Grains of Nontraditional Crops as Sources of Retrograded Resistant Starch

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Abstract: The content of retrograded resistant starch of the RS_3 type was determined in six plant species and their accessions. Besides sorghum and foxtail millet, plant genotypes were cultivated in Piešťany locality in the year 2003. There were significant differences in RS_3 and total starch content in analysed crops and their accessions. Chickpea and buckwheat had the highest average content of RS_3, 5.2% and 3.8%, respectively. Millet and foxtail millet contained less RS_3, 2.9% and 2.8%, respectively. Millet was rich in total starch. The lowest amounts of RS_3 were detected in sorghum (1.6%) and amaranth (1.2%). The lowest variation in the RS_3 content was detected within the set of millet accessions and the highest within amaranths.

Keywords: resistant starch; retrograded starch; amaranth; buckwheat; chickpea; foxtail millet; millet; sorghum

The basic function of crop production is to produce feeds and foods. The product has to meet high requirements, e.g. high quality, long post-harvest and shelf life, manufacturing, nutritiousness and other traits. Among the other less highlighted attributes until now, the functionality of feeds and foods is increasingly required. The functional foods have been defined as foods which apart from basic nutritional functions provide a physiological benefit and/or reduce the risk of chronic diseases (Huggett & Schliter 1996). Resistant starch (RS) has been recognised as functional fibre with an important role in digestive physiology. Resistant starch, i.e. the fraction of starch that escapes hydrolysis by enzymes in the small intestine, involves physically inaccessible starch (type RS_1), native granular starch (RS_2), retrograded starch (RS_3), and chemically and thermally modified starch (RS_4) (Englyst & Kingman 1990; Asp & Björck 1992). Due to its physiological implications, RS was also considered as a component of dietary fibre (Annison & Topping 1994). It was defined as the sum of starch and products of starch degradation taking place in the small intestine of healthy humans (Englyst & Kingman 1992). Resistant starch offers many health-promoting effects. Metabolites originating during its fermentation are necessary for the normal physiological function of the bowel (Silvester *et al.* 1995). In this process a considerably high level of butyrate is generated, which is an important source of energy for colonocytes. It also activates cell proliferation (Mortensen & Clausen 1996). RS represents a barrier with the protecting and nutritious function in the colon, and has a protective effect in the genesis of colorectal cancer and diversion or ulcerative colitis (Hill 1995; Hylla *et al.* 1998). RS-rich food has a low glycaemic index (Liljeberg & Björck 1994) and maintains the amount of glucose (Willett *et al.* 2002), insulin (Pereira *et al.* 2002), cholesterol, and triacylglycerols (Liu *et al.* 2001) in human blood at a normal level. A long-time low glycaemic index diet has protective

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effects in healthy organisms against the development of non-insulin dependent diabetes mellitus (Björck *et al.* 2000) as well as of cardiovascular diseases (Behall & Howe 1995).

Starch consists of two D-glucose homopolymers – highly branched amylopectin and relatively unbranched amylose. Retrograded amylose is mainly responsible for the generation of RS (Pomeranz 1992). Therefore, the long-term intake of a high-amylose diet improved fasting triacylglycerols and cholesterol levels to a much larger extent than did a high-amylopectin diet (Behall *et al.* 1989).

Starch is the most abundant carbohydrate in human diet. Some starch types are more beneficial than others. Retrograded resistant starch – the RS_3 type is produced by hydrothermal treatment or by long storage of starch or starch-containing raw materials in specific conditions. Such treatment resembles cooking, cooling and storing in food preparation. Therefore the inclusion of RS_3 into human nutrition can be straight and very easy. Rich RS_3 sources can be consumed as groats or flour for the processing of foods, moreover, such raw material can be blended with wheat and other flours in the baking industry.

Plant breeders develop new advanced lines and cultivars possessing specific traits required by farmers. The most important are yield potential, quality of products, resistance against various biotic and abiotic stresses, and many others. Breeders can also create cultivars with specific traits designed for specific purposes, e.g. production of starch, biofuel. Among them, breeders can also select individuals and lines with specific traits aimed to improve the nutrition of the human population through functional foods. Moreover plant analysts can reveal the chemical composition of edible plant seeds which should be processed for foods or mixed with other food ingredients. Taking into account that resistant starch is one of the components for improvement of food qualities, the goal of this study was to detect the level of retrograded starch of the RS_3 type as well as soluble and total starch in seeds of six non-traditional and less frequently grown crops.

