[30] Treasury, Energy Departments Announce More than $ 3 Billion in Recovery Act Funds for Renewable Energy Projects, July 9, 2009, *http://*www1.eere.energy.gov/financing/printable_version/news_detail.html?news_id=12639;
[31] Treasury, Energy Announce More Than $2 Billion in Recovery Act Tax Credits for Energy Manufacturers, August 13, 2009, *http://*www.energy.gov/news20009/print2009/7801.htm.
[32] Trittin J.: Obamas'Green New Deal', Die Stunde der Staaten, *Internationale Politik*, XII 2008, nr 12;
[33] Walewska D.: Motoryzacyjne show w USA w cieniu kryzysu, *Rzeczpospolita*,12 stycznia 2008, nr 9 (8214);
[34] Zwaniecki A.: Obama Sets Bold New Principles for U.S. Energy, Climate Policies. President moves to reverse some policies of his predecessor, http://www.america.gov/econ-english/2009/January/2009012618...;

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Bioproducts made from spelt wheat (*Triticum spelta*) and their antioxidant properties

Słowa kluczowe: ziarna pszenicy, kasze, ekosystem, bioprodukty

Key words: spelt wheat, cereals, ecological system, bioproducts

Introduction

The spelt wheat (Triticum spelta) is one of the oldest cultural cereals, which is originated from crossing of *Aegilops squarrosa* (L.) with *Triticum dicoccon* (Schrank.). Popular in Europe for centuries, spelt is used in a wide variety of cereals, pastas, crackers, baked goods, and beers.

Cereal grains contain a wide variety of biologically active compounds, including dietary fibre, microelements, sterols, phenolic compounds, peptides, vitamins, and the effects of these have been associated with antioxidant properties [14,1].

Natural antioxidants have been of interest for many years. However, an upsurge in interest in these components has occured in recent years because of their importance for the prevention of diseases mediated by free radical reactions *in vivo*. The onset of a variety of major health problems, including cancer, atherosclerosis, rheumatoid arthritis, inflammatory bowel disease, immune system decline, brain dysfunction, cataracts, and malaria may be delayed by natural antioxidants. Natural antioxidants can be found in a wide range of food raw materials [6]. Considerable scientific evidence suggests that whole grains, as commonly consumed in the United States and Europe, reduce risk for chronic disease including cancer and heart disease. Whole grains provide a wide range of nutrients and phytochemicals that may work synergistically to optimize human health [9].

The objective of the study was to evaluate the antioxidant properties of selected spelt wheat bioproducts (products from *Triticum spelta*).

Materials and methods

Three sort of bioproducts were obtained directly from trade network in Slovak Republic: spelt groats, whole spelt groats and spelt bread (steamed grains – produced by means of steam).

Antiradical activity of ethanolic extracts of samples was determined using the free $DPPH^{\bullet}$ radical. The modified method by Brand-Williams et al. [2] and Sanchéz-Moreno et al. [12] was used. Absorbance at 515.6 nm was measured at different time intervals using Shimadzu 1601 UV/VIS spectrophotometer (UV-1601, Shimadzu, Tokyo, Japan) until the reaction reached a plateau. The absorbance of the 2,2-diphenyl-1-pikrylhydrazyle radical ($DPPH^{\bullet}$) without an antioxidant (i.e. the control), was measured first. The percent of inhibition of the $DPPH^{\bullet}$ radical by the sample was then calculated according to the formula: % inhib = $[(A_{C0} - A_{At})/A_{C0}]$ x 100, where A_{C0} is the absorbance of the control at t = 0 minute, A_{At} is the absorbance of the antioxidant at time t minutes, % inhib equals percentage of free $DPPH^{\bullet}$ radicals.

Reduction power of compounds was evaluated spectrophotometrically by the modified method according to Prieto (1999). A spectrophotometric method has been developed for the quantitative determination of antioxidant capacity. The phosphomolybdenum method is according to Prieto [10] routinely applied in the laboratory to evaluate the total antioxidant capacity of plant extracts. This method is established on reduction of Mo (VI) to Mo (V) with an effect of reduction parts in the presence of phosphor under formation of green phosphomolybdenum complex. Solu-tion absorbance of reducing sample was measured at 705 nm (UV-1601, Shimadzu, Tokyo, Japan) toward black experiment (distilled water). Reduction power of compounds (RPKA) expressed as quantity of ascorbic acid necessary to achieve the same effect in ($mg.l^{-1}$) was calculated using the equation:

$RP_{KA} = (A705\,nm - 0.0011) / 0.00236$.

Results and Discussion

The antiradical activity was in the particular samples in range from 48.94% to 72.00% (average 59.24 ± 0.47%). Testing of antioxidant effect of our samples showed the best result at sample of spelt bread (71.57 ± 0.43%), followed by whole spelt groats and spelt bread with very good scavenging ability as well (Table 1). The value of antiradical activity for spelt bread was by 44,56% higher than that for spelt groats and by 26.38% *versus* whole spelt groats.

