Vegetable Crops

The main colouring substance and essential oil components of different carrot varieties

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Key words: carrot, colouring material, a and b carotene content, essential oil components

Summary: Investigating colouring components it was found that the β carotene being the most important from the point of view of nutrition constitutes about 60–70% of the total colouring material, whereas the ratio of α carotene is 18–34%.

Among the varieties having a short growing season the common incidence rate of the α and β carotene is very high (92.49 %), even a lower total colouring material content (178.02 ppm) results in bright orange red carrot roots.

The incidence of α and β carotene represents, however, only 84.24% of the similar total colouring material value (171.74 ppm) measured in Nantesi.

Among the storage varieties Ferődi vörös has the highest value of total colouring substance (213.04 ppm) from which the common proportion of the two carotene (α and β) compounds amounts to 93.77%.

When testing the essential oil components the caryophyllen shows the highest incidence rate, which has a negative influence on the flavour materials of the carrot. Among the early varieties in Nantesi Forte this quantity amounts to 24.08 ppm which is almost twice as much as the amount measured in Nantesi. We found a similarly unfavourable quantity in Vörös orlás (25.47 ppm).

Looking at the beta-pinen and l-limonen of a bactericidal effect the quantity of l-limonen is higher (1.36 ppm on the average of the varieties).

Among the varieties that have a longer growing season and which are suitable for processing Ferődi vörös is the best in terms of essential oil and colour content. Its beta-pinen content was above the average of this variety (1.12 ppm) while its l-limonen content was considerably high (1.26 ppm).

Introduction

The quality of the carrot is considerably determined by the inner content: colour, carotene, dry matter and sugar content, and the appropriate flavours.

The good quality raw material of the processing industry determines the value of the final product. Beside the production process the appropriate variety plays an important role in it. There are considerable differences in inner content among these varieties that have to be revealed in order to ensure that the given variety is processed in the best way and to enable it to be a starting basic material in several selection programs.

Colouring substance

Carotenoids cause the orange-red colour of the carrot. These are isoprene-framed compounds and liposoluble natural dyes.

The carotenoids consist of lycopene, α, β and γ carotene. The lycopene can be consideres as the basic compound of all carotenoids since the three other carotenes can be originated from it.

The lycopene (C40H56) is an open carbon chain compound consisting of 13 double bonds (Fig. 1). In the α and β carotene the lycopene chain at the end of it contains two hexagonal rings. So the two compounds differ only in
the position of their double bonds (Fig. 2). In the gamma carotene only one of the chain ends closes in a ring (Fig. 3).

The beta carotene is the typical pigment of the carrot, but also the alpha and gamma isomers can be found in the plant (Nádor, 1982). The alpha and beta carotene are the provitamins of vitamin A, so they have a high nutritive value. From this point of view the beta carotene is more important, it is twice as active as the alpha carotene.

Bajaj et al. (1980) have found a significant positive relationship between the beta carotene and the thickness of the pulp. From the 23 varieties they examined the No.10-75-A contained the most beta carotene (8.50 mg/100 g) while less was found in Yellow Carrot (0.85 mg/100 g). The average beta carotene content of the examined varieties amounted to 4.67 mg/100 g.

According to Fedorova et al. (1982) the carotene content varies in the orange-red varieties from 4.5 to 22 mg per 100 g raw fruit. In the course of their experiments it was found that the accumulation of the carotene content needs a heat sum of approximately 1500 °C during the growing season. In addition to the higher air temperature the optimal soil humidity is needed, too.

The carotene content of the carrot was also examined using different fertilizer doses. Michalk and Wieczorek (1990) found that this parameter has been influenced rather by the year effect than the nutrient supply.

The crop quality is influenced especially by the weather before the harvesting period. The decreasing precipitation quantity and the higher temperature before harvest increase the carotene content of the carrot (Fedorova et al. 1982).

This compound which is of great importance in nutrition does not decrease in the product even on freezing or preserving (Bajaj, 1980). So the preserved carrot is also of high value.

**Essential oil**

In the developing of the flavour and aroma compounds of the carrot mainly the sugars take part, but also the essential oil components play an important role (Simon, 1985). Some of them have been proved to have bactericidal effect. These are, for example, the l-limonen and beta-pinene that destroy Escherichia coli that causes the dangerous infantile diarrhoea. The beta-pinene also inhibits the reproduction of Staphylococcus. At the same time there are also essential oil components that have an unfavourable effect on the carrot’s flavour. They are e.g. the sabinen and the cariophyllen.

**Material and methods**

The experiments were carried out in 1997, in Szarvas at the Agropark of the Research Institute for Irrigation. The heat and precipitation amounts of the growth season are seen in Fig. 4.

Five varieties of carrots were tested in the experiment (Nantais, Nantais Forto, Fertődi vörös, Vörös átás, Danvers) for colour material and essential oil components.

Seeds were sown on 24 April 1997 in four replications. In the course of the laboratory investigations carotenoids (among them alpha and beta carotene, lutein and violaxanthin) and essential-oil components were measured. After the appropriate sample preparation the main
colouring substance components of the carrot were determined using the HPLC method. The measurements were performed at the Central Research Institute of Food Industry, Budapest.

In the course of the sample preparation of the following operations were carried out: homogenization, calibration, rubbing with siliceous sand, extraction (methanol dichlorethane), vibration, filtration and condensation. The essential oil content was determined after making a steam distillation recovery by means of gaschromatograph GC-MS, in the following way.

The washed carrot was chopped into small pieces by fruit extractor then homogenized with Ultra-Turrax by adding distilled water to it. The pulp produced in this way was subjected to a steam distillation-extraction treatment.

Results

The content of colouring substance of the carrot is an important component of quality. However, the quantity of the colouring substance doesn’t give sufficient information about the occurrence of beta carotene, the most important substance of the variety from nutrition’s point of view.

The survey results of the colouring substance composition are in the Table 1. Among the tested varieties Fertődi vörös has shown the highest total colouring substance content (213.04 ppm). Danvers is only slightly behind it (206.45 ppm). The beta carotene content of these varieties is also very high. 135.45 respectively 144.39 ppm (Table 2, Fig. 5).

The carotenoid content of the varieties that have a short growing season (Nantais, Nantais Forta) represented a

<table>
<thead>
<tr>
<th>Variety</th>
<th>Total colouring substance (ppm)</th>
<th>β carotene content (ppm)</th>
<th>α and β carotene</th>
<th>Lutein</th>
<th>β carotene</th>
<th>α carotene</th>
<th>violaxantene</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nantais</td>
<td>171.74</td>
<td>104.42</td>
<td>84.24</td>
<td>3.98</td>
<td>60.80</td>
<td>23.44</td>
<td>0.55</td>
</tr>
<tr>
<td>2. Nantais Forta</td>
<td>178.02</td>
<td>103.32</td>
<td>92.49</td>
<td>2.94</td>
<td>58.04</td>
<td>34.45</td>
<td>0.40</td>
</tr>
<tr>
<td>3. Fertődi vörös</td>
<td>213.04</td>
<td>134.45</td>
<td>93.77</td>
<td>4.75</td>
<td>63.11</td>
<td>30.66</td>
<td>0.58</td>
</tr>
<tr>
<td>4. Vörös örös</td>
<td>158.81</td>
<td>108.47</td>
<td>95.49</td>
<td>3.14</td>
<td>68.30</td>
<td>27.19</td>
<td>0.62</td>
</tr>
<tr>
<td>5. Danvers</td>
<td>206.45</td>
<td>144.39</td>
<td>88.26</td>
<td>3.90</td>
<td>69.94</td>
<td>18.32</td>
<td>0.63</td>
</tr>
<tr>
<td>LSD&lt;sup&gt;95&lt;/sup&gt;</td>
<td>20.645</td>
<td>12.14</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
quantity between 170 to 180 ppm. It is evident that by the latter varieties it is their earthiness rather than the intensity of their inner colour that has priority.

Examining the components of colouring substance the varieties Nantais Forto, Fertődi Vörös and Vörös Ortiz have shown the highest carotene content (more than 92%).

In Nantais and Danvers this value is lower, 84.24, 88.26 %. Surveying the presence of beta carotene separately, it has been found that at the storage varieties (Fertődi vörös, Vörös Ortiz, Danvers) this proportion was between 63–70%.

Looking at components of essential oil of the varieties considerable differences were found (Table 3 and Fig. 6). The incidence of the pharmacologically effective beta-pinene is the greatest in the varieties Fertődi vörös (1.12 ppm) and Danvers (1.19 ppm), while l-limonen in Vörös Ortiz was prominent (2.16 ppm).

The carophyllen plays a negative role in developing flavour materials. The highest quantity was measured among the examined varieties in Nantais Forto and Vörös Ortiz (24.04 respectively 25.47 ppm).

**Table 2** α and β carotene content of carrot varieties on the average of the repetitions, Szarvas, 1997

<table>
<thead>
<tr>
<th>Varieties/Name of colouring substance</th>
<th>β carotene</th>
<th>α carotene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nantais</td>
<td>103.25</td>
<td>41.49</td>
</tr>
<tr>
<td>Nantais Forto</td>
<td>103.32</td>
<td>61.33</td>
</tr>
<tr>
<td>Fertődi vörös</td>
<td>134.45</td>
<td>65.32</td>
</tr>
<tr>
<td>Vörös Ortiz</td>
<td>108.47</td>
<td>43.19</td>
</tr>
<tr>
<td>Danvers</td>
<td>144.39</td>
<td>37.83</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>12.14</td>
<td>NS</td>
</tr>
</tbody>
</table>

**Table 3** Development of essential oil components of different carrot varieties (ppm) on the average of the repetitions

<table>
<thead>
<tr>
<th>A</th>
<th>Essential oil components</th>
<th>β-pinene</th>
<th>l-limonen</th>
<th>caryophyllen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nantais</td>
<td>0.66</td>
<td>1.07</td>
<td>12.73</td>
<td></td>
</tr>
<tr>
<td>Nantais Forto</td>
<td>0.55</td>
<td>0.83</td>
<td>24.08</td>
<td></td>
</tr>
<tr>
<td>Fertődi vörös</td>
<td>1.12</td>
<td>1.26</td>
<td>17.0</td>
<td></td>
</tr>
<tr>
<td>Vörös Ortiz</td>
<td>0.59</td>
<td>2.16</td>
<td>25.47</td>
<td></td>
</tr>
<tr>
<td>Danvers</td>
<td>1.19</td>
<td>1.51</td>
<td>16.33</td>
<td></td>
</tr>
<tr>
<td>Essential oil in the average of varieties</td>
<td>0.82</td>
<td>1.36</td>
<td>19.14</td>
<td></td>
</tr>
</tbody>
</table>

Significant differences:

- Between two versions of ‘A’ in the average of ‘B’ (P = 5%) 0.88
- Between two versions of ‘B’ in the average of ‘A’ (P = 5%) 0.60
- Between two versions of ‘B’ in the same level of ‘A’ (P = 5%) 1.33
- Between two versions of ‘A’ in the same level of ‘B’ (P = 5%) 54.21

**Fig. 5** Alpha- and beta carotene content of carrot varieties (ppm) Szarvas, 1997.

**Fig. 6** Development of essential oil components of different carrot varieties on the average of four repetitions (ppm)

**References**