MATERIAL AND METHODS

Seeds of six analysed crops were obtained from the collections of plant genetic resources maintained

Table 1. Starch content in chickpea accessions

Accession	Soluble starch (%)	RS_3 (%)	Total starch (%)
Alfa (I)	44.3 ± 0.33	5.7 ± 0.11**	49.7 ± 0.23
Slovák (I)	40.8 ± 0.27	5.2 ± 0.04	45.9 ± 0.24
189 (I)	42.5 ± 0.34	4.9 ± 0.12	47.4 ± 0.22
88 193 (K)	43.2 ± 0.27	5.5 ± 0.09**	48.7 ± 0.18
88 194 (K)	42.9 ± 0.33	5.4 ± 0.05	48.3 ± 0.28
KNOOR 91 (K)	44.9 ± 0.34	5.1 ± 0.05	50.0 ± 0.38
89 ETA 403 (K)	45.2 ± 0.46	5.2 ± 0.11	50.4 ± 0.57
BG 004233 (K)	45.7 ± 1.01	5.6 ± 0.04**	51.3 ± 0.96
PK 51 833 (D)	38.5 ± 0.60	4.6 ± 0.08	43.1 ± 0.52
87 192 (D)	41.2 ± 0.26	5.1 ± 0.03	46.3 ± 0.30
CM-7-1/85 (D)	45.3 ± 0.54	5.7 ± 0.01**	51.0 ± 0.55
PK 52 291 (D)	39.5 ± 0.53	5.0 ± 0.05	44.6 ± 0.49
Punjab 91(D)	40.7 ± 0.79	5.1 ± 0.04	45.8 ± 0.85
AVG 480 (D)	41.4 ± 0.86	5.2 ± 0.03	46.6 ± 0.83
PK 50 759 (D)	38.7 ± 0.39	5.3 ± 0.04	44.0 ± 0.35
PK 51 814 (D)	40.8 ± 0.87	5.6 ± 0.04**	46.5 ± 0.92

**significantly higher RS_3 content than the mean, $P < 0.01$; K – kabuli type; D – desi type; I – intermediate type in Research Institute of Plant Production, Piešťany, and Research Institute of Crop Production, Prague-Ruzyně. Seeds of chickpea, buckwheat, millet and amaranth were grown in Piešťany locality. Materials harvested in 2003 were analysed. We had only some information about the sorghum and foxtail millet seeds which were obtained from the Gene Bank in Prague. We did not have any information about the locality and year of production. The analysed set of six plant species contained seed samples of 16 chickpeas (*Cicer arietinum* L.) (Table 1), 15 buckwheats (*Fagopyrum esculentum* MOENCH) (Table 2), 18 millets (*Panicum miliaceum* L.) (Table 3), 10 foxtail millets (*Setaria italica* (L.) P. BEAUV) (Table 4), 6 sorghums (*Sorghum bicolor* (L.) MOENCH) (Table 5) and 15 amaranths (*Amaranthus* L.) (Table 6). Non-husked seeds were used for analyses. Groats from all analysed plant species were prepared by Perten Laboratory Mill 3100. The hydrothermal treatment of groats was performed according to Skrabanja *et al.* (1998). Two grams of groats were mixed with l ml of 70% ethanol, dried for 10 min at 30°C and additionally 1 h at room temperature. Dry groats were wetted with 3.3 ml of distilled water and autoclaved for 1 h at 120°C and 110 kPa. Consequently, samples were slowly cooled to room temperature and retrogradation of starch continued on drying for 8 h at 50°C. The measuring of resistant, soluble (non-resistant) and total starch content was performed by Resistant Starch Assay Kit (Megazyme Int., Ireland) based on the McCleary *et al.* (2002) method. Data on each genotype represent the mean of duplicate determinations ± SD (standard deviation). RS_3 content and SD were defined per dry matter weight of groats. Statistical significance within each crop-plant was evaluated by analysis of variance.

RESULTS AND DISCUSSION

The hydrothermal treatment of groats samples of all species was carried out in the same way. The used treatment procedure was optimised previously for buckwheat groats (Skrabanja *et al.* 1998), i.e. the amount of retrograded resistant starch RS_3 produced in groats of other plant species need not be maximum. The set of analysed plant species contained a different number of accessions, therefore the average content of RS_3 in some species could be biased by the presence of the high RS_3 content variation within species. Mean percentages of RS_3 in analysed plant species

Table 2. Starch content in buckwheat accessions

Accession	Soluble starch (%)	RS_3 (%)	Total starch (%)
FAG 29/79	54.3 ± 0.26	3.8 ± 0.05	58.2 ± 0.21
FAG 38/82	53.0 ± 0.27	3.6 ± 0.04	56.6 ± 0.31
FAG 88/84	55.6 ± 0.47	3.5 ± 0.03	59.1 ± 0.43
Emka	47.7 ± 0.46	3.3 ± 0.05	51.0 ± 0.52
Hruszowska	51.4 ± 0.27	3.5 ± 0.03	54.9 ± 0.24
Kora	54.6 ± 0.67	4.2 ± 0.07**	58.8 ± 0.74
Špačinská	55.9 ± 0.19	3.6 ± 0.05	59.5 ± 0.25
Bogatyr	57.4 ± 0.93	4.4 ± 0.04**	61.8 ± 0.96
Ballada	54.0 ± 0.47	3.5 ± 0.04	57.5 ± 0.50
La Harpé	59.1 ± 0.60	4.5 ± 0.01**	63.5 ± 0.61
Pyra	55.8 ± 0.79	4.3 ± 0.03**	60.1 ± 0.82
Východoslovenská krajová	55.4 ± 1.34	4.0 ± 0.04	59.4 ± 1.31
PY-EP-2	56.9 ± 1.14	3.7 ± 0.12	60.6 ± 1.26
FAG 120/82	57.2 ± 0.47	4.0 ± 0.03	61.2 ± 0.51
PY-EP-1	56.9 ± 0.71	3.8 ± 0.06	60.6 ± 0.65

**significantly higher RS_3 content than the mean, $P < 0.01$

Table 3. Starch content in millet accessions

Accession	Soluble starch (%)	RS_3 (%)	Total starch (%)
IHAR 2	60.9 ± 0.61	2.7 ± 0.08	63.7 ± 0.52
IHAR 3	62.3 ± 0.34	2.9 ± 0.08	65.1 ± 0.26
PAN 1/79	61.1 ± 0.27	3.0 ± 0.07	64.1 ± 0.34
Jugoslavia	65.2 ± 0.67	3.0 ± 0.11	68.2 ± 0.57
PAN 14/80	65.3 ± 0.14	3.0 ± 0.03	68.3 ± 0.11
Unikum	62.7 ± 1.14	2.7 ± 0.08	65.3 ± 1.22
Charkovskoje 57	63.6 ± 0.47	2.8 ± 0.07	66.5 ± 0.54
Voronežskoje 420	62.0 ± 0.54	3.2 ± 0.06*	65.3 ± 0.59
ABY-BS 4091.00	64.6 ± 0.47	3.1 ± 0.04	68.0 ± 0.50
IHAR 13	62.7 ± 0.61	2.9 ± 0.11	65.6 ± 0.72
PAN 16/91	62.1 ± 0.73	3.0 ± 0.06	65.1 ± 0.71
ABY-BS 389186	61.6 ± 0.33	2.8 ± 0.04	64.4 ± 0.37
Černosemiannoje 1	63.3 ± 1.14	2.8 ± 0.03	66.1 ± 1.18
IHAR 4	60.8 ± 0.94	2.9 ± 0.12	63.7 ± 0.82
IHAR 5	63.5 ± 0.33	2.8 ± 0.09	66.3 ± 0.24
Biserka	65.1 ± 0.10	2.7 ± 0.08	67.9 ± 0.01
Harkovskaje	61.9 ± 1.07	2.6 ± 0.05	64.5 ± 1.02
Polnar 99-38	61.2 ± 0.40	2.7 ± 0.06	63.9 ± 0.46

*significantly higher RS_3 content than the mean, $P < 0.05$

were as follows: 5.2% ± 0.29 in chickpea, 3.8% ± 0.36 in buckwheat, 2.9% ± 0.16 in millet, 2.8% ± 0.87 in foxtail millet, 1.6% ± 0.32 in sorghum, and 1.2% ± 1.22 in amaranth. The lowest variation in RS_3 content was in millet accessions. The highest variation was found in amaranths where the content of RS_3 ranged from 0.2% ± 0.05 to 3.1% ± 0.04. Reliable data on RS_3 content in seeds and groats of a majority of plant species are very scarce or they have not been published at all. Therefore, the RS_3 content in some plant species analysed in this study and determined by the used method, is not reviewed.

The assessment of RS_3 by the method applied in this study allows to estimate also the amount of soluble starch content, and consequently total starch content. Total starch contents were as follows: 69.4% ± 4.93 in sorghum, 65.7% ± 1.59 in millet, 62.4% ± 3.93 in amaranth, 61.8% ± 2.93 in foxtail millet, 58.3% ± 2.96 in buckwheat, and 47.5% ± 2.54 in chickpea. The lowest variation in total starch content was in millet accessions, the highest in sorghum.

Some of the analysed chickpeas had the highest content of RS_3. Only two of them contained below 5%, and two had 5.7% of RS_3. A subgroup of five out of the 16 analysed chickpeas had a significantly ($P < 0.01$) higher RS_3 content (Table 1). Both the Slovakian registered cultivars, Alfa and Slovák, contained a relatively high amount of RS_3. Both were bred in agro-environmental conditions of Central Europe and their better adaptation to these growing conditions and practice should be appreciated. No differences in RS_3 content between desi, kabuli and intermediate types of chickpea were recorded but the amount of total starch in the desi variants was below the mean of all other species. RS_3 accounted for about 11% of total starch. The relatively high content of RS_3 in chickpeas corresponded to data from experiments of Tovar *et al.* (1990), who demonstrated that legume starches had a relatively high level of amylose, a potential source of retrograded starch. Further optimisation of chickpea groats treatment and starch retrogradation did not result in any increase in the RS_3 amount. Thus, chickpea might be considered as a useful supplement for RS-containing functional food.

The accessions of buckwheat also had a relatively high amount of RS_3 (Table 2). Buckwheat starch is known for its higher amylose content (Qian *et al.* 1998), some cultivars over 50% (Soral-Smietana *et al.* 1984). A subgroup of four accessions had RS_3 significantly ($P < 0.01$) over the average content. The average content of RS_3 in buckwheat groats in this study was lower than in a previously published paper (Skrabanja & Kreft 1998). They reported about 4.5% RS_3 in dehusked seeds of cultivar Darja. Contrary to these authors we used unhulled seeds for grinding in our study. The weight of glumes was about 25% of total seed weight, therefore the real content of RS_3 could be around 4.7%. The mean fraction of RS_3 in buckwheat starch was about 6.5%. Thus also buckwheat seeds might be a source of nutritive resistant starch.

Millet contains less retrograded resistant starch of type RS_3 than both chickpeas and buckwheats (Table 3). Only small differences between millet accessions were observed. Statistically significantly ($P < 0.05$) higher content of RS_3 than the mean value was detected only in one accession. The average ratio of RS_3 in the total starch in millet groats was about 4.4%. Improvement of hydrothermal and storage treatment of millet groats could increase the level of RS_3. Thereafter it would be interesting to see that millet was a traditional, although marginal, crop grown in Central Europe for food supply.

There are significant differences in RS_3 as well as in total starch content within the foxtail millet set (Table 4). The statistically significantly ($P < 0.01$) higher RS_3 level than the mean value was found in four out of the 10 accessions. Content of RS_3 in foxtail millet was similar to millet, and also the ratio of RS_3 in total starch (about 4.6%) was very similar.

Sorghum, similarly like amaranth and some of foxtail millet accessions, has a low RS_3 content (Table 5). Two accessions contained a significantly higher level. Low RS_3 content is related with low amylose content in sorghum starch. There are evident and significant differences in total starch content between the accessions. Content of RS_3 in total sorghum starch was about 2.4%. Due to unknown growing conditions, the results in foxtail millet and sorghum could partly be affected by different environment. The highest variation in RS_3 content was detected within accessions of amaranths. Some accessions had a very low level while others showed a higher level. Very low content of RS_3 was found in nine out of the 15 tested amaranths. A subgroup of six accessions had a significantly higher RS_3 content (Table 6). Very contrast variations in RS_3 content related to the cultivar selection were generally detected in amaranths (Halasová *et al.* 1992; Kalač & Moudrý 2000). There are waxy (glutinous) and non-waxy (non-glutinous) starches in the perisperm of amaranth grains (Okuno & Sakaguchi 1981). The majority of amaranth cultivars (populations) contains

Table 4. Starch content in foxtail millet accessions

Accession	Soluble starch (%)	RS_3 (%)	Total starch (%)
01Z2300006	60.1 ± 0.47	3.5 ± 0.06**	63.6 ± 0.42
01Z2300009	56.4 ± 1.55	2.5 ± 0.03	58.8 ± 1.58
01Z2300010	58.5 ± 0.87	2.1 ± 0.07	60.7 ± 0.95
Kitaj	65.3 ± 0.47	1.3 ± 0.01	66.5 ± 0.48
01Z2300017	57.6 ± 0.88	3.0 ± 0.05	60.5 ± 0.93
01Z2300019	61.2 ± 0.27	3.6 ± 0.08**	64.7 ± 0.35
01Z2300021	53.7 ± 0.59	3.0 ± 0.04	56.7 ± 0.56
84-371	58.4 ± 0.26	1.9 ± 0.05	60.3 ± 0.22
Sibirske klasnate	59.4 ± 0.87	3.8 ± 0.04**	63.2 ± 0.83
Sovietzka	59.2 ± 0.19	3.7 ± 0.07**	62.9 ± 0.28

**significantly higher RS_3 content than the mean, $P < 0.01$

Table 5. Starch content in sorghum accessions

Accession	Species	Soluble starch (%)	RS3 (%)	Total starch (%)
Hemaize	*bicolor*	73.9 ± 0.55	1.6 ± 0.02	75.5 ± 0.57
3′ (sorghum)	ssp.	58.7 ± 0.35	1.8 ± 0.06*	60.5 ± 0.40
6 – without tannin	ssp.	70.3 ± 0.28	1.3 ± 0.05	71.6 ± 0.23
Capricom	*bicolor*	66.7 ± 0.42	1.4 ± 0.04	68.0 ± 0.38
Gyongy	*bicolor*	66.7 ± 0.97	1.5 ± 0.07	68.2 ± 0.89
SO-H-29	ssp.	70.2 ± 0.83	2.2 ± 0.08**	72.4 ± 0.91

**, *significantly higher RS3 content than mean, $P < 0.01$ or $P < 0.05$, respectively

only 5–8% of amylose (Soral-Smietana *et al.* 1984; Baker & Rayas-Duarte 1998; Kalač & Moudrý 2000). The content of RS_3 in amaranths was the lowest in the six studied species, only about 2.0%. The amaranth was rich in total starch content (Table 6). High variations of RS_3 content in amaranths indicate that the selection of cultivars high in RS_3 could be useful. Moreover, the amaranth is not a demanding crop usable for food and feed production, it is highly yielding even though important agronomical traits must be improved for effective seed production.

The content of RS_3 largely depends on conditions of gelatinised starch retrogradation, e.g. on exposure to hydrothermal treatment and different storage conditions (temperatures and duration). This affects retrogradation of starch. Starches originating from different plant seeds retrograde in coincident conditions in a different way (Baker & Rayas-Duarte 1998). In laboratories the quantification of RS_3 content in plant seeds, groats or in foods depends on methods used for the analysis. The comprehensive original method of McCleary *et al.* (2002) should yield a higher amount of RS_3 but the

Table 6. Starch content in amaranth accessions

Accession	Species	Soluble starch (%)	RS_3 (%)	Total starch (%)
5DF 118	*caudatus*	67.8 ± 0.53	0.4 ± 0.04	68.2 ± 0.57
Burgundy	*edulis*	65.5 ± 0.39	0.3 ± 0.06	65.7 ± 0.45
29 USA	*cruentus*	68.2 ± 0.93	0.5 ± 0.06	68.7 ± 0.99
PI 604672	*hybridus*	50.6 ± 0.33	3.1 ± 0.04**	53.7 ± 0.29
PI 604671	*powellii*	55.7 ± 0.61	2.9 ± 0.08**	58.6 ± 0.52
Fakel	ssp.	62.3 ± 0.53	0.3 ± 0.03	62.6 ± 0.50
A-70	*cruentus*	63.1 ± 0.86	0.2 ± 0.07	63.4 ± 0.93
A 102	*caudatus*	63.0 ± 0.87	0.3 ± 0.04	63.3 ± 0.91
17 GUA	*cruentus*	64.3 ± 0.40	0.3 ± 0.04	64.6 ± 0.35
Lider	ssp.	60.2 ± 0.47	0.2 ± 0.05	60.4 ± 0.43
5DF 111	*paniculatus*	59.1 ± 0.60	1.6 ± 0.01**	60.7 ± 0.59
Metelcatyj	ssp.	56.1 ± 0.38	2.9 ± 0.04**	59.0 ± 0.43
A 47	*hypochondriacus*	59.2 ± 0.21	2.8 ± 0.06**	62.0 ± 0.14
AMAR-2R-R 158	*cruentus*	62.8 ± 0.54	2.6 ± 0.04**	65.4 ± 0.49
PI 538320	*powellii*	59.3 ± 0.53	0.3 ± 0.05	59.6 ± 0.48

**significantly higher RS_3 content than the mean, $P < 0.01$

assay used in this study based on a modification of the same method, and moreover this kit-based procedure, is more feasible for the screening of genotypes or populations within plant genetic resources maintained in the gene bank collections. The treatment of groats before analyses is essential for RS_3 production. Only one cycle of autoclaving was used in our study. This practice need not be as yielding for resistant starch of RS_3 type as the application of three cycles of groats autoclaving but it is more similar to food processing and daily dish preparation.

Significant differences in resistant starch as well as in total starch were demonstrated between individual crop-plants and also between genotypes in the framework of the crop in this study. Five chickpea accessions (Alfa, BG 004233, CM-7-1/85, 88 1963, and PK 51 814) and four buckwheat accessions (Bogatyr, La Harpé, Kora, and Pyra) are suitable as RS_3 sources.

Common starches consist of 20–30% amylose and 70–80% amylopectin (Preiss 1991). There also exist so called waxy starches which have only a minimum content of amylose. On the other hand, there are also cultivars with higher amylose contents in comparison with common cultivars. The amylose to amylopectin ratio influences physical and chemical properties of starch. At least 14 enzymes are involved in starch synthesis. Three of them are regarded to be key enzymes – ADP glucose-pyrophosphorylase (AGP), starch synthase (SS) and starch branching enzyme (SBE). Plants possess several isoenzymes with different activities. *In vivo* amylose and amylopectin synthesis takes place together but different isozymes are involved in this process. Mutations at the granule-bound starch synthase I (GBSSI) loci also decrease the amylose content substantially (Shure *et al.* 1983). Starch of these mutants consists of amylopectin almost exclusively (waxy mutants). On the other hand, mutations at other loci result in increased amylose content (Stinard *et al.* 1993; Burton *et al.* 1995). Both mutations cause a loss of starch branching isozyme SBEIIb which preferentially branches amylopectin, i.e. the amylose to amylopectin ratio can be altered by mutations. Amylose is needed for the production of RS_3. Its higher level is associated with decreased starch branching enzyme SBEIIb. According to our opinion cultivars with statistically significantly elevated RS_3 levels could also possess a genetically determined decrease of SBEIIb activity. Genotypes with minimum RS_3 content are similar to waxy types containing particularly amylopectin and their GBSSI activity is depressed. It is known that resistant starch has beneficial effects on health and is suitable in human diet (Szczodrak & Pomeranz 1991). The most effective way of introducing resistant starch into foodstuffs is to use a raw material containing a substance for RS_3 creation and its appropriate processing. The origin of RS_3 resides in plant seeds containing amylose. Individual crops differ in total starch content as well as in the amylose : amylopectin ratio. For foods and especially for functional food products containing resistant starch it is necessary to identify suitable plant resources among traditional and non-traditional crop-plants. Moreover their production in fields must be effective, i.e. they have to be adapted to recent agricultural practices. The richest reservoirs for discovering chemical composition variations are collections of plant genetic resources maintained in the gene banks over the world.

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Abstrakt

Mikulíková D., Čičová I., Antalíková G., Kraic J. (2005): **Semená netradičných plodín ako zdroje retrogradovaného rezistentného škrobu**. Czech J. Genet. Plant Breed., **41**: 96–104.

V semenách šiestich rastlinných druhov bol stanovený obsah retrogradovaného rezistentného škrobu typu RS_3. V analyzovaných druhoch a ich genotypoch boli zistené rozdiely v obsahu RS_3 i v obsahu celkového škrobu. Najvyšší priemerný obsah RS_3 bol detekovaný v cíceri (5,2 %) a pohánke (3,8 %). V prose a mohári bol nižší obsah RS_3, 2,9 %, resp. 2,8 %, proso je však bohaté na celkový škrob. Nízke úrovne RS_3 boli detekované v ciroku (1,6 %) a láskavci (1,2 %). Najnižšia úroveň variability v obsahu RS_3 bola zistená v súbore genotypov prosa, najvyššia v súbore genotypov láskavca.

Kľúčové slová: rezistentný škrob; retrogradovaný škrob; láskavec; pohánka; cícer; proso; mohár; cirok

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