Table 1 Antiradical and antioxidant activity of selected spelt wheat bioproducts

Products	**DPPH** (% of inhibition)		$\mathbf{RP_{AA}}$ ($mg.l^{-1}$)	
	average	**SD**	**average**	**SD**
Spelt groats	49,51	0,57	148,90	2,30
Whole spelt groats	56,63	0,42	166,90	2,90
Spelt bread	71,57	0,43	205,30	4,20
Average	**59,24**	**0,47**	**173,70**	**3,13**

Reduction power of spelt bread compounds was higher (205.30 ± 3.13 $mg.l^{-1}$) than of whole spelt groats. Comparison of whole spelt groats with spelt groats refers on lower values in case of spelt groats *versus* whole spelt groats. Reduction power for spelt bread was by 37.88% higher than that for spelt groats and by 23.01% versus whole spelt groats. Antioxidant capacity (expressed as reduction power) of compounds of selected bio-products from *Triticum spelta* was at average high.

Antiradical activity (as determined by the DPPH radical scavenging method) decreased in the same order than antioxidant capacity (as determined by the phosphomolybdenum method): spelt bread > whole spelt groats > spelt groats. In present investigations, great variability regarding antioxidant capacity and antiradical activity in selected bioproducts was found.

Obtained results we compared with earlier data [5] from the antioxidant evaluation of three different bioproducts made from spelt wheat: superfine spelt wheat flour, dehulled spelt wheat, spelt grain "kernotto" (peeled grain of spelt).

The antiradical activity was in the particular samples in range from 49.76 to 55.60% (average 52.60 ± 2.30%). Difference between the highest and the lowest antiradical activity was 4.63%, and the moderate value differ from the highest in 4.38%. Testing of antioxidant effect of our samples showed the best result at sample of spelt wheat flour (55.60 ± 0.58%), followed by dehulled spelt wheat and spelt grain "kernotto" with very good scavenging ability as well.

Reduction power of spelt wheat flour compounds was higher (210.30 ± 2.30 $mg.l^{-1}$) than of dehulled spelt wheat. Comparison of dehulled spelt wheat with spelt grain "kernotto" refers on lower values in case of spelt grain "kernotto" than in case of dehulled spelt wheat. The value of reduction power for spelt wheat flour was approximately 1.6-fold higher (i.e. by 9,08%) than that for spelt grain "kernotto". Antioxidant capacity (expressed as reduction power) of compounds of selected bio-products from *Triticum spelta* was at average 163.93 ± 33.79 $mg.l^{-1}$.

Antiradical activity decreased also in the same order than antioxidant capacity: spelt wheat flour > dehulled spelt wheat > spelt grain "kernotto" [45].

Table 2 Antiradical and antioxidant activity of selected spelt wheat bioproducts [5]

Products	**DPPH** (% of inhibition)		$\mathbf{RP_{AA}}$ ($mg.l^{-1}$)	
	average	**SD**	**average**	**SD**
Spelt grain "kernotto"	50,97	1,21	130,90	1,10
Dehulled spelt wheat	51,22	0,67	150,60	0,80
Superfine spelt wheat flour	55,60	0,58	210,30	2,30
Average	52,60	0,82	163,93	1,40

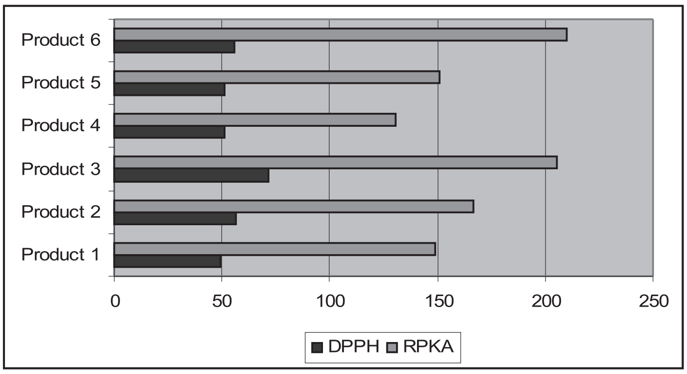

Fig. 1 Antioxidant properties of the spelt wheat bioproducts

Explanatory text:
DPPH – (antiradical activity) inhibition of the DPPH• radical (%)
RPKA – (antioxidant capacity) reduction power expressed in equivalents of ascorbic acid ($mg.l^{-1}$)
*Product 6 – spelt wheat flour **
*Product 5 – dehulled spelt wheat **
*Product 4 – spelt grain "kernotto" **

Product 3 – spelt bread
Product 2 – whole spelt groats
Product 1 – spelt groats
* [5]

The order of spelt products according to antiradical activity is similar to antioxidant capacity:
The order according to antiradical activity: spelt bread > whole spelt groats > spelt wheat flour > dehulled spelt wheat > spelt grain "kernotto" > spelt groats.
The order according to antioxidant capacity: spelt wheat flour > spelt bread > whole spelt groats > dehulled spelt wheat > spelt groats > spelt grain "kernotto".
Free radicals are believed to trigger the initiation phase of several diseases. The ability of natural antioxidants to react with free radicals makes them of special interest. Naturallyoccurring antioxidants number in the thousands, and the average diet may include hundreds of antioxidant compounds [4].

