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Evaluation and comparison of the content of total polyphenols and antioxidant activity of selected species of the genus *Allium*

Vyhodnotenie a porovnanie obsahu celkových polyfenolov a antioxidačnej aktivity vo vybraných druhoch rodu *Allium*

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Abstract

The species of the genus *Allium* are very important crops for human health. They contain many health beneficial substances, such as polyphenols (especially flavonoids), sulphur compounds, vitamins, mineral substances and substances with antioxidant activity. This work has focused on the comparison of total phenolic content and antioxidant activity of selected species of the genus *Allium* – garlic (*Allium sativum* L.), chives (*Allium schoenoprasum* L.), ramson (*Allium ursinum* L.) and red, yellow and white onion (*Allium cepa* L.). Samples of plant material were collected at the stage of full maturity in the area of Nitra. Total polyphenols content was determined using the spectrophotometric method of Folin-Ciocalteu agents. Determined the content of total polyphenols were in the range 444.3 - 1591 mg*kg^{-1}. Total polyphenols content in the observed crops declined in the following order: chives > red onion > garlic > yellow onion > ramson > white onion. Antioxidant activity was measured by the spectrophotometric method using a compound DPPH (2.2-diphenyl-1-picryhydrazyl). Determined the value of antioxidant activity ranged 12.29 – 76.57%. Antioxidant activity observed in crops declined in the following order: chives > ramson > red onion > yellow onion > garlic > white onion. In all the analysed crop plants was confirmed by the strong dependence of the antioxidant activity and the total content of polyphenolic substances.

Keywords: antioxidant activity, chives, garlic, onion, polyphenols, ramson

Abstrakt

Druhy z rodu *Allium* sú veľmi dôležité plodiny pre ľudské zdravie. Obsahujú množstvo dôležitých zdraviu prospešných látok, medzi ktoré patria polyfenoly (hlavne flavonoidy), sírne zlúčeniny, vitamíny, minerálne látky a látky s antioxidačnou aktivitou. Táto práca bola zameraná na porovnanie obsahu celkových polyfenolov a antioxidačnej aktivity vo vybraných druhoch z rodu *Allium* – cesnak (*Allium sativum* L.), pažítka (*Allium schoenoprasum* L.), cesnak medvedí (*Allium ursinum* L.) a červená, žltá a biela cibuľa (*Allium cepa* L.). Vzorky rastlinného materiálu boli zhromažďované v štádiu plnej zrelosti v lokalite Nitra. Obsah celkových polyfenolov bol stanovený spektrofotometrickou metódou s použitím Folin-Ciocalteuovho činidla. Stanovené obsahy celkových polyfenolov sa pohybovali v rozmedzí 444.3 – 1591 $mg*kg^{-1}$. Obsah celkových polyfenolov v sledovaných plodinách klesal v nasledujúcom poradí: pažítka > červená cibuľa > cesnak > žltá cibuľa > cesnak medvedí > biela cibuľa. Antioxidačná aktivita bola meraná spektrofotometrickou metódou za použitia zlúčeniny DPPH (2.2-difenyl-1-pikryhydrazyl). Stanovené hodnoty antioxidačnej aktivity sa pohybovali v rozmedzí 12.29 – 76.57%. Antioxidačná aktivita v sledovaných plodinách klesala v nasledujúcom poradí: pažítka > cesnak medvedí > červená cibuľa > žltá cibuľa > cesnak > biela cibuľa. Vo všetkých analyzovaných plodinách bola potvrdená silná závislosť medzi antioxidačnou aktivitou a celkovým obsahom polyfenolických látok.

Kľúčové slová: antioxidačná aktivita, cesnak, cesnak medvedí, cibuľa, pažítka, polyfenolové zlúčeniny

Introduction

Food of plant origin, such as vegetables and fruit which contain significant amounts of bioactive phytochemicals, may provide desirable health benefits beyond basic nutrition to reduce the risk of chronic diseases (Liu, 2003; Yang et al., 2004). Genus *Allium* is characterized by large number of primary and secondary types of nutritional and medicinal components (Rizwani and Shareef, 2011).

Allium species, the most important genus of the *Alliaceae* family, are among the oldest cultivated vegetables (Fritsch et al., 2010). The species may differ in form and taste, but they are close in biochemical and phytochemical contents (Lanzotti, 2006). Garlic (*Allium sativum* L.) and onion (*Allium cepa* L.) are the most important *Allium* species consumed all over the world (Kim et al., 2004). *Allium* includes some economically important species like common onion, garlic, chives, leek and also species used as herbal crops, as traditional medicines and as ornamental plants (Fritsch and Friesen, 2002; Tepe et al., 2005).

Onion (*Allium cepa* L.) is probably native of south west Asia. It has a globose bulb that is an underground part of the stem (Ozougwu, 2011). Onions contain generous amounts of the flavonoid (mainly quercetin). Studies have shown that quercetin protects against cardiovascular disease, and cancer. Onions contain organosulfur compounds that have been linked to lowering blood pressure and cholesterol levels

(Kumar et al., 2010), anthelmintic, antiseptic and hypoglycaemic (Ozougwu, 2011). Onions contain high levels of antioxidant compounds (polyphenolics) which have protective effects against different degenerative pathologies (Griffiths et al., 2002).

