ANTIOXIDANT ACTIVITY IN YELLOW AND PURPLE-FLESHED POTATOES CULTIVATED IN DIFFERENT CLIMATIC CONDITIONS

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Introduction

Potato tubers represent in human nutrition a significant source of antioxidants, which has a beneficial effect on cardiovascular diseases, inhibit certain types of cancer and the degeneration of the retina [STINTZING, CARLE 2004]. Major potato antioxidants are polyphenols and L-ascorbic acid. These compounds are principally soluble in water alike to a lesser degree contained selenium. Among antioxidants soluble in lipids, potatoes contained carotenoids, α-tocopherol and α-lipoic acid [LACHMAN, HAMOUZ 2005]. Potatoes with purple-coloured peels and flesh are new for consumers, and contain natural anthocyanin pigments. The first such cultivar (Valfi) was registered in the Czech Republic in 2005 [ŠULC et al. 2007]. Purple-fleshed cultivars have according to the literature references, higher antioxidant tuber activity as compared to traditional yellow-fleshed cultivars [REYES et al. 2005]; it is related to the content of anthocyanin pigments [BROWN 2005; BROWN et al. 2005]. Main anthocyanin glycosides, which contribute to the antioxidant properties of purple-fleshed potatoes are glycosides of peonidin, petunidin and malvidin, whereas in purple-fleshed potatoes glycosides of pelargonidin prevail [BROWN 2004].

The target of this work was to compare the antioxidant activity (AA) determined in some purple or red-fleshed cultivars with its values in common yellow-fleshed potatoes. The other aim was to determine the impact of climatic conditions in individual localities with different levels above the sea on the antioxidant activity of tubers.

Material and methods

In precise field trials in the years 2006 and 2007 the total of five purple-fleshed, one red-fleshed and two yellow-fleshed cultivars (Tab. 2) were cultivated according to the unified method in the three localities with different levels above the sea (Tab. 1).

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After harvest the tuber samples of individual cultivars from all locations were analyzed in the laboratory. Antioxidant activity was determined by the ABTS [2,2’-azinobis(3-ethylbenzothiazolin)-6-sulfonate] method and total anthocyanin content (TAC) was determined at the Department of Chemistry of CULS in Prague.

### Table 1; Tabela 1

**Characteristics of experimental locations**

<table>
<thead>
<tr>
<th>Locality; Miejscowość</th>
<th>Altitude above the sea level; Wysokość nad poziomem morza (m)</th>
<th>Average annual temperature; Średnia roczna temperatura (°C)</th>
<th>Annual sum of precipitations; Roczna suma opadów (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Přerov nad Labem 1)</td>
<td>178</td>
<td>8.8</td>
<td>622</td>
</tr>
<tr>
<td>Praha-Suchdol</td>
<td>286</td>
<td>8.2</td>
<td>510</td>
</tr>
<tr>
<td>Valečov 2)</td>
<td>460</td>
<td>6.9</td>
<td>649</td>
</tr>
</tbody>
</table>

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### Table 2; Tabela 2

**Impact of variously colour-fleshed cultivars on antioxidant activity (AA) of tubers - average from 3 locations**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>AA 1) sign.; istot. 3)</td>
<td>AA 1) sign.; istot. 3)</td>
<td>AA 1) sign.; istot. 3)</td>
<td></td>
</tr>
<tr>
<td>Karin / y</td>
<td>40.1 e</td>
<td>13.6 f</td>
<td>26.8 e</td>
<td></td>
</tr>
<tr>
<td>Saturna / y</td>
<td>28.1 f</td>
<td>13.4 f</td>
<td>20.7 f</td>
<td></td>
</tr>
<tr>
<td>Highland Burgundy Red / r</td>
<td>82.8 b</td>
<td>55.1 b</td>
<td>69.0 b</td>
<td></td>
</tr>
<tr>
<td>Blue Congo / lp</td>
<td>66.3 c</td>
<td>47.0 d</td>
<td>56.7 c</td>
<td></td>
</tr>
<tr>
<td>Salad Blue / lp</td>
<td>60.1 d</td>
<td>50.1 c</td>
<td>5.1 c</td>
<td></td>
</tr>
<tr>
<td>Valfi / lp</td>
<td>65.3 c</td>
<td>38.1 e</td>
<td>51.7 d</td>
<td></td>
</tr>
<tr>
<td>Violette / dp</td>
<td>65.3 c</td>
<td>38.1 e</td>
<td>51.7 d</td>
<td></td>
</tr>
<tr>
<td>Vitelotte / dp</td>
<td>114.2 a</td>
<td>70.2 a</td>
<td>92.2 a</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

1) ascorbic acid amount in mg, which is its AA equivalent to 100 g FM of tubers; ilość kwasu askorbinowego w mg, która jest równoważna z punktu widzenia AA 100 g św. m. ziemniaków
2) y - yellow; żółte   r - red; czerwone  lp - light purple; jasnofioletowe
dp - dark purple; ciemnofioletowe
3) homogenous groups; grupy jednorodne

### ABTS assay

54.2 mg ABTS were dissolved in phosphate buffer (pH 7.0; 5 mM) and activated to ABTS⁺ radical by the addition of 1 g MnO₂ with occasional stirring and 30 min time of activation [PENNYCOOKE et al. 2005]. Then the solution was centrifuged (5 min, 7 000 g), filtered (25 µm) and diluted with phosphate buffer to absorbance (t₀) 0.700 ± 0.01. Sample addition was 5 µl, time of reaction 20 min. The absorbance of the solution was measured at the wavelength of λ = 734 nm.
Total anthocyanin content (TAC) determination

The measurement of non hydrolysed TAC using the pH differential method described by LAPORNIK et al. [2005] based on the total anthocyanin transformation to flavylium cation at pH of extracts decreasing to values between 0.5 and 0.8 was carried out. TAC was expressed as cyanidin ($\varepsilon_{1\%}^{1\text{cm}} = 300; 523 \text{ nm}$).