Known antioxidants are of specific interest, but studies of the antioxidant activity of extracts show that known compounds account for only a fraction of total activity [11,3]. A large share of biologically important compounds may be unknown. It is also possible that antioxidant activity in general is important and not just that of a few compounds. The typical diet contains a mixture of hundreds of antioxidant compounds, and composition changes daily depending on foods consumed [9].

The study by Zieliński et al. [13] showed that spelt breads and their crumbs formulated on white flours possessed similar antioxidant capacity comparable to that of wheat bread, however the spelt bread crusts showed higher antioxidant capacity than the wheat bread crust. Moreover, the reducing capacity of spelt breads and separated crumbs and crusts was significantly higher in comparison with that of wheat samples but lower than that of rye samples. Quality of *Triticum spelta* examined Mareček et al. [7]. Mikulajová et al. [8] found a good correlation between antioxidant capacities and contents of phenolic compounds in wheat genotypes (measured by DPPH method). Based on these findings, it was possible to deduce a significant contribution of phenolics to the antioxidant effects of cereals and pseudocereals.

Miller et al. [9] compared the antioxidant activity of whole grain, ready-to-eat breakfast cereals to that of fruits and vegetables and found out that whole grain breakfast cereals, fruits and vegetables are all important dietary sources of antioxidants.

Conclusions

From investigated bioproducts made from *Triticum spelta* the spelt bread disposed of the best antioxidant properties. Further studies of the antioxidant properties and the antioxidant components are necessary to clarify the antioxidant effect of spelt wheat products.

Acknowledgement

The study was supported by Grant Agency of SUA No. 724/02380, KEGA 301-035SPU-4/2010 and ITMS 26220120015: This work has been supported by the Excellence Center for Agrobiodiversity Conservation and Benefit project implemented under the Operational Programme Research and Development financed by European Fund for Regional Development.

LITERATURA:

[1] Andreasen M.F. et al. (2001) Intestinal release and uptake of phenolic antioxidant diferulic acids. *Free Radic Biol Med*. 31: 304-314.
[2] Brand-Williams W. et al. (1995) Use of a free radical method to evaluate antioxidant activity. *Lebensm. Wiss. u. Technol*. 28: 25-30.
[3] Cao G., Booth S.L., Sadowski J.A., Prior R.L. (1998) Increases in human plasma antioxidant capacity after consumption of controlled diets high in fruit and vegetables. In Am J Clin Nutr 67:1081–1087, 1998.
[4] Croft K.D. (1999) Antioxidant effects of plant phenolic compounds. In Basu TK, Temple NJ, Garg, ML (eds): 'Antioxidants in Human Health and Disease.' New York: CABI, p. 112–115, 1999.
[5] Fatrcová-Šramková K., Lacko-Bartošová M., Rédlová M., Máriássyová M. (2008) Bioproducts made from spelt wheat (*Triticum spelta*) and their antioxidant activity. In *Acta Biochimica Polonica*, vol. 55, 2008, Supplement 4, p. 150.
[6] Gordon M.H. (2003) Natural Antioxidants. In *Encyclopedia of Food Sciences and Nutrition*. Volume 1. Oxford : Elsevier Science, 2003. p. 261-265. ISBN 0-12-227056-8
[7] Mareček J. et al. (2008) Kvalita pšenice špaldovej (Triticum spelta L.) ako biopotraviny. *Sborník souhrnu sdělení* XXXIV. Semináře o jakosti potravin a potravinových surovin. Brno: MZLU. pp. 32.
[8] Mikulajová A. et al. (2007) Total phenolic contents and antioxidant capacities of cereal and pseudocereal genotypes. *J. Food Nutr. Res.* 46: 150-157.
[9] Miller H.E., Rigelhof F., Marquart L., Prakash A., Kanter M. (2000) Antioxidant Content of Whole Grain Breakfast Cereals, Fruits and Vegetables. In *Journal of the American College of Nutrition,* vol. 19, 2000, no. 90003, p. 312S-319S.
[10] Prieto P. et al. (1999) Spectrophotometric quantification of antioxidant capacity through the formation of a phosphomolybdenum complex: specific application to the determination of vitamin E. *Anal Bioch* 269: 337-341.
[11] Rice-Evans C.A., Miller N.J., Paganga G. (1997) Antioxidant properties of phenolic compounds. Trends in Plant Sci 2:152–159, 1997.
[12] Sanchéz-Moreno C. et al. (1998) A procedure to measure the antioxidant efficiency of polyphenols. *J. Sci. Food Agric*. 76: 270- 276.
[13] Zieliński H. et al. (2008) Antioxidant properties of spelt bread. In *Pol. J. Food Nutr. Sci*. 58: 217-222.
[14] Zieliński H. (2002) Low molecular weight antioxidants in the cereal grains - a review. In Pol. *J. Food Nutr. Sci*. 11: 3-9.