Garlic (*Allium sativum* L.) is a plant which has been grown for more than 5000 years for culinary and therapeutic purposes. Its best known chemical compound is allicin, which has extensive pharmacological effects (Trifunschi et al., 2015). Today, in many parts of the world garlic is being used as prophylaxis and for the cure of numbers of diseases including acute and chronic infections (Srivastava and Pathak, 2012). Garlic is a source of various biologically active phytomolecules, including organosulfur compounds, polyphenolics (phenolic acid, flavonoids) and vitamins (Chen et al., 2013).

Chives (*Allium schoenoprasum* L.) come from cold regions of Europe and Asia. Chives have slim, dark green leaves and pale purple flowers. The plant was used in traditional folk medicine to stimulate digestion, treat anemia and to cleanse the blood (Grzeszczuk et al., 2011). The pharmacological effects are caused by diallyl sulphides (diallyl monosulphide, diallyl disulphide, diallyl trisulphide, diallyl tetrasulphide), polyphenolic compounds, vitamin C and carotenoids (Vlase et al., 2013). In opinion of Parvu et al. (2010) the main polyphenolic compounds of chives are p-coumaric acid, ferulic acid, isoquercitrin and rutin.

Ramson (*Allium ursinum* L.) - the species name “ursinum” is of Latin origin, being derived from “ursus” (bear), and is related to folk tales, according to which bears after awakening from winter hibernation consume this plant to remove toxins from the body and to regain strength. The plant is a bulbiferous. Its bulb is narrow, elongated, about 1.5 - 6 cm long. Ramson grows up to the height of 50 cm (Sobolewska et al., 2015). *Allium ursinum* L. is spread through the entirety of Europe, Asia Minor, Caucasus and Siberia up to the Kamchatka Peninsula (Djurdjevic et al., 2004). In recent years, the potential health benefits of ramson have been attributed mainly to the sulfur-containing compounds (Parvu et al., 2011).

The health properties of these natural plants depend on the contents of bioactive compounds, mainly polyphenolics and substances with antioxidant effects (Chun et al., 2005; Beato et al., 2011).

Polyphenols have been classified by their source of origin, biological function, and chemical structure. The majority of polyphenols in plants exist as glycosides with different sugar units and acylated sugars at different positions of the polyphenol skeletons. Distribution of polyphenols according to the chemical structures of the aglycones: phenolic acids, flavonoids, polyphenolic amides, other polyphenols (Tsao, 2010). The phenolic compounds have antiproliferative and tumour arresting effects (Kuceková et al., 2011). Plant phenolics are generally involved in protection against ultraviolet radiation or aggression by pathogens, parasites and predators (Priecina and Karlina, 2013). Flavonoids are major phenolics in genus *Allium* and can be classified in different subclasses (flavones, flavanones, flavonols, isoflavones, flavanonols, flavanols, chalcones and anthocyanins) according to the degree of unsaturation and degree of oxidation of the 3-carbon skeleton. Flavonols and anthocyanins are the main subclasses of flavonoids present in genus *Allium* (Pérez-Gregorio et al., 2009).

The antioxidant activity of *Allium* species is due to several of sulphur-containing compounds and their precursors, but it is also related to other bioactive compounds such as polyphenols, dietary fiber and microelements (Vlase et al., 2013).

The physiological role of antioxidants is to prevent damage to cellular components arising as a consequence of chemical reactions involving free radicals (Young and Woodside, 2001). Antioxidants may be divided into enzymatic (superoxide dismutase - SOD, catalase, glutathione peroxidase - GSHP) and non-enzymatic (vitamins E, C, A) groups (Capasso, 2013).

Polyphenolic compounds are effective antioxidants due to their capability to scavenge free radicals of fatty acids and oxygen (Lachman et al., 2003). Genus *Allium* has been widely used to scavenge reactive oxygen species (ROS) and treat a variety of diseases including heart disease and cancer (Oak et al., 2005; Chen et al., 2013). These antioxidant properties were highly correlated with the presence of the primary phenolic compounds (Chen et al., 2013). Polyphenols behave as antioxidants by a variety of way including trapping of reactive oxygen species, inhibition of enzymes responsible for superoxide anion production, chelation of transition metals involved in process forming radicals and prevention of the peroxidation process by reducing alcoxyl and peroxyl radicals (Priecina and Karlina, 2013). It is known that the contents of bioactive compounds and related antioxidant activity in vegetables are influenced by geographical region, climatic and storing conditions, and degree of ripeness (Saxena et al., 2007).

Materials and methods

The local climate conditions

This study was performed in area of Nitra, Slovak Republic. She is situated on the southern Slovakia. Nitra belongs to warmer areas in Slovakia. Nitra has very good natural and climatic conditions for crop growth, without any adverse effects. The average annual rainfall is 550 – 600 mm and the average annual temperature is 9.9 ºC.

