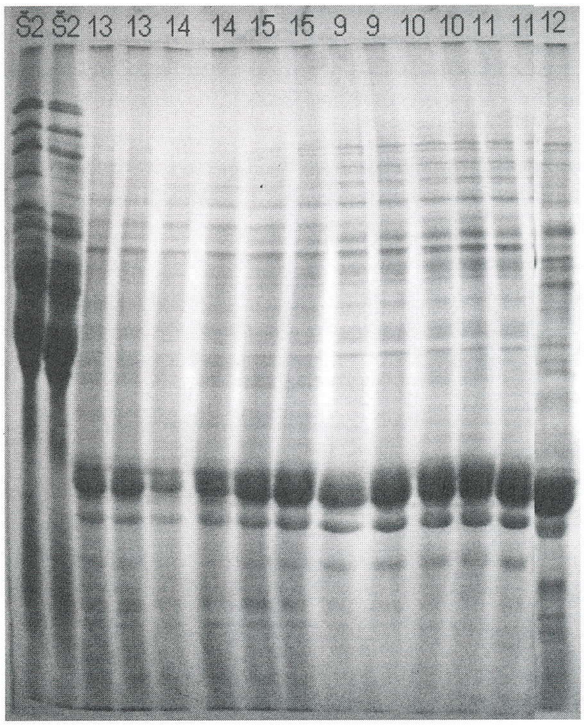

Fig. 1. Electrophoretic composition of storage proteins of sorghum

Š2 = standard (spring wheat, *Triticum aestivum* L. var. Chinese Spring)
13 = +Grain sorghum GK Zsófia (Hungary)
14 = +Grain sorghum without tannin (Hungary)
15 = +Grain sorghum GK Zsófia, hybrid F1 (Hungary)
9 = +Low sweet sorghum (Seva Flora Valtice)
10 = +Spike sweet sorghum, 150 cm tall, black (Seva Flora Valtice)
11 = +Low sweet sorghum (Seva Flora Valtice)
12 = ++Grain sorghum GK Zsófia, hybrid F1 (Hungary)
+ Provenance the Experimental Station Prague-Uhříněves
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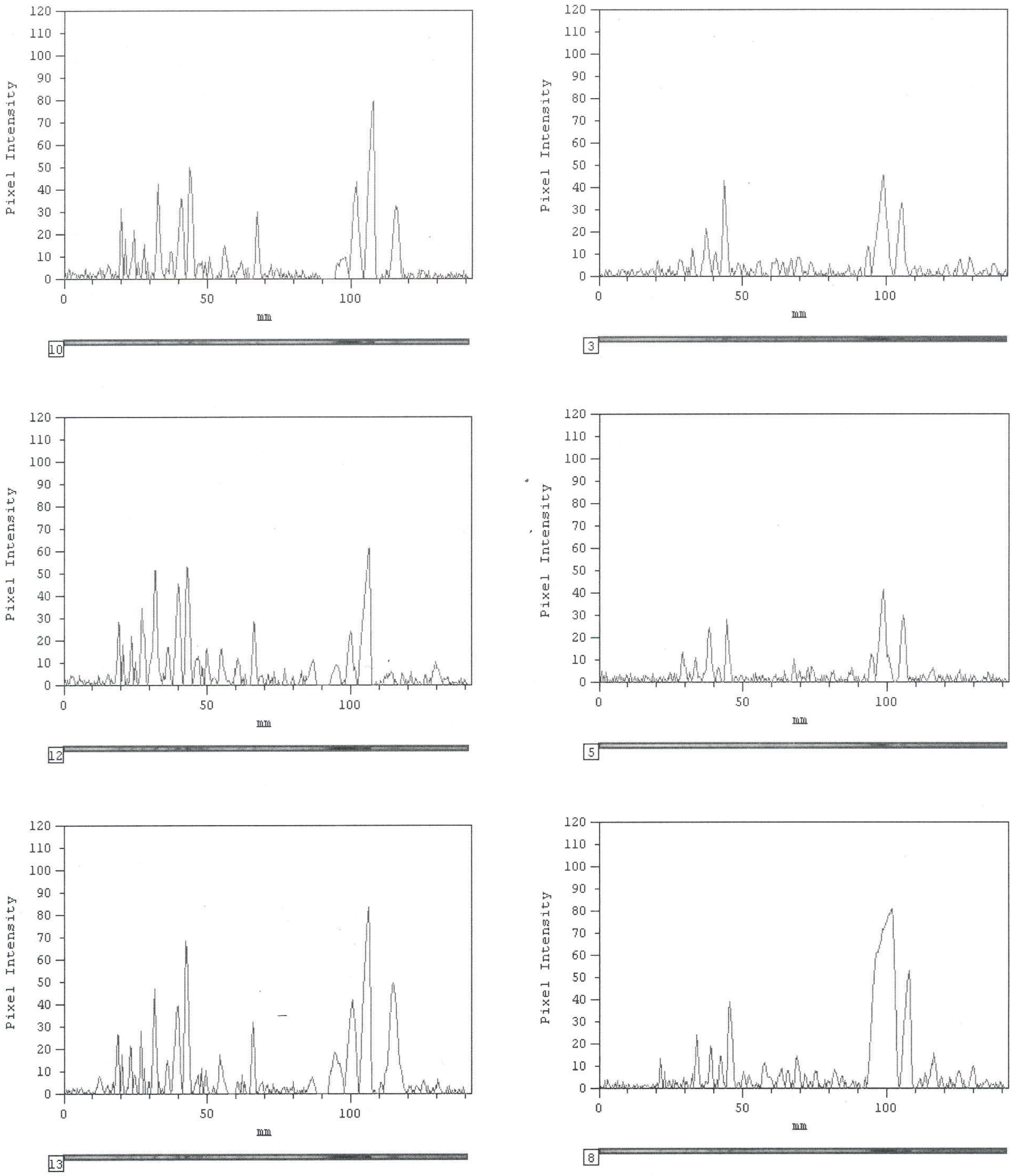

