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Communication

Content of carotenoids in roots of seventeen cultivars of *Daucus carota* L.

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The aim of this study was to compare the content of carotenoids in seventeen cultivars of carrots grown in Poland. Conventional orange cultivars with rarely grown were compared: white, yellow and purple with yellow core cultivars. To determine the content of carotenoids, extracts from lyophilized carrot roots were prepared and analyzed by spectrophotometric as well as HPLC methods with DAD detector. The highest content of carotenoids was found in cultivars: 'Korund F_1' (48 mg/100g of fresh weight) and 'Salsa F_1' (36 mg/100g of fresh weight). The antioxidant properties of selected cultivars were compared using the DPPH method.

Key words: carotenoid, carrot, antioxidant activity

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INTRODUCTION

Carrots are an important source of carotenoids in daily diet (Arscott & Tanumihardjo, 2010). They mainly provide not only β-caroten which is needed as provitamin A (Rao & Rao, 2007; Grune *et al.*, 2010), but also other carotenids for example lutein which protects against age-related macular degeneration and cataract (Mozaffarieh *et al.*, 2003; El-Agamey *et al.*, 2004). Carotenoids present in *Daucus carota* L., are also antioxidants that are able to reduce the risk of chronic diseases (cardiovascular diseases, cancer ect.) (Krinsky & Yeum, 2003; Paolini *et al.*, 2003; Stahl & Sies, 2003). In Poland, the carrot is grown on a large scale (813 000 tons in 2009) and has great economic importance (GUS 2009). New cultivars introduced into crops are not only different in shapes and colors, but also in the content of bioactive and important for health compounds including carotenoids. Several studies on carotenoids content of carrots have been reported (Surles *et al.*, 2004; Grassmann *et al.*, 2007; Sun *et al.*, 2009) however, none of them includes differences in cultivars. Identifying the *Daucus carota* L. cultivars with the highest carotenoids content in roots will make it possible to recommend them for cultivation, especially for farms specializing in production of preserves with high carotenoids content and contribute to further selection of new cultivars in horticultural breeding.

MATERIALS AND METHODS

Seventeen selected cultivars of carrots were grown on plots at the Experimental Station of Agricultural University in Mydlniki. After harvesting, samples of carrot roots were immediately frozen at –20°C. Each 10 g sample was freeze-dried. After lyophilisation, the carrots were extracted using n-hexane/ethanol 96% (1:1, v/v), until complete exhaustion of colour (Andersson *et al.*, 2009). The whole extract was kept at –20°C and used for HPLC and spectrophotometric analyses within 72 h. The HPLC system consisted of a Shimadzu LC-20 AD model with a LiChrospher RP-18, 250 mm column. The mobile phase comprised 1% water in methanol (A), methanol (B), 10% n-hexane with acetonitrile (C) with gradient method at a flow rate of 2.0 ml/min. Detection was carried out using a DAD (diode array detector). Quantification of total carotenoids was performed on UV/Vis Spectrophotometer JASCO V-530. To determine the antioxidant capacity of carrots extract DPPH (Wang *et al.*, 2010) method was used. Statistical analysis were performed with Statistica (version 9). Analysis of variance (ANOVA) was used to investigate differences among carotenoids content of various cultivars. To find out relation between carotenoids content and antioxidant capacity test of correlation was performed.

RESULTS AND DISCUSSION

Because of the high carotenoids content, carrot is main vegetable consumed in Europe. In this research seventeen new carrot cultivars were compared in consideration of their total carotenoids content. Among all examined cultivars the highest total carotenoids content (all types of carotenoids) were found in orange carrots (14 cultivars). The studies showed that the most valuable cultivars in terms of their carotenoids content, are 'Korund F_1', 'Salsa F_1', 'Afro F_1' ,'Kazan F_1', 'Polka F_1', 'Kongo F_1', 'Niland F_1' (Fig. 1). The yellow, white and purple cultivars as we expected contained much less carotenoids. Especially white ('White Satin') and yellow ('Yellowstone') cultivars had small amounts of carotenoids: 'White Satin' — 0.54 mg/100 g fresh weight, 'Yellowstone' — 2.75 mg/100 g fresh weight (Table 1). The purple roots with yellow core ('Deep Purple') had more carotenoids (3.46 mg/100 g fresh weight) but still much less than traditional orange cultivars. Grassmann *et al.* (2007) found higher values of total carotenoids for

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Abbreviations: DPPH, diphenylpicrylhydrazyl; HPLC, high performance liquid chromatography.