Samples of plant material

The samples of plant material (yellow, red and white onion, garlic, chives and ramson) were collected in the phase of full ripeness from area of Nitra. For analysis was used fresh material soil samples and plant, samples were analysed by selected methodologies (determination of total polyphenols and antioxidant activity). All samples of plant material were grown under the same conditions. The soil samples from the area, where was grown plant material, was analysed (Table 1 and Table 2). The analysis of soil samples was carried out four times in four sampling sites. Only NPK fertilization (200 g per m^2) was used for the achievement of favourable soil macroelements content.

Table 1. Agrochemical characteristic of soil substrate in mg*kg^{-1}, content of nutrients from locality Nitra

Tabuľka 1. Agrochemická charakteristika pôdneho substrátu v mg*kg^{-1}, obsah živín z lokality Nitra

Locality	Cultivar	K	Ca	Mg	P	pH_{KCl}	Humus %	Cox %
1	garlic, chives, red, yellow, white onion	392 ± 4.67	38.6*10^2 ± 2.15	13.1*10^2 ± 0.98	97.4 ± 3.61	6.91 ± 0.073	2.9 ± 0.026	1.68 ± 0.011
2	ramson	412 ± 5.19	61.9*10^2 ± 2.33	362 ± 4.29	46.9 ± 1.72	7.2 ± 0.094	3.47 ± 0.035	2.01 ± 0.017

Table 2. Content of heavy metals (mg*kg^{-1}) in soil substrate (extraction by aqua regia)

Tabuľka 2. Obsah ťažkých kovov (mg*kg^{-1}) v pôdnom substráte (extrakcia lúčavkou kráľovskou)

Locality	Cultivar	Zn	Cu	Ni	Pb	Cd
1	garlic, chives, red, yellow, white onion	55.7 ± 2.03	27.1 ± 1.43	42.3 ± 1.87	40.7 ± 1.69	4.04 ± 0.042
2	ramson	190 ± 3.15	24.8 ± 1.02	39.1 ± 1.62	40.8 ± 1.73	3.88 ± 0.047
Limit[1]		150	60	50	70	0.7

[1] Limitná hodnota pre lúčavku kráľovskú – zákon č. 220/2004

[1] Limit value for aqua regia – Law No. 220/2004

Preparations of samples

Extract was prepared from the 25 g samples yellow, red and white onion, garlic, ramson and chives, which were shaken (shaker GFL 3006, 125 rpm) in 50 ml of 80% ethanol for sixteen hours. Samples were kept at laboratory room temperature in dark conditions until the analysis. Each determination was carried out in six replications.

Determination of total polyphenols

Total polyphenols content (TPC) was determined by the method according to Lachman et al. (2003). It is expressed as mg of gallic acid equivalent per kg of fresh matter. Total polyphenols content was determined using the Folin-Ciocalteu reagent. 2.5 ml of Folin-Ciocalteu reagent was added to 100 μl extract to volumetric flask. The content was mixed. After 3 minutes, 5 ml 20% solution of sodium carbonate was added. Then the volume was adjusted to 50 ml with distilled water. After 2 hours, the samples were centrifuged (centrifuges UNIVERSAL 320, 15000 rpm) for 10 minutes. The absorbance was measured of the spectrophotometer Shimadzu UV/VIS – 1240 at 765 nm. The concentration of polyphenols was calculated from a standard curve with known concentration of gallic acid.

Determination of antioxidant activity

Antioxidant activity (AOA) was measured according to Brand-Williams et al. (1995). The method is based on using $DPPH^{\cdot}$ (2.2-diphenyl-1-picrylhydrazyl). $DPPH^{\cdot}$ (3.9 ml) was pipetted into the cuvette and the absorbance was measured using the spectrophotometer Shimadzu UV/VIS – 1240 at 515.6 nm. The measured value corresponds to the initial concentration of $DPPH^{\cdot}$ solution at the time A_0. Then 0.1 cm^3 extract was added to start measuring dependence A=f*(t). The content of cuvette was mixed and the absorbance was measured at 1, 5 and 10 minutes in the same way as DPPH solution. The percentage of inhibition expresses how antioxidant compounds are able to remove $DPPH^{\cdot}$ radical at the given period of time.

Inhibition (%) = $(A_0 - A_t / A_0) \times 100$

Statistical analysis

Results were statistically evaluated by the Analysis of Variance (ANOVA – Multiple Range Tests, Method: 95.0 percent LSD). It was used by the statistical software STATGRAPHICS (Centurion XVI.I, USA).

Results and discussion

The total content of polyphenols in the samples rages from 444.3 ± 6.93 to 1591 ± 10.89 $mg*kg^{-1}$ (Table 3). Statistically significant differences in the content of polyphenols were detected among all analysed crop. The highest value of total polyphenols was measured in chives. The lowest total polyphenol content was observed in the white onion. The determined quantity of TPC in the analysed samples can be arranged in the following order: chives > red onion > garlic > yellow onion > ramson > white onion. In comparison with this study Batcioglu et al. (2012)

indicated lower total polyphenol content in garlic is 780 mg*kg^{-1}, similarly Charles (2013) recorded that TPC in garlic is 812 mg*kg^{-1}. Some authors reported even a lower value of TPC in garlic: 436 mg*kg^{-1} (Chekki et al., 2014), 410 mg*kg^{-1} (Wangcharoen and Morasuk, 2007), 493 mg*kg^{-1} (Jastrzebski et al., 2007). By way of contrast Wangcharoen and Morasuk (2009) recorded in another study higher values of TPC in garlic (1290 mg*kg^{-1}). A wide range of TPC in ramson from 190 to 910 mg*kg^{-1} was indicated by Sapunjieva et al. (2012). Even higher value of TPC in ramson (1280 mg*kg^{-1}) was recorded by Mahmutovic et al. (2014). In comparison with this study lower content of TPC in chives (844 mg*kg^{-1}) was measured by Greszczuk et al. (2011) as well as by. Charles (2013) found 749 mg*kg^{-1}. Nuutila et al. (2003) indicated that total polyphenol content in onion is like in the ramson in the wide range from 845 to 2075 mg*kg^{-1}. In agreement with Lachman et al. (2003) the highest content of TPC was determined in red onion, and followed the yellow onion. The lowest content of total polyphenols contained white onion. Pérez-Gregorio et al. (2009) also noted that white onion had the lowest content of total polyphenols.

Table 3. Average content of total polyphenols (mg*kg^{-1}) and antioxidant activity (% inhibition)

Tabuľka 3. Priemerný obsah celkových polyfenolov (mg*kg^{-1}) a antioxidačnej aktivity (% inhibície)

Vegetable	Variety	TPC	AOA (%)
Garlic	Mojmír	1051 ± 18.09^{d}	17.17 ± 0.634^{b}
Ramson	Wild garlic	871 ± 8.16^{b}	45.34 ± 0.622^{e}
Chives	Pražská	1591 ± 10.89^{f}	76.57 ± 0.67^{f}
Red onion	Red mate	1313 ± 29.74^{e}	40.58 ± 1.157^{d}
Yellow onion	Sherpa	935.2 ± 9.23^{c}	21.09 ± 2.418^{c}
White onion	White solid	444.3 ± 6.93^{a}	12.29 ± 1.592^{a}
$HD_{0.05}$[1]		23.43	2.008
$HD_{0.01}$		32.10	2.752

[1] Viac rozsahový test, Metóda 95.0 percent LSD, Písmena (a, b, c, d, e, f) medzi faktormi ukazujú štatisticky významné rozdiely (P < 0.05) – LSD test

[1] Multiple Range Tests, Method: 95.0 percent LSD, Different letters (a, b, c, d, e and f) between the factors show statistically significant differences (P < 0.05) – LSD test

The values of antioxidant activity in the studied samples are presented in Table 3. The antioxidant activity of the sample is varied from 12.29 ± 1.592% to 76.57 ± 0.67% and statistically significant differences in the strength of antioxidant effect were also detected among all analysed crops. The highest value of antioxidant

activity was measured in the chives. The lowest value of antioxidant activity was measured in the white onion. In chives average value of antioxidant activity is 6.23-times higher than in the white onion and 4.45-times higher than in garlic. According to determined values of AOA the analysed samples of the genus *Allium* can be arranged in the following order: chives > ramson > red onion > yellow onion > garlic > white onion. Chen et al. (2013) indicate that the values of the antioxidant activity of garlic move in wide range from 3.60% to 45.63%. El-Hamidi and El-Shami (2015) recorded the values of antioxidant activity of 16.39% to 27.25%. Charles (2013) mentioned value 15.5%, which good correlate with the results of this work. But Choi et al. (2014) report a lower value of antioxidant activity in garlic (4.65%). In comparison with this study slightly lower strength of antioxidant effect in ramson (37%) was found by Gitin et al. (2014). Sapundjieva et al. (2012) measured also lower values of antioxidant activity in ramson (22.49%). Unlike above mentioned authors Mnayer et al. (2014) indicate that the antioxidant activity in ramson moves from 39.08% to 81.73% and AOA of ramson determined in this study belong to this range. Ashwini et al. (2013) noted that the scope of the antioxidant activity of onion from 13.6% to 84.1%. According to Cheng et al. (2013) the antioxidant activity in red onion is 41.22%.

Relations among content of polyphenols and antioxidant activity in garlic, ramson, chives and red, yellow and white onion were evaluated (Figure 1 – 6). The coefficient of correlation (r = 0.827 – 0.937) confirmed strong dependency between the AOA and the TPC and the results are in good agreement with the findings of Chen et al. (2013), Ramkissoon et al. (2012), Hu (2012) and Chekki et al. (2014) who also indicated correlations between content of polyphenols and antioxidant activity in the garlic, onion, carrot and other vegetable.

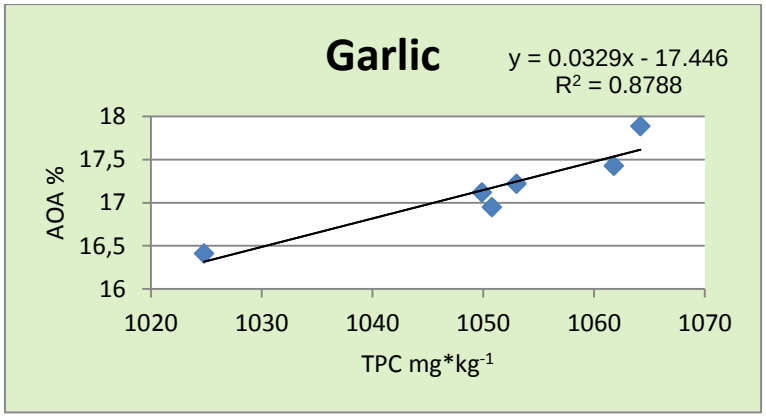

Figure 1. Relationship between TPC and AOA in garlic

Obrázok 1. Vzťah medzi TPC a AOA v cesnaku

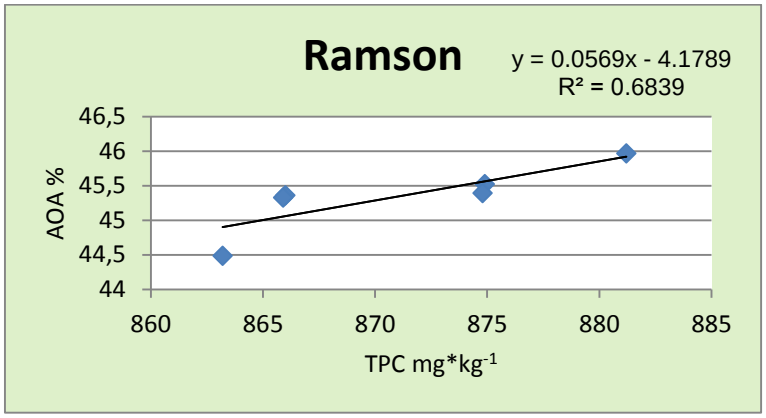

Figure 2. Relationship between TPC and AOA in ramson

Obrázok 2. Vzťah medzi TPC a AOA v cesnaku medveďom

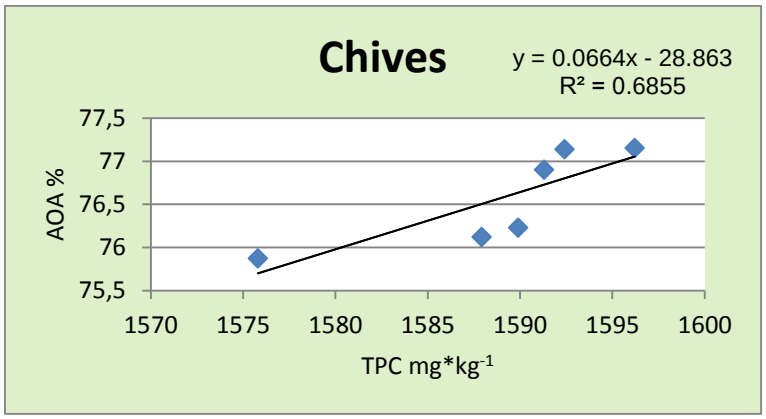

Figure 3. Relationship between TPC and AOA in chives

Obrázok 3. Vzťah medzi TPC a AOA v pažítke

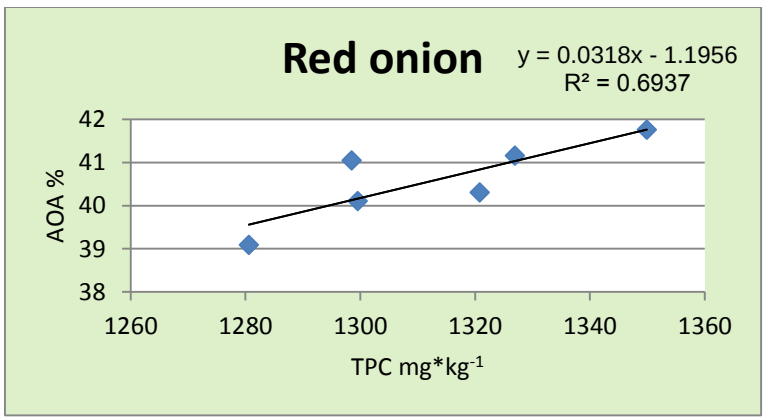

Figure 4. Relationship between TPC and AOA in red onion

Obrázok 4. Vzťah medzi TPC a AOA v červenej cibuli

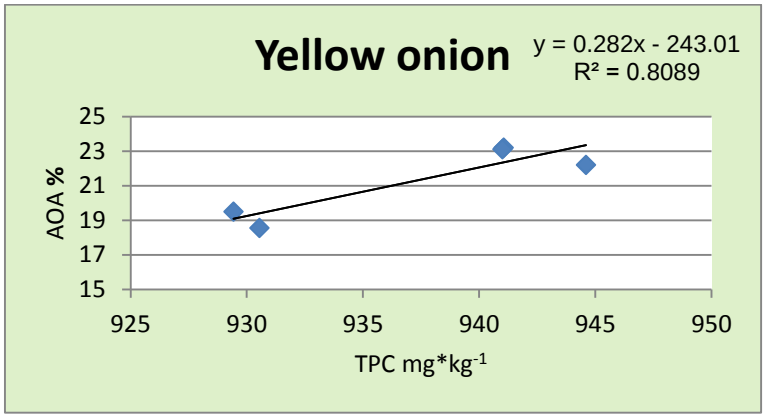

Figure 5. Relationship between TPC and AOA in yellow onion

Obrázok 5. Vzťah medzi TPC a AOA v žltej cibuli

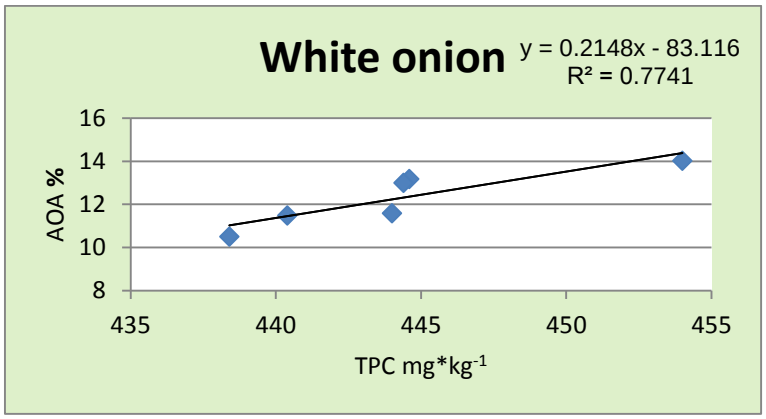

Figure 6. Relationship between TPC and AOA in white onion

Obrázok 6. Vzťah medzi TPC a AOA v bielej cibuli

Conclusions

The total content of polyphenols and antioxidant activity of selected crops of the genus *Allium* (garlic, ramson, chives and red, yellow and white onion) grown in the locality Nitra were comparable to or higher than those described in the literature but statistically significant differences in both the total content of polyphenols and the antioxidant activity were detected among all analysed crops. The highest value of total polyphenols and antioxidant activity as well as was determined in chives. The lowest level of both followed indicators was found in white onion. The coefficient of correlation confirmed strong dependency between the antioxidant activity and the total content of polyphenols. Vegetables should be an important part of your daily diet due to high content of biologically active substances that can help to protect you from some diseases.

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References

Ashwini, M., Balaganesh, J., Balamurugan, S., Muruga, S. B., Sathishkumar, R. (2013) Antioxidant Activity in vivo and in vitro Cultures of Onion Varieties. Food and Nutrition Sciences, 4, 918-923. DOI: http://dx.doi.org/10.4236/fns.2013.49119

Batcioglu, K., Yilmaz, Z., Satilmis, B., Uyumlu, A. B., Erkal, H. S., Yucel, N., Gunals, S., Serin, M., Demirtas, H. (2012) Investigation of in vivo radioprotective and in vitro antioxidant and antimicrobial activity of garlic (Allium sativum). European Review for Medical and Pharmacological Sciences, 16, 47-57

Beato, V. M., Orgaz, F., Mansilla, F., Montan, O. A. (2011) Changes in phenolic compounds in garlic (Allium sativum L.) owing to the cultivar and location of growth. Plant Food for Human Nutrition, 66 (3), 218-223. DOI: http://dx.doi.org/10.1007/s11130-011-0236-2

Brand-Williams, W., Cuvelier, M. E., Berset, C. (1995) Use of a free radical method to evaluate antioxidant activity. Lebensmittel-Wissenschaft and Technologie, 28, 25-30. DOI: http://dx.doi.org/10.1016/S0023-6438(95)80008-5

Capasso, A. (2013) Antioxidant Action and Therapeutic Efficacy of Allium sativum L. Molecules, 18, 690-700. DOI: http://dx.doi.org/10.3390/molecules18010690

Charles, D. J. (2013) Antioxidant Properties of Spices, Herbs and Other Sources. NY: Springer science

Chekki, R. Z., Snoussi, A., Hamrouni, I., Bouzouita, N. (2014) Chemical composition, antibacterial and antioxidant activities of Tunisian garlic (Allium sativum) essential oil and ethanol extract. Mediterranean Journal of Chemistry, 3 (4), 947-956. DOI: http://dx.doi.org/10.13171/mjc.3.4.2014.09.07.11

Chen, S., Shen, X., Cheng, S., Li, P., Du, J., Chang, Y., Meng, H. (2013) Evaluation of Garlic Cultivars for Polyphenolic Content and Antioxidant Properties. Plos One, 8 (11), e79730. DOI: http://dx.doi.org/10.1371/journal.pone.0079730

Cheng, A., Chen, X., Jin, Q., Wang, W., Shi J., Liu, Y. (2013) Comparison pf Phenolic Content and Antioxidant Capacity of Red and Yellow Onions. Czech Journal of Food Sciences, 31 (5), 501-508

Choi, S., Cha, H. S., Lee, Y. S. (2014) Physicochemical and Antioxidant Properties of Black Garlic. Molecules, 19, 16811-16823. DOI: http://dx.doi.org/10.3390/molecules191016811

Chun, O. K., Kim, D. O., Smith, N., Schroeder, D., Han, J. T., Lee, C. Y. (2005) Daily consumption of pheolics and total antioxidant capacity from fruit and vegetables in the American diet. Journal of the Science of Food and Agricultural, 85, 1715-1724. DOI: http://dx.doi.org/10.1002/jsfa.2176

Djurdjevic, L., Dinic, A., Pavlovic, P., Mitrovic, M., Karadzic, B., Tesevic, V. (2004) Allelopathic potential of Allium ursinum L.. Biochemical Systematics and Ecology, 32 (6), 533-544. DOI: http://dx.doi.org/10.1016/J.BSE.2003.10.001

El-Hamidi, M., El-Shami, S. M. (2015) Scavenging Activity of Differnet Garlic Extracts and Garlic Powder and their Antioxidant Effect on Heated Sunflower Oil. American Journal of Food Technology, 10, 135-146. DOI: http://dx.doi.org/10.3923/ajft.2015.135.146

Fritsch, M. R., Friesen, N. (2002) Evolution, domestication and taxonomy. Wallingford UK: CABI Publishing

Fritsch, R. M., Blattner, F. R., Gurushidze, M. (2010) New classification of Allium L. subg. Melanocrommyum (Webb & Berthel) Rouy (Alliaceae) based on molecular and morphological characters. Phyton, 49, 145-220

Gitin, L., Dinica, R., Neaqu, C., Dumitrascu, L. (2014) Sulfur compounds identification and quantification from Allium spp. fresh leaves. Journal of Food and Drug Analysis. 22 (4), 425-430. DOI: http://dx.doi.org/10.1016/j.jfda.2014.04.002

Griffiths, G., Trueman, I., Crowther, T., Thomas, B., Smith, B. (2002) Onion – A global benefits to health. Phytotherapy research, 16, 603-615. DOI: http://dx.doi.org/10.1002/ptr.1222

Grzeszczuk, M., Wesolowska, A., Jadczak, D., Jakubowska, B. (2011) Nutritional value of chives edible Flowers. Acta Scientiarum Polonorum Hortorum Cultus, 10 (2), 85-94

Hu, Ch. (2012) Factors affecting phytochemical composition and antioxidant activity of Ontario vegetable crops. Ontario Canada: Guelphl

Jastrzebski, Z., Leontowicz, H., Leontowicz, M., Namiesnik, J., Zachwieja, Z., Barton, H., Pawelzik, E., Arancibia-Avila, P., Toledo, F., Gorinstein, S. (2007) The bioactivity of processed garlic (Allium sativum L.) as shown in vitro and in vivo studies on rats. Food and Chemical Toxicology, 45, 1626-1633

Kim, J. W., Huh, J. E., Kyung, S. H., Kyung, K. H. (2004) Antimicrobial activity of alk(en)yl sulfides found in essential oils of garlic and onion. Food Science and Biotechnology, 13, 235-239

Kuceková, Z., Mlcek, J., Humpolicek, P., Rop, O., Valasek, P., Saha, P. (2011) Phenolic Compounds from Allium schoenoprasum, Tragopogon pratensis and Remux acetosa and their antiproliferative effects. Molecules, 16, 9207-9217. DOI: http://dx.doi.org/10.3390/molecules16119207

Kumar, K. P. S., Bhowmik, D., Chiranjib, Biswajit, Tiwari, P. (2010) Allium cepa: a traditional medicinal herb and its health benefits. Journal of Chemical and Pharmaceutical Research, 2 (1), 283-291

Lachman, J., Proněk, D., Hejtmanková, A., Dudjak, J., Pivec, V., Faitová, K. (2003) Total polyphenol and main flavonoid antioxidant in different onion (Allium cepa L.) varieties. Horticultural Science, 30 (4), 142-147

Lanzotti, V. (2006) The analysis of onion and garlic. Journal of Chromatography A, 1112 (1-2), 3-22.DOI: http://dx.doi.org/10.1016/j.chroma.2005.12.016

Liu, R. H. (2003) Health benefits of fruit and vegetables are from additive and synergistic combinations of phytochemicals. The American Journal of Clinical Nutrition, 78 (3), 517-520

Mahmutovic, O., Tahirovic, I., Copra, A., Memic, M., Ibragic, S., Karic, L. (2014) Correlation of Total Secondary Sulfur Compounds, Total Phenols and Antioxidant Capacity in the Ramsons and Garlic. British Journal of Pharmaceutical Research, 4 (23), 2662-2669. DOI: http://dx.doi.org/10.9734/BJPR/2014/13977

Mnayer, D., Fabiao-Tixier, A. S., Petitcolas, E., Hamieh, T., Nehme, N., Ferrant, C., Fernandez, X., Chemat, F. (2014) Chemical Composition, Ativacterial and Antioxidant Activities of sic Essential Oils from the Alliaceae Family. Molecules, 19, 20034-20053. DOI: http://dx.doi.org/10.3390/molecules191220034

Nuutila, A. M., Puupponen-Pimia, R., Aarni, M., Oksman-Caldentey, K. M. (2003) Comparison of antioxidant activities of onion and garlic extracts by inhabitation of lipid peroxidation and radical scavenging activities. Food Chemistry, 81, 485-493. DOI: http://dx.doi.org/10.1016/S0308-8146(02)00476-4

Oak, M. H., El Bedoui, J., Schini-Kerth, V. B. (2005) Antiangiogenic properties of natural polyphenols from red wine and green tea. The Journal of Nutritional Biochemistry, 16, 1-8. DOI: http://dx.doi.org/10.1016/j.jnutbio.2004.09.004

Ozougwu, J. C. (2011) Anti-diabetic effects of Allium cepa (onions) aqueous extracts on alloxan-induced diabetic Rattus novergicus. Journal of Medicinal Plants Research, 5 (7), 1134-1139

Parvu, M., Toiu, A., Vlase, L., Parvu, A. E. (2010) Determination of some polyphenolic compounds from Allium species by HPLC-UV-MS. Natural Product Research, 24 (14), 1318-1324. DOI: http://dx.doi.org/10.1080/14786410903309484

Parvu, M., Parvu, A. E., Vlase, L., Rosca-Casian, O., Parvu, O. (2011) Antifugal properties of Allium ursinum L. ethanol extract. Journal of Medicinal Plants Research, 5 (10), 2041-2046

Pérez-Gregorio, R. M., Garcia-Falcon, M. S., Simal-Gandara, J., Rodriguez, A. S., Almeida, D. P. F. (2009) Identification and quantification of flavonoids in traditional cultivars of red and white onions at harvest. Journal of Food Composition and Analysis, 23, 592-598. DOI: http://dx.doi.org/10.1016/j.jfca.2009.08.013

Priecina, L., Karlina, D. (2013) Total Polyphenol, Flavonoid Content and Antiradical Activity of Celery, Dill, Parsley, Onion and Garlic Dried in Conventive and Microwave-Vacuum Dryer. 2nd International Conference on Nutrition and Food Sciences, 53, 107-112

Ramkissoon, J. S., Mahomoodally, M. F., Ahmed, N., Subratty, A. H. (2012) Relationship between total phenolic content, antioxidant potencial, and antiglycation abilities of common culinary herbs and spices. Journal of Medical Food, 15 (12), 1116-1123. DOI: http://dx.doi.org/10.1089/JMF.2012.0113

Rizwani, G. H., Shareef, H. (2011) Genus Allium: The Potential Nutritive and Therapeutic Source. Journal of Pharmacy and Nutrition Sciences, 1, 158-165

Sapundjieva, T., Alexieva, I., Mihavlova, D., Popova, A. (2012) Antimicrobial and antioxidant activity of extracts of Allium ursium L.. Journal of Bioscience and Biotechnology, 7, 143-145

Saxena, R., Venkajah, K., Anitha, P., Venu, L., Raghunath, M. (2007) Antioxidant activity of commonly consumed plant foods of India: cotribution of their phenolic content. International Journal of Food Science and Nutrition, 58, 250-260. DOI: http://dx.doi.org/10.1080/09637480601121953

Sobolewska, D., Podolak, I., Makowska-Was, J. (2015) Allium ursinum: botanical, phytochemical and pharmacological overview. Phytochemistry Review, 14 (1), 81-97. DOI: http://dx.doi.org/10.1007/s11101-013-9334-0

Srivastava, S., Pathak, P. H. (2012) Garlic (Allium sativum) extract supplementation alters the glycogen deposition in liver and protein metabolism in gonads of female albino rats. International Journal of Pharmaceutical Sciences and Drug Research, 4 (2), 126-129

Tepe, B., Sokmen, M., Akpulat, H., Sokmen, A. (2005) In vitro antioxidant activities of the methanol extract of five species from Turkey. Food Chemistry, 92 (1), 89-92. DOI: http://dx.doi.org/10.1016/j.foodchem.2004.04.030

Trifunschi, S., Munteanu, M. F., Agotici, V., Pitea, S., Gligor, R. (2015) Determination of Flavonoid and Polyphenol Compounds in Viscum Album and Allium sativum Extract. International Current Pharmaceutical Journal, 4 (5), 382-385

Tsao, R. (2010) Chemistry and Biochemistry of Dietary Polyphenols. Nutrients, 2, 1231-1246. DOI: http://dx.doi.org/10.3390/nu2121231

Vlase, L., Parvu, M., Parvu, E. A., Toiu, A. (2013) Chemical Constituents of Three Allium Species From Romania. Molecules, 18, 114-127. DOI: http://dx.doi.org/10.3390/molecules18010114

Wangcharoen, W., Morasuk, W. (2007) Antioxidant capacity and phenolic content of some Thai culinary plants. Maejo International Journal of Science and Technology, 1, 100-106

Wangcharoen, W., Morasuk, W. (2009) Effect of heat treatment on the antioxidant capacity of garlic. Maejo International Journal of Science and Technology, 3 (01), 60-70

Yang, J., Meyers, K. J., Van Der Heide, J., Liu, R. H. (2004) Varietal differences in phenolic content and antioxidant and antiproliferative activities of onions. Journal of Agricultural and Food Chemistry, 52, 6787-6793. DOI: http://dx.doi.org/10.1021/JF0307144

Young, I. S., Woodside, J. V. (2001) Antioxidants in health and disease. Journal of Clinical Pathology, 54, 176-186