Quality of Coloured Varieties of Potatoes

K. HEJTMÁNKOVÁ[1]*, V. PIVEC[1], E. TRNKOVÁ[1], K. HAMOUZ[2] and J. LACHMAN[1]

[1]Department of Chemistry, and [2]Department of Crop Production, Czech University of Life Sciences Prague, 165 21 Prague, Czech Republic, *E-mail: hejtmankovak@af.czu.cz

Abstract: Coloured potatoes (*Solanum tuberosum* L.) were evaluated as important source of natural antioxidants. Eight varieties of these potatoes (Salad Blue, Shetland Black, Blue Congo, Blaue St. Galler, Highland Burgundy Red, Violette, Valfi, Vitelotte) grown in four different locations in the Czech Republic (Přerov nad Labem, Suchdol, Valečov and Stachy) were analysed. Content of majority antioxidants (anthocyanins, chlorogenic acid and ascorbic acid) was determined and the obtained results were correlated with antioxidant activity. Total anthocyanin content and antioxidant activity were determined spectrophotometrically and phenolic acids by HPLC-DAD. The best positive correlation was observed between total anthocyanin content and antioxidant activity (R^2 = 0.64). Good correlation was found between chlorogenic acid content and antioxidant activity (R^2 = 0.55); however, no correlation between ascorbic acid content and antioxidant activity (R^2 = 0.08) was found.

Keywords: coloured potatoes; antioxidant activity; total anthocyanins; chlorogenic acid; ascorbic acid

INTRODUCTION

Potato tubers are, due to consumed amount, one of the major sources of antioxidant compounds in human diet. Compounds with antioxidant activity have capability to inactivate free radicals, which negatively influence biologically important compounds (lipids, proteins and nucleic acids). Major antioxidant compounds in common yellow potatoes are polyphenols (chlorogenic acid, neochlorogenic acid, caffeic acid, ferulic acid, etc.), ascorbic acid, carotenoids, tocopherols, lipoic acid and selenium. Antioxidant compounds also prove to possess synergic effect (Lachman *et al*. 2009). Brown (2005) has found that coloured potatoes contain twice high levels of phenolic acids compared to yellow-fleshed potatoes. Moreover, coloured varieties of potatoes contain in pulp and peel plant natural pigments anthocyanins. These compounds are considered as potential replacements for banned dyes due to their incorporation into aqueous food system as well as possible health benefits (Rodriguez-Saona *et al*. 1998). The pigments have been determined to be varied types of acylated anthocyanidin glycosides (Brown *et al*. 2003). Main anthocyanidins in coloured varieties of potatoes are peonidin, malvidin, pelargonidin, petunidin, cyanidin and delphinidin (Fossen *et al*. 2003). Coloured varieties are different in composition and representation of individual anthocyanidins. Due to the fact that the coloured varieties have 2–3 times higher antioxidant capacity than yellow varieties, these potatoes could be preferred in the diet. Coloured potatoes could be used as novel sources of natural colorants and antioxidants with added value for the food industry and human health (Lachman *et al*. 2009). Furthermore, they offer unconventional resource suitable for diversification of potato dishes. In the Czech Republic it was registered so far only one coloured cultivar – Valfi in the year 2005.

The objectives of this study were to characterise relation between antioxidant compounds (anthocyanins, chlorogenic acid and ascorbic acid) and antioxidant activity of coloured varieties of potatoes.

MATERIAL AND METHODS

Samples. Samples were collected from potato cultivars produced in the Czech Republic in the

year 2008 in precise field trials. For analyses only mechanically and physiologically undamaged tubers of 20–80 g mass were used. For analyses individual samples of 5 tubers were used and every determination was done 3 times.

Analytical methods. Determination of total anthocyanin content and antioxidant activity was performed spectrophotometrically; total anthocyanin content was measured according to Lapornik *et al.* (2005) method. Antioxidant activity was measured using the modified ABTS [2,2'- azinobis(3-ethylbenzothiazoline-6-sulfonic acid)] diammonium salt radical decolourisation assay (Pennycooke *et al.* 2005). Antioxidant activity was expressed as % inhibition of radical ABTS according to equation: %inhibiton ABTS = $[(A_0 - A_t)/A_0] \times 100$. Chlorogenic acid and ascorbic acid were determined by RP-HPLC-DAD. Chlorogenic acid was extracted with methanol, the extract was diluted with deionised water and the aliquot was then transferred into the vial. Gradient elution was used; detector was set to wave length λ = 324 nm. Ascorbic acid was extracted with 3% metaphosphoric acid and the aliquot was transferred into the vial. Isocratic elution was used and the detector was set to wave length λ = 251 nm.