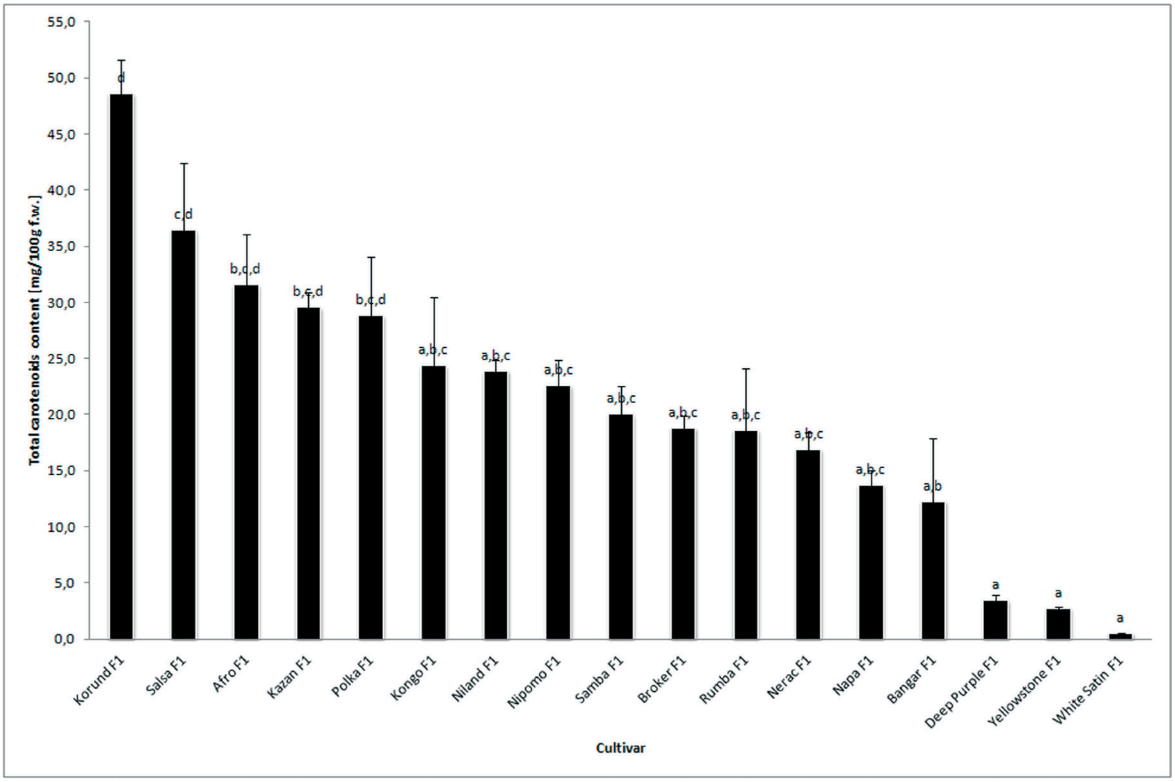

Figure 1. Content of total carotnenoids in seventeen different cultivars of carrot.
Data with significant differences are labeled with different letters.

purple cultivar. This difference is probably due to the fact that Grassmann studied the purple cultivar with orange core, in turn, the object of our study was also a purple cultivar but with a yellow core. Other researchers have also investigated the carrots of different colors. Surles *et al.* (2004) showed that in the white roots the total of carotenoids content was 0.014 mg/100 g of fresh weigh, the yellow 0.71 mg/100 g of fresh weigh, while the purple had 17.5 mg. These results are significantly different from obtained by us. A similar relationship is visible when compared with data obtained by Sun *et al.* (2009). This probably results from the different methods of extraction and chromatographic separation. The results received from analysis of traditional orange carrots seems to be noteworthy. The content of total carotenoids in the cultivars with orange roots ranged from 12.29 to 48.6 mg/100 g of fresh weigh. These results are really difficult to confront. As mentioned earlier, most work on the total content of carotenoids in carrots, considers only the differences resulting from different color and regrettably there is lack of the cultivars characteristics. The literature data provide content from 9.1 to 40 mg/100 g fresh weight (Konings & Roomans, 1997; Burns *et al.*, 2003; Surles *et al.*, 2004; Mayer-Miebach *et al.*, 2005; Sun *et al.*, 2009; Murillo *et al.*, 2010). Orange cultivars which have been tested, contain concentration of carotenoids located in these range, with the exception of 'Korund F_1', which showed a slightly higher carotenoids content (Table 1.).

Table 1. Content of β-caroten, total carotenes and xanthophylls in seventeen cultivars of *Daucus carota* L.

Total content [mg/100 g f.w.*] Cultivar	β-caroten	Carotenes	Xanthophylls
Korund F_1	13.0 ±7.31^{c}	19.7±1.27^{b}	1.8±0.25^{f,g,h}
Salsa F_1	13.9±4.41^{a,b}	22.8±7.29 ^{b}	1.3±0.32^{b,c,d}
Afro F_1	16.7±7.2^{b,c}	27.4±7.31^{b}	1.1±0.06^{b,c}
Kazan F_1	17.1±3.7^{b,c}	28.0±6.42^{b}	1.5±0.05^{c,d,e,f}
Polka F_1	11.9±2,13^{a,b}	24.5±6.19^{b}	1.8±0.18^{e,f,g}
Kongo F_1	13.7±0.83^{a,b}	20.2±0.71^{b}	2.3±0.11^{i}
Niland F_1	13.1±0.6^{a,b}	19.5±0.66^{b}	1.6±0.05^{d,e,f}
Nipomo F_1	13.5±4.0^{a,b}	15.1±2.54^{a,b}	1.2±0.02^{b,c,d}
Samba F_1	11.1±1.06^{a,b}	16.8±1.46^{a,b}	1.0±0,18^{b}
Broker F_1	10.2±0.54^{a,b}	15.7±1.03^{a,b}	2.2±0.07^{g,h,i}
Rumba F_1	10.2±1.15^{a,b}	16.2 ±1.80^{a,b}	1.4±0.13^{b,c,d}
Nerac F_1	9.8±0.27^{a,b}	15.2±0.85^{a,b}	1.4±0.03^{b,c,d}
Napa F_1	7.2±0.85^{a,b}	12.4±1.28^{a,b}	1.4±0.06^{b,c,d}
Bangor F_1	7.1±1.00^{a,b}	11.4±3.72^{a,b}	1.1±0.12^{b,c}
Deep Purple F_1	0.9±0.34^{a}	1.3±0.53^{a}	2.2±0.07^{g,h,i}
Yellowstone F_1	0.5±0.09^{a}	0.5±0.13^{a}	2.2±0.02^{h,i}
White Satin F_1	0.1±0.001^{a}	0.1±0.01^{a}	0.4±0.04^{a}

*f.w. – fresh weight. Date represents the mean ±S.E.M. of four independent measurements. Values within column followed by the same letter are not significantly different at P=0.05 (Duncan's test).

The antioxidant capacity of extracts, measured by DPPH method, doesn't correspond with the carotenoids content. Method demonstrated that cultivars containing the highest level of carotenoids have average antioxidant capacity. 'Kazan F_1' is an exception which shows positive correlation between carotenoids content and antioxidant capacity. The purple cultivar 'Deep Purple' revealed high antioxidant capacity despite the fact that it contain low level of carotenoids. Probably the antioxidant properties of hexane-ethanol extracts were caused not only by carotenoids but also by other compounds like tocopherols, unsaturated fatty acids and polyphenols like anthocyanidins ('Deep Purple'). Cultivars with low concentration of total carotenoids, like 'Deep Purple F_1' and 'Yellowstone F_1' have demonstrated a higher proportion of xanthophylls in relation to β-carotene and other carotenoids (Table 1).

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