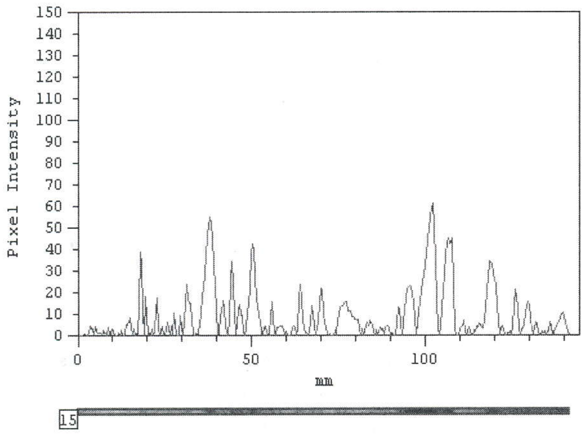

Fig. 2. Electrophoretic composition of storage proteins of sorghum (graphs)

Š2 = standard (spring wheat, *Triticum aestivum* L. var. Chinese Spring)
13 = +Grain sorghum GK Zsófia (Hungary)
14 = +Grain sorghum without tannin (Hungary)
15 = +Grain sorghum GK Zsófia, hybrid F1 (Hungary)
9 = +Low sweet sorghum (Seva Flora Valtice)
10 = +Spike sweet sorghum, 150 cm tall, black (Seva Flora Valtice)
11 = +Low sweet sorghum (Seva Flora Valtice)
12 = ++Grain sorghum GK Zsófia, hybrid F1 (Hungary)
+ Provenance the Experimental Station Prague-Uhříněves
++ Provenance the Experimental Station Prague-Suchdol

Table 5. Amount of gluten in sorghum varieties determined by the ELISA method

Variety	Amount of gluten (mg.100 g^{-1})
3. +Grain sorghum without tannin (Hungary)	2.1
2. +Grain sorghum GK Zsófia (Hungary)	3.5
6. +Low black sweet sorghum BAZ (VÚRV Prague-Ruzyně)	3.4
7. +Spike sweet sorghum, 150 cm tall, black (Seva Flora Valtice)	2.6
4. +Grain sorghum GK Zsófia, hybrid F1 (Hungary)	2.1
9. +Low sweet sorghum (Seva Flora Valtice)	3.2
4. ++Grain sorghum GK Zsófia, hybrid F1 (Hungary)	< std

< std – lower than standard (limit value is up to 10 mg.100 g^{-1})
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coeliac disease but the presence of fragments of prolamine proteins that induce immunity response of the body including production of specific antibodies.

As presented above, according to Jambunathan et al. (1981), the average content of albumins and globulins was 17.4%, gliadins 6.4%, cross-linked gliadins 18.8%, gliadins in total 25.2%, glutenin-like 4.0%, glutelins 35.7%, total 39.7% and the rest represents 10.6%.

It is evident that cultivation conditions participate significantly in the percentage of different fractions, particularly the site of cultivation, weather pattern and cultural practices. The group of prolamines is most affected by nitrogen fertilisation; nevertheless albumins and globulins are conditioned mainly genetically. The content of gliadins and glutelins is very low in our sorghum samples compared with the content of sorghum varieties cultivated in warmer and drier southern regions of the world. It is generally valid for the crops cultivated in northern regions where is solar radiation lower. Synthesis of proteins is for a plant more demanding for energy than e.g. synthesis of starch. This lower content should have been more suitable for our research intentions.

Qualitative evaluation of SDS-PAGE electrophoretic analysis of storage proteins showed that representation of storage proteins with higher molecular weight does not exceed the value 5.57%, prolamines with lower molecular weight including monomer prolamines of the type ω-, β- and γ-, α-gliadins is ranging between 26 and 53% (Table 4). There are significant qualitative and quantitative differences what the results of electrophoreograms (Fig. 1) and their graphs (Fig. 2) have confirmed.

Immunological testing of presence of gliadin by ELISA is a decisive criterion to prove the suitability for diet for those suffering from the coeliac disease in sorghum varieties. The results are presented in Table 5. As it is evident from this table, all values of the gluten content are deep below the limit value 10 mg.100 g^{-1}. The suitability of the studied varieties for gluten-free diet purposes has been confirmed by a decisive way. The results presented confirmed the prerequisites that prolamine proteins of sorghum do not showcross reactivity with gliadin and therefore they are not supposed to induce a series of specific reactions on the level of the mucosa of small intestine that result in coeliac disease. For the above reason it can be said that analysed grain sorghum samples can be used for testing whether the patients with coeliac disease can tolerate prolamines of sorghum varieties without exacerbation of disease. Immunological determination has limits given by its specificity. Wheat gliadins are used to prepare antibodies that are used in ELISA kits. These antibodies can identify rye and barley prolamines, but we cannot exclude the possibility that the newly proposed plant products (sorghum) do contain prolamines whose structure is not recognized by antigliadinanting used in ELISA, exert some immunological activity in patients.

Practical application of this recommendation in the conditions of the Czech Republic bound to the possibility of cultivation use of this thermophile species. We have data from the past on the possibility of sorghum cultivation in the Czech Republic but it was sugar sorghum for green feed, hay or silage, eventually for production of ethanol from the organic fluid of sugar sorghum.

Safe possibility of sorghum varieties follow from Hungarian experience where grain maize is cultivated with the number of earliness FAO to 300 (Rajki-Siklósi, 1993). This corresponds to Czech warm sugar beet-growing region, sugar beet- and maize-growing regions of Moravia. The cultivation is identical with that of maize; it does not require any special technical equipment and machinery. The hopeful is a progress in breeding of hybrid varieties that are bred for earliness among other things.

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Využití zrna čiroku zrnového a cukrového (*Sorghum bicolor* L. Moench, *S. saccharatum* L. Moench, var. *saccharatum*) pro bezlepkovou dietu při celiakii.

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Sledovali jsme soubor plodin uvažovaných pro rozšíření zdrojů rostlinných produktů pro dietu při celiakii. V rámci tohoto souboru jsme použili sedm odrůd čiroku zrnového *Sorghum bicolor* (L.) Moench a cukrového *Sorghum saccharatum* (L.) Moench, var. *saccharatum*.

Analyzován byl celkový dusík s průměrným obsahem 1,72 % a bílkovinný dusík s průměrným obsahem 1,55 %. Hrubý protein při N x 5,7 byl 9,83 %, při N x 6,25 byl 10,78 %, přičemž z celkového obsahu hrubého proteinu tvoří 91 % čisté bílkoviny.

Při analýze frakcí zásobníeh bílkovin získaných extrakcí etanolem při 65 °C byl zjištěn v těchto vzorcích podíl gliadinů 32,33–44,82 % a glutelinů 14,22–16,72 %. Nejnižší obsah gliadinů měl hybrid GK Zsófia F_1 z Maďarska, naproti tomu nejvyšší podíl gliadinů vykazoval čirok cukrový 150 Seva Flora.

Vyhodnocení elektroforetické analýzy zásobních bílkovin metodou SDS-PAGE potvrdilo přítomnost monomerních a agregovaných prolaminů.

Rozhodujícím kritériem z hlediska možnosti využití čiroku pro bezlepkovou dietu je imunologické vyšetření testem ELISA, při kterém se prokázalo, že zjištěné hodnoty obsahu gliadinů jsou hluboko pod limitní hranicí 10 mg.100 g^{-1}.

Tyto výsledky umožňují doporučit čiroky k využití pro dietu při celiakii. Přitom se ukazuje, že pěstování velmi raných hybridů bude možné v teplé řepařské a kukuřičné oblasti Čech a Moravy v místech, kde se pěstuje kukuřice na zrno.

čirok; obsah celkového a bílkovinného dusíku; frakce bílkovin; bezlepková dieta; celiakie

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