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

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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 *Nantais*.
Among the storage varieties *Fertődi 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 cariophyllen shows the highest incidence rate, which has a negative influence on the flavour materials of the carrot. Among the early varieties in *Nantais Forto* this quantity amounts to 24.08 ppm which is almost twice as much as the amount measured in *Nantais*. We found a similarly unfavourable quantity in *Vörös óriás* (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 *Fertődi 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 ($C_{40}H_{56}$) is an open carbon chain compound consisting of 13 double bounds *(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

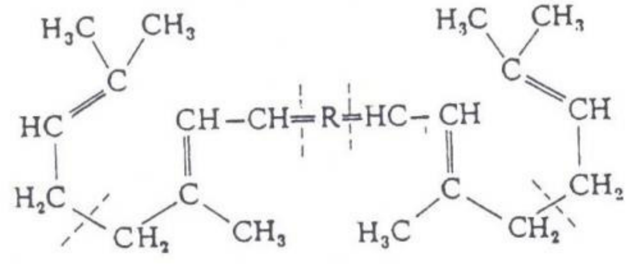

Fig. 1 Structural formula of licopene

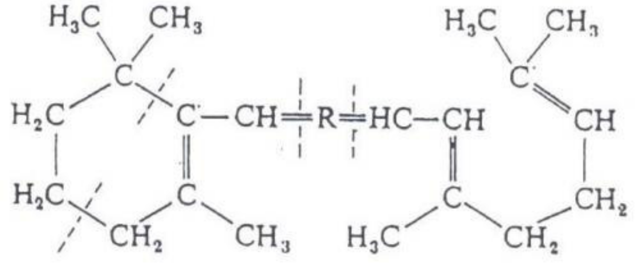

Fig. 3 Structural formula of γ carotene

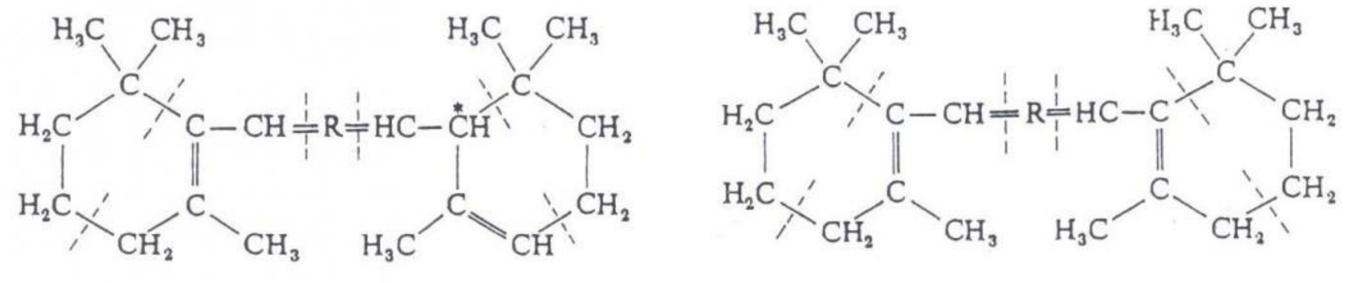

Fig.2 Structural formula of α and β carotene

the position of their double bounds *(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. *Michalik* 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 and important role (*Simon*, 1985). Some of them have been proved to have bactericidal effect. These are, for example, the l-limonen and beta-pinen that distroy *Escherichia coli* that causes the dangerous infantile diarrhoea. The beta-pinen 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 Reseach 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 óriás, Danvers*) for colour material and essential oil components.

Seeds were sown on 24 April 1997 in four repetitions.

In the course of the laboratory investigations carotenoids (among them alpha and beta carotene, lutein and violaxantin) and essential-oil components were measured.

After the appropriate sample preparation the main

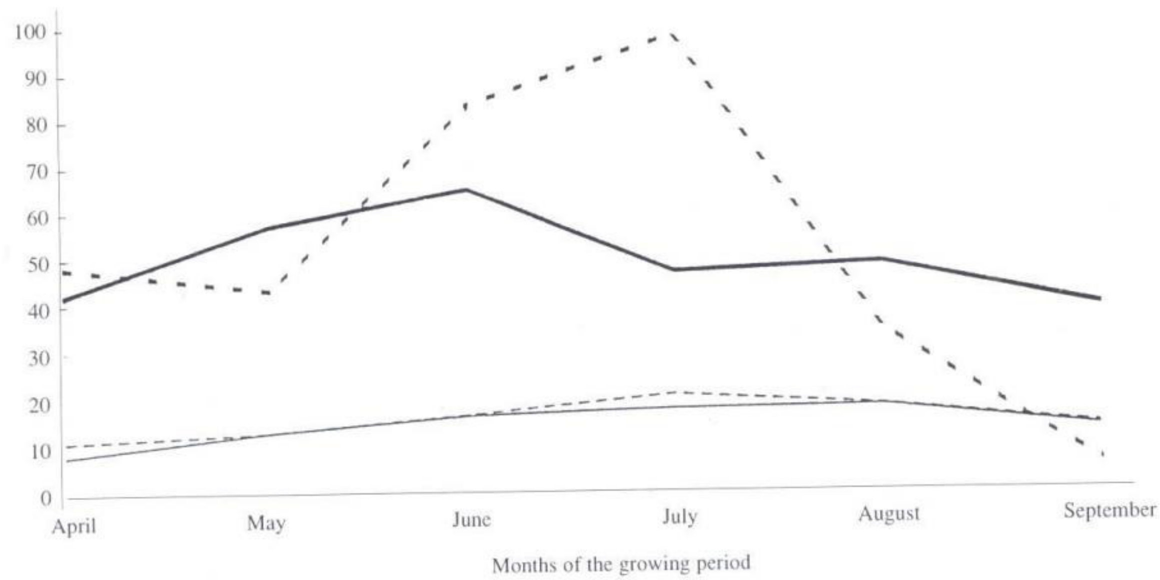

Fig. 4 Meteorological means and date of 1997, Szarvas, 1997.

colouring substance components of the carrot were determined using the HPLC method. The measurements were performed at the Central Research Institut 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 occurence 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 Forto*) represented a

Table 1 Content of colouring substance in carrot varieties and the incidence rate of their important colouring substance components Szarvas, 1997

Variety	Total colouring substance (ppm)	β carotene content (ppm)	α and β carotene	Lutein	β carotene	α carotene	viola-xantene
				in the % of the total colouring substance			
1. Nantais	171.74	104.42	84.24	3.98	60.80	23.44	0.55
2. Nantais Forto	178.02	103.32	92.49	2.94	58.04	34.45	0.40
3. Fertődi vörös	213.04	134.45	93.77	4.75	63.11	30.66	0.58
4. Vörös óriás	158.81	108.47	95.49	3.14	68.30	27.19	0.62
5. Danvers	206.45	144.39	88.26	3.90	69.94	18.32	0.63
$LSD_{5\%}$		12.14					

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

Varieties/Name of colouring substance	β carotene	α carotene
Nantais	103.25	41.49
Nantais Forto	103.32	61.33
Fertődi vörös	134.45	65.32
Vörös óriás	108.47	43.19
Danvers	144.39	37.83
$LSD_{5\%}$	12.14	NS

quantity between 170 to 180 ppm. It is evident that by the latter varieties it is their earliness 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 óriás* 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 óriás, Danvers*) this proportion was between 63–70%.

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

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

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

A / B Variety	Essential oil components		
	β-pinen	l-limonen	caryophyllen
Nantais	0.66	1.07	12.73
Nantais Forto	0.55	0.83	24.08
Fertődi vörös	1.12	1.26	17.0
Vörös óriás	0.59	2.16	25.47
Danvers	1.19	1.51	16.33
Essential oil in the average of varieties	0.82	1.36	19.14

Significant differencies:

Between two versions of 'A'	in the average of 'B' (P = 5%)	0.88
Between two versions of 'B'	in the everage 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

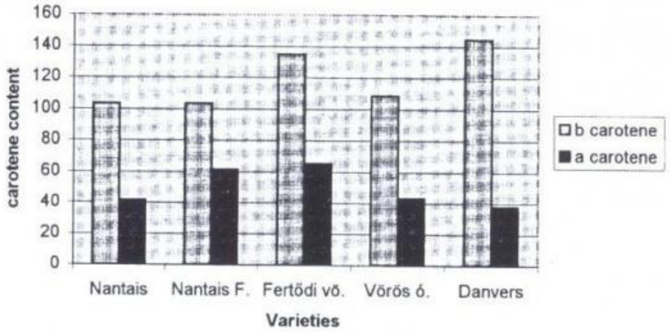

Fig. 5 Alpha- and beta carotene ontent of carrot varieties (ppm) Szarvas, 1997.

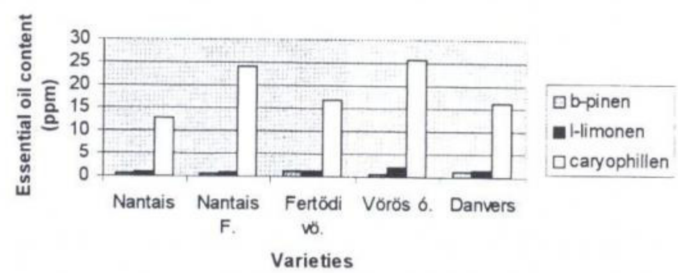

Fig. 6 Development of essential oil components of different carrot varieties on the average of four repetitions (ppm)

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