Results and Discussion

Table 2 shows the apparent differences in AA of tubers between yellow, purple or red-fleshed cultivars. Purple and red-fleshed cultivars showed a significantly higher AA (in average 2.9 times) in comparison to yellow-fleshed cultivars. In addition, REYES et al. [2005] obtained similar results. The highest AA value between purple-fleshed cultivars was determined in the cv. Violette (95.4 mg ascorbic acid $100 \text{ g FM} = 100\%$), in the other purple-fleshed cultivars the AA decreased Vitelotte 3.4%, Blue Congo 40.6%, Salad Blue 42.2% and Valfi 46.0%. In the red-fleshed cv. Highland Burgundy Red AA decreased as compared to the cv. Violette 27.7% and the highest decrease was shown by yellow-fleshed cv. Karin 71.9% and Saturna 78.4%. Higher AA values of the cvs Violette and Vitelotte as compared to a other purple-fleshed cultivars are obviously related to their darker colour of the flesh and to higher content of anthocyanins, as described by BROWN [2004]. Other evidence of BROWN [2005] also confirms our results and according to them anthocyanins could be taken together with chlorogenic acid and caffeic acid for main potato contributors to AA. Between the yellow-fleshed cultivars, the cv. Karin significantly exceeded the cv. Saturna in AA.

The total anthocyanin content (TAC) was determined in purple and red-fleshed cultivars. The highest values were determined in the cultivars with the darkest flesh colour Violette and Vitelotte and further in the red-fleshed cv. Highland Burgundy Red (Fig. 1). These cultivars at the same time had demonstrated the highest AA values and TAC well correlated with them. The range of TAC between the cultivars was relatively tidy; var. Blue Congo with the lowest content reaching 29% of the value determined in the var. Violette (64.1 mg per 100 g FM) with the highest TAC. In addition, BROWN [2005] attained the similar results and showed TAC in purple and red-fleshed potatoes within the range from 9 to 38 mg per 100 g FM. Our results are in agreement with DELGADO et al. [2001], who determined highly positive correlations between the antioxidant capacity and anthocyanin content and total polyphenol content and consider the former compounds as the major source of antioxidant capacity.
Fig. 1. Effect of cultivar on total anthocyanin content (mg of cyanidin-100 g^{-1} FM); 2006, average for 3 locations

Rys. 1. Wpływ odmiany na ogólną zawartość antocyjanów (mg cyjanidyny-100 g^{-1} św.m.), średnia dla 3 miejscowości

^{1)} homogenous groups; grupy jednorodne
The present two-year results did not confirm the impact of a location on AA of tubers. A trend was observed in 2006, when a significantly lesser AA was noted on the warmest location Přerov nad Labem in the low ground alongside the Labe river however those observations were not confirmed in 2007.

Conclusions

1. Potato AA is demonstrably affected by the varietal genotype.
2. Purple and red-fleshed potato cultivars showed on average 2.9 times higher AA of tubers in comparison with yellow-fleshed potatoes.
3. Considerable differences of AA and TAC was found in the purple and red-fleshed cultivars, where the highest AA were noted in the cultivars with high content of total anthocyanins.
4. The obtained results did not prove the impact of location on AA of tubers.

References
Key words: potatoes, purple and red-fleshed cultivars, antioxidant activity, anthocyanins

Summary

In precise field trials on three locations in the Czech Republic the impact of yellow, red and purple-fleshed potato cultivars in the years 2006 and 2007 was investigated as well as the effect of location conditions on antioxidant activity (AA) of tubers (expressed by ABTS assay in mg ascorbic acid 100 g⁻¹ FM). The highest AA was determined in the darkly purple-fleshed cv. Violette (95.4 mg ascorbic acid·100 g⁻¹ FM). In the purple and red-fleshed cultivars, AA was on the average 2.9 times higher as compared to yellow-fleshed cultivars. Significant AA differences between purple and red-fleshed cultivars were found; the cultivars of the highest total anthocyanin content (TAC ranged from 18.6 to 64.1 mg·100 g⁻¹ FM) were reaching the highest AA values. The obtained results did not prove the impact of location on AA of tubers.
Słowa kluczowe: ziemniaki, odmiany z żółtym i fioletowym miąższem, aktywność przeciwutleniająca, antocyjan

Streszczenie

W ściśłych doświadczeniach polowych przeprowadzonych w trzech miejscowościach w Republice Czeskiej, w latach 2006 i 2007, stwierdzono wpływ odmian ziemniaków o żółtym, czerwonym i fioletowym zabarwieniu miąższu oraz wpływ warunków badań na aktywność przeciwutleniającą - AA - bulw (ABTS metoda w mg kwasu askorbinowego w 100 g św.m.). Najwyższą AA stwierdzono u odmiany Violette o cieniofioletowym zabarwieniu miąższu - 95,4 mg kwasu askorbinowego-100 g ś.w.m. U odmian o fioletowym i czerwonym zabarwieniu miąższu stwierdzono AA średnio 2,9 raza wyższą niż u odmian o zabarwieniu żółtym. Istotne różnice AA występowały też między odmianami o fioletowym lub czerwonym zabarwieniu miąższu. Najwyższe wartości AA miały odmiany o największej zawartości antocyjanów (wahała się w granicach od 18,6 do 64,1 mg-100 g ś.w.m.). Wyniki nie wykazały wpływu środowiska na AA bulw.

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