RESULTS AND DISCUSSION

Statistical evaluation

Measured values were processed by the analysis of variance method (ANOVA, α = 0.05) using Tukey's test for more detailed evaluation. Statistical analysis of results showed that total content of anthocyanins and antioxidant activity can be influenced significantly not only by variety, but also by the location of potato cultivation. Furthermore, statistically significant influence (ANOVA, α = 0.05) of variety on chlorogenic acid and the location of cultivation on ascorbic acid content in potatoes samples was found. Results are summarised in Table 1.

Table 1. Analysis of variance (α = 0.05)

Analyte	Location	Cultivar
Anthocyanins	✓	✓
Ascorbic acid	✓	×
Chlorogenic acid	×	✓
Antioxidant activity	✓	✓

✓statistical significant influence
× non statistical significant influence

Quantitative parameters of coloured potatoes

Content of ascorbic acid ranged between 407 mg/kg d. m. (cv. Violette, location Stachy) and 1054 mg/kg d. m. (cv. Salad Blue, location Přerov nad Labem). Average value was 730 mg/kg d. m.

Content of chlorogenic acid ranged between 990 mg/kg d.m. (cv. Shetland Black, location Valečov) and 7624 mg/kg d. m. (cv. Vitelotte, location Stachy). Average value was 3086 mg/kg d. m.

Total content of anthocyanins ranged between 188 mg/kg d. m. (cv. Shetland Black, location Valečov) and 2929 mg/kg d. m. (cv. Violette, location Stachy). Average value was 844 mg/kg d. m.

Antioxidant activity ranged between 21% (cv. Shetland Black, location Valečov) and 68% (cv. Violette, location Valečov). Average value was 37%.

Table 2. Comparison of coloured and yellow-fleshed potatoes (mg/kg d. m.)

Analyte	Cultivar	Location		
		Přerov nad Labem	Suchdol	Stachy
Ascorbic acid	coloured	925	669	573
	yellow	1190	1003	904
Chlorogenic acid	coloured	–	–	3487
	yellow	–	–	533

– not determined

Chlorogenic and ascorbic acid in coloured and yellow-fleshed potatoes

According to Lewis *et al.* (1998), content of chlorogenic acid is significantly higher in coloured than in yellow-fleshed potatoes. Average content in coloured potatoes from location Stachy was 3487 mg/kg d. m., whereas in yellow-fleshed (Karin, Saturna) from the same location was just 533 mg/kg d. m.. The obtained results represent 6.5 times higher content in the coloured varieties of potatoes in comparison to yellow-fleshed ones. A similar trend has been observed also in other contained polyphenolic compounds (ferulic acid, caffeic acid, etc.). In comparison of the content of ascorbic acid in purple-fleshed potatoes 4 yellow-fleshed varieties were used (Karin, Saturna, Ditta, Impala). In the yellow-fleshed potatoes the content of ascorbic acid was slightly higher (in average 1.4 times, Table 2).

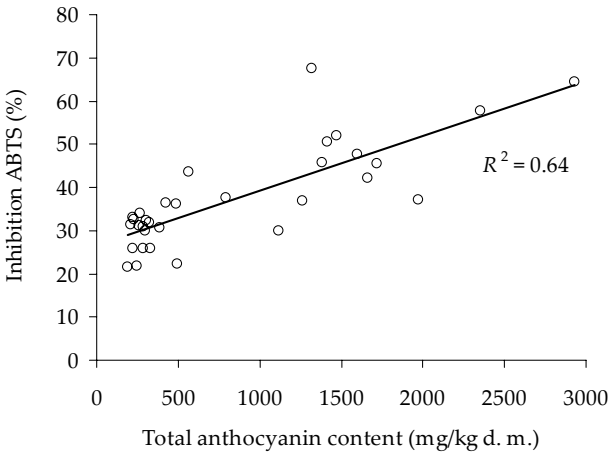

Figure 1. Relationship between total anthocyanin content and antioxidant activity

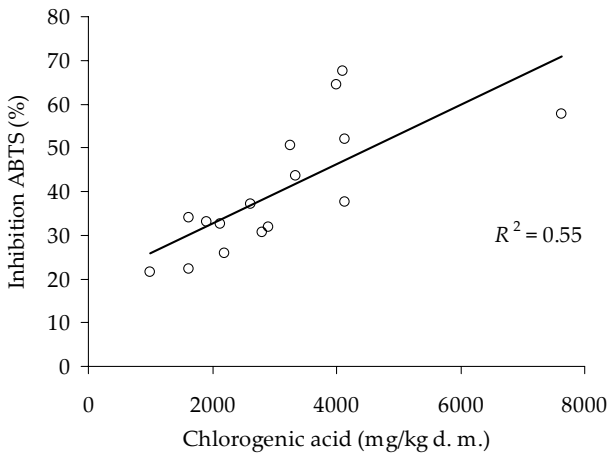

Figure 2. Relationship between chlorogenic acid content and antioxidant activity

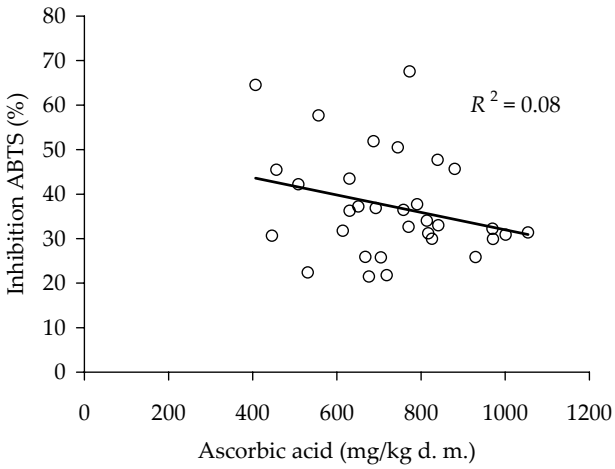

Figure 3. Relationship between ascorbic acid content and antioxidant activity

Relationship between individual analytes and antioxidant activity

Content of individual constituents was correlated with antioxidant activity (Figures 1–3); the best positive correlation was found between total content of anthocyanins and antioxidant activity (R^2 = 0.64). In the case of comparison of chlorogenic acid content and antioxidant activity the coefficient of determination was 0.55. No dependency was observed between ascorbic acid content and antioxidant activity (R^2 = 0.08). The obtained results indicate that high antioxidant activity of coloured potatoes is created and caused not only by anthocyanins but also by another polyphenolic compound – chlorogenic acid.

Acknowledgements: This study was supported by the Ministry of Agriculture of the Czech Republic, Project No. QH 92110, and by the Ministry of Education, Youth and Sports of the Czech Republic, Project No. MSM 6046070901.

References

Brown C.R. (2005): Antioxidants in potato. American Journal of Potato Research, **82**: 163–172.

Brown C.R., Wrolstad R., Durst R., Yang C.-P., Clevidence B. (2003): Breeding studies in potatoes containing high concentrations of anthocyanins. American Journal of Potato Research, **80**: 241–250.

Fossen T., Ovstedal D.O., Slimestad R., Andersen O.M. (2003): Anthocyanins from a Norwegian potato cultivar. Food Chemistry, **81**: 433–437.

Lachman J., Hamouz K., Šulc M., Orsák M., Pivec V., Hejtmánková A., Dvořák P., Čepl J. (2009): Cultivar differences of total anthocyanins and anthocyanidins in red and purple-fleshed potatoes and their relation to antioxidant activity. Food Chemistry, **114**: 836–843.

Lapornik B., Prošek M., Wondra A.G. (2005): Comparison of extracts prepared from plant by-products using different solvents and extraction time. Journal of Food Engineering, **71**: 214–222.

Lewis C.E., Walker J.R.L., Lancaster J.E., Sutton K.H. (1998): Determination of anthocyanins, flavonoids and phenolic acids in potatoes. I: Coloured cultivars of *Solanum tuberosum* L. Journal of the Science of Food and Agriculture, **77**: 45–57.

Pennycooke J.C., Cox S., Stushnoff C. (2005): Relationship of cold acclimation, total phenolic content and antioxidant capacity with chilling tolerance in petunia (*Petunia* × *hybrida*). Environmental and Experimental Botany, **53**: 225–232.

Rodriguez-Saona L.E., Giusti M.M., Wrolstad R.E. (1998): Anthocyanin pigment composition of red-fleshed potatoes. Journal of Food Science, **63**: 458–465.