

## DETERMINATION OF THE CHEMICAL AND SENSORY CHARACTERISTICS OF SOME CARROT VARIETIES GROWN IN TURKEY

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**Abstract.** This study was conducted in Konya region where 60% of the carrot production of Turkey is realized. Eight different-colored carrot varieties were used in the study and their sensory and chemical quality characteristics were determined. It was determined that the orange-colored root varieties were preferred more than those with other colored root varieties in terms of outer and inner color, juiciness, taste and bitterness. A correlation between some sensory and chemical quality characteristics was determined. The most phenolic matter content was determined in Purple carrot (163.52 mg 10<sup>-2</sup> g<sup>-1</sup> GAE) and Bolero (orange) (155.90 mg 10<sup>-2</sup> g<sup>-1</sup> GAE) varieties. The most antioxidant activity (45.91% inhibition), dry matter content (16.77%), total sugar content (8.27 g 10<sup>-2</sup> g<sup>-1</sup>) and  $\beta$  carotene (183.01  $\mu$ g g<sup>-1</sup>) content were determined in the Maestro (orange) variety. It was determined that the orange colored was preferred more than the other colored varieties in terms of sensory features.

**Key words:** *Daucus carota*, sensory quality,  $\beta$  carotene, antioxidant activity

### INTRODUCTION

Carrot is among the most important ten vegetables in the world in terms of production areas, production rates and market value [Rubatzky et al. 1999, Fontes and Vilela 2003, Simon et al. 2008]. Today, it is cultivated worldwide and used as the source of pro-vitamin A. It also contains various vitamins, carotenoids, phenolic substances and volatile compounds [Holley et al. 2000, Alasalvar et al. 2001, Kjellenberg 2007]. It is proved that these nutrients that carrot contains act an important role in preventing various degenerative illness such as cataracts, cancer, cardio-vascular diseases, neuro-

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logical diseases which are resulted from oxidative stress [Fikselova et al. 2010]. For this reason, the consumption of vegetables that are useful for health has been increased [Elhadi 2010]. Different colored carrot varieties are now on sale in big markets. These carrot varieties show differences in terms of quality characteristics [Alasalvar et al. 2001, Kreutzmann et al. 2008]. However, there is little knowledge about these varieties in terms of sensory quality features. The quality in carrot can be measured firstly with the sensory method or secondly with chemical, mechanical and optical method. Genetic factors and environmental conditions affect the sensory quality in carrot [Seljasen et al. 2001, Rosenfeld et al. 2002, Wrzodak et al. 2012]. Precipitation, temperature, soil type, fertilizer used and different maturity phases which are among the environmental factors affect the sensory quality [De Belie et al. 2002].

Carrot is a very complex and delicious vegetable and the flavor is affected by many components. Carrot contains hundreds of terpenoid, volatile compounds and non-volatile compounds. The flavor of the carrot is affected by the sugar content, bitter compounds, volatile compounds and free amino acids. Its genetic also affects a carrot's flavor [Sulaeman and Driskell 2010]. Other factors that affect the flavor of the carrot are the location, climate (temperature, light, etc.), soil type and cultivation method [De Belie et al. 2002, Sulaeman and Driskell 2010].

Consumer preference generally increases with the decreasing levels of the volatile compounds that cause a bitter taste in the carrot and with the increasing level of sugar. On the contrary, the bitter taste increases with the decreasing level of sugary compounds and with the increasing level of volatile compounds [Suojala and Tupasela 1999]. It has been reported in the studies related with the flavor of the carrot that there is a correlation between the chemical and sensory analyses [Alasalvar et al. 2001, Kjeldsen et al. 2003]. The purpose of this study is to determine the sensory and chemical characteristics of eight different root-colored carrot varieties; examine the effect of the sensory and chemical characteristics on the consumer preferences and to find the correlation between sensory and chemical characteristics.

## MATERIAL AND METHODS

**Experiment.** The experiment were conducted in 2010 and 2011 in Konya Karapınar District, Soil, Water and Desertation Research Station Center according to random block design in three recurrences. The station that the experiment was conducted in 37°42'45.43" north latitude and 33°31'33.30" east longitude.

Orange root colored Nantindo, Maestro, Bolero, Berlikum, Amsterdam 2, Tarenco F<sub>1</sub>; orange-red root colored Paris market; yellow root colored Yellow inter; and purple root colored Purple carrot varieties were used in the experimentation period. It was established in a way that there was 10 cm interrow and 2 cm in a row between the seeds, with 3 rows and 150 roots in a square meter. The dropping irrigation system was used in the experimentation.

The roots were collected during the harvest in the 0.5 m<sup>2</sup> of each parcel after the edge effects were performed. The harvest was performed on the 8–9 October 2010/2011 and the carrot samples were collected in such a design that would include six roots in

each recurrence to represent all the plants in the parcel. The total phenolic substance, antioxidant activity, total dry matter, total sugar and  $\beta$  carotene contents were examined. In addition, twenty first class samples from each variety collected for the sensory quality analysis were stored in cold air storages for 10 days at 0–1°C storage temperature with 99% humidity.

**Sensory quality analysis.** The carrots were washed, peeled. 1 cm area was removed from crown and tip of each carrot. Each panelist was served with the carrot samples cut in 1–2 cm<sup>3</sup> slices in white plastic plates at room temperature.

For introducing the scale to the participants, each feature was handled separately and assessed with regard to category scale low (0) and high (9) (tab. 1). Assessments for each year were carried out in a session that took two hours by the six estimators who were trained with regard to ISO 8586-1 [1993]. The assessments were performed at room temperature (20°C) in separate cabinets. Each portion was served in random order. All samples were assessed 3 times by all the participants.

Table 1. Description of the comments on sensory attributes of carrots [Haglund et al. 1999, Da Silva et al. 2007]

Sensory features		Recognition and interpretation
External root color	color density	low color = 0, high color = 9
Internal root color	color density	low color = 0, high color = 9
Juiciness	water released from grated carrots while chewing the sample	little juice = 0, much juice = 9
Crispness	according to crispness sense	little crisp = 0, very crisp = 9
Taste	the intensity of the taste of carrot	tasteless = 0, very tasty = 9
Sweetness	the intensity of sweetness	little sweet taste = 0, very sweet taste = 9
Bitterness	the intensity of bitterness	little bitter taste = 0, very bitter taste = 9

**Chemical quality analysis.** The determination of the total phenolic substance content was performed according to the Folin-Ciocalteu colorimetric method and the results were recorded as mg 10<sup>-2</sup> g<sup>-1</sup> GAE fresh carrot [Slinkard and Singleton 1977]. In determining the antioxidant activity, 1 mL was taken from 10<sup>-3</sup> M DPPH from the solution of ethanol and 3 mL extract solution was added and shaken violently with vortex. It was kept in darkness for 30 minutes and the absorbance value was read in 517 nm. The results were reported as the percentage of DPPH (1.1-diphenyl-2-picrylhydrazyl) inhibited by 1 g fresh carrot/10 ml ethanol extract [Gyamfi et al. 1999]. In determining the  $\beta$  carotene content, 50 ml petrol ether and 50 ml acetone were added to 20 g carrot pulp sample and mixed than went through separation funnel. The extract was taken to the separation funnel again and the acetone layer was removed and the remaining extract was washed with pure water for 2–3 times and then dry Na<sub>2</sub>SO<sub>4</sub> was applied to remove the pure water from the extract. As the last process, the extract was completed to 100 mL with petrol ether and the absorbance degree was read in spectrophotometer in 452 nm and the  $\beta$  carotene amount was calculated [Yanmaz et al. 1995]. The total sugar analysis was performed according to the Loof-Schoorl method and the results were

expressed as  $\text{g } 10^{-2} \text{ g}^{-1}$  [Cemeroğlu 1992]. To determine the dry matter amount, the roots were grated homogenously and 10 g samples were kept in 70°C vacuumed incubator until the weight was stable and the dry matter amount was determined in percentage. The statistical data analyses were performed by using the JAMP package program. The data were adjusted by analysis of variance by ANOVA test. The significance of differences between mean values was tested using Tukey's Honestly Significant Difference test (HSD) at  $\alpha = 0.05$ . We also estimated the Pearson correlations among adjusted characteristics.

## RESULTS AND DISCUSSION

In our study, the sensory quality features of eight carrot varieties with different root colored grown in Turkey and affect the consumer preferences were determined, and the differences between the varieties that affect the consumer preference in terms of quality characteristics were determined. The varieties with orange colored received the highest scores in terms of sensory characteristics of outer and inner color (tab. 2). Bolero that is among the orange-colored carrot varieties was the mostly preferred variety in terms of both characteristics (8.42; 8.17 respectively). The Nantindo, Maestro and Tarenco F<sub>1</sub> varieties that have the same root color followed this variety. The Purple carrot, Paris market and Yellow inter formed a separate group and were the last ones in terms of consumer preference. A relation with  $r = 0.68$  was determined between the inner and outer color. Da Silva et al. [2007] strong relation  $r = 0.80$  is determined between inner and outer color in his work which studies the different carrot varieties' sensory features. A positive correlation of  $r = 0.63$  was determined between the inner color and the  $\beta$  carotene and also  $r = 0.52$  between the outer color and  $\beta$  carotene. This situation may be explained as the  $\beta$  carotene having a positive effect on the color perception.

Table 2. Sensory quality features of different colored carrots

Variety	Outer color	Inner color	Juiciness	Crispness	Taste	Sweetness	Bitterness
Nantindo	7.50 ab	7.92 ab	7.42 ab	7.92 a	7.67 ab	7.08 a	3.83 ac
Maestro	7.42 ac	8.08 ab	7.75 ab	7.75 ab	7.92 a*	7.83 a *	2.83 c
Bolero	8.42 a*	8.17 a*	6.75 ac	7.50 ac	7.58 ab	6.75 a	2.50 c
Tarenco F <sub>1</sub>	7.50 ab	7.50 ab	7.42 ab	7.17 ac	6.92 ac	7.50 a	3.58 bc
Berlikum	7.42 ac	6.42 b	6.67 ac	7.00 ac	6.17 ac	6.17 ab	2.92 c
Amsterdam 2	7.33 ac	7.33 ab	8.08 a*	8.33 a*	6.00 bd	6.83 a	5.25 ab
Paris market	5.33 bc	4.17 c	5.08 c	5.92 ac	4.25 ed	5.42 ab	5.17 ab
Yellow inter	5.25 c	3.42 c	4.83 c	5.42 bc	3.42 e	3.75 b	6.00 a*
Purple carrot	5.50 bc	4.67 c	5.67 bc	5.17 c	5.67 cd	6.00 ab	5.17 ab

\* Means within a row with the same superscripts are not significant ( $P \leq 0.05$ )

It was determined that the most preferred carrot variety in terms of juiciness and crispness was the Amsterdam 2 (8.08; 8.33 respectively) (tab. 2). Nantindo and Maestro

varieties with orange-colored roots were determined as the most liked varieties. Paris market and Yellow inter were the least preferred varieties in terms of juiciness feature and the Purple carrot was the least preferred carrot variety in terms of crispness. A high relation between crispness and juiciness was determined with  $r = 0.70$ .

Flavor is one of the very important total quality features. Consumers usually prefer sweet edible carrots without bitterness [Karkleliene et al. 2012]. It was determined that the most preferred variety in terms of taste and sweetness was the Maestro (7.92, 7.83 respectively) (tab. 2). It was also determined that the Yellow inter variety was the least preferred in terms of both features. A relation was determined between the taste and juiciness with  $r = 0.65$ ; and between the taste and crispness with  $r = 0.51$ . A high relation was determined between the sweetness and taste with  $r = 0.74$ ; and between sweetness and juiciness with  $r = 0.63$ . In his study Haglund et al. [1999] found a positive correlation between sweetness and taste with  $r = 0.57$ . A positive correlation between taste and total sugar content was found with  $r = 0.46$ ; and between sweetness and total sugar content with  $r = 0.42$ . Seljasen et al. [2001] reported a correlation between total sugar content and taste with  $r = 0.51$  which shows parallelism with our study.

It was determined that the highest score in terms of bitterness was received by the Yellow inter variety (tab. 2). Yellow inter was preferred the least in terms of sweetness and taste. A negative correlation was found between the bitterness and taste; bitterness and sweetness with ( $r = -0.40$ ,  $r = -0.24$  respectively). Da Silva et al. [2007] reported in their studies that there was a negative correlation between the bitterness and sweetness with  $r = -0.24$ . A negative correlation between the bitterness and total sugar was determined with  $r = -0.55$ . It was also determined that the most preferred varieties were Bole-ro and Maestro with their orange colors in terms of taste, sweetness and bitterness.

The highest total phenolic matter content was determined in Purple colored carrot ( $163.52 \text{ mg } 10^{-2} \text{ g}^{-1} \text{ GAE}$ ). In other yellow and orange colored carrots, it was determined that this amount changed between  $74.22\text{--}155.90 \text{ mg } 10^{-2} \text{ g}^{-1} \text{ GAE}$  (tab. 3). In our study, like in other studies, it was determined that the purple colored carrot contains more phenolic matter than the other colored carrot varieties [Nicole et al. 2004]; and other colored carrot varieties that do not contain anthocyanin have less phenolic matter [Kramer et al. 2012]. A strong relation between the purple color density and phenolic matter content was determined [Nicole et al. 2004]. The reason for the purple colored carrot having rich phenolic matter content is not only due to its having anthocyanin but also due to its having more polyphenolic compounds such as chlorogenic acid, caffeic acid than the other colored carrot varieties [Grassman et al. 2007]. According to the results of our study, which show parallelism with the other previous studies, significant difference was determined between the different colored carrot varieties in terms of total phenolic matter content [Alasalvar et al. 2001, Kreutzmann et al. 2008, Sun et al. 2009, Gajewski et al. 2010, Kramer et al. 2012].

A significant difference was determined between the carrot varieties in terms of antioxidant activity and the highest activity was determined in Maestro variety (tab. 3). Purple colored carrot contains high phenolic matter and for this reason it shows high antioxidant activity [Alasalvar et al. 2005, Gajewski et al. 2007]. It was observed that the variety that has high total phenolic substance content also has high antioxidant activity. A high correlation was determined between the total phenolic substance content and

antioxidant activity with  $r = 0.80$ . A similar relation was determined in other studies [Kaur and Kapoor 2002, Stintzing et al. 2002, Song et al. 2010].

Table 3. Chemical compound features of the different colored carrot varieties

Variety	Total phenolic substance ( $\text{mg } 10^{-2} \text{ g}^{-1} \text{ GAE}$ )	Antioxidant activity (%)	Dry matter (%)	Total sugar ( $\text{g } 10^{-2} \text{ g}^{-1}$ )	$\beta$ carotene ( $\mu\text{g g}^{-1}$ )
Nantindo	97.32 cd	37.07 e	14.40 c	7.48 b	170.91 b
Maestro	138.12 b	45.91 a*	16.77 a*	8.27 a*	183.01 a*
Bolero	155.90 a	44.79 ab	16.00 b	7.50 b	163.51 b
Tarenco F <sub>1</sub>	79.53 ef	34.10 f	10.25 g	6.65 c	117.04 c
Berlikum	92.76 cd	41.05 c	13.38 d	7.58 b	115.91 c
Amsterdam 2	98.48 c	38.54 de	12.62 e	6.62 c	100.04 d
Paris market	88.19 de	39.22 cd	14.45 c	7.42 c	124.29 c
Yellow inter	74.22 f	35.00 f	11.45 f	6.23 d	87.49 e
Purple carrot	163.52 a*	43.48 b	15.82 b	7.62 b	97.89 d

\* – means within a row with the same superscripts are not significant ( $P \leq 0.05$ )

Among the carrot varieties that were examined in terms of dry matter, total sugar and  $\beta$  carotene content, the Maestro variety was determined to have the highest amounts (tab. 3). Significant differences were found among the carrot varieties in terms of dry matter content. The dry matter content varied between 10.25–16.77% among different colored carrot varieties. The total sugar content varied between 6.23–8.27  $\text{g } 10^{-2} \text{ g}^{-1}$ . Half of the dry matter content of the carrot is the soluble sugar. The sugar content varies between 30–70% of the dry matter [Suojala 2000]. It has been reported that there is a strong relation between the total dry matter content and the sugar content [Gajewski et al. 2009]. As parallel to previous studies, it is determined in our study that there is a strong relation between the total dry matter content and the total sugar content with  $r = 0.74$ , and a very strong relation between the total dry matter and total phenolic matter and the antioxidant activity (respectively  $r = 0.78$ ;  $r = 0.82$ ).

The total carotene content is closely related with the root color [Baranski et al. 2012]. The highest  $\beta$  carotene content was observed in orange-colored carrot firstly, and then in orange-red colored, and in purple and yellow carrot varieties (tab. 3). The orange-colored carrots contain 141.74  $\mu\text{g g}^{-1}$   $\beta$  carotene content in average, and the yellow and purple colored carrots contain 30% less than this amount. A strong relation was determined between total  $\beta$  carotene content and total sugar content with  $r = 0.70$ . Meanwhile, a relation between the  $\beta$  carotene content and the total dry matter content with  $r = 0.56$ .

## CONCLUSIONS

The varieties with orange colored roots were preferred more in terms of outer and inner colors, juiciness and taste which are among sensory characteristics. This situation shows that the characteristics of the varieties affect the sensory quality. It is also determined that there are important differences between the carrot varieties with different root colored in terms of quality characteristics. The Maestro and Bolero varieties among carrots with orange-colored roots were determined to be the prominent varieties in terms of sensory and other quality characteristics.

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## OKREŚLENIE CHEMICZNYCH I SENSORYCZNYCH CECH NIEKTÓRYCH ODMIAN MARCHWI UPRAWIANEJ W TURCJI

**Streszczenie.** Badanie przeprowadzono w rejonie Konya, gdzie produkuje się 60% tureckiej marchwi. W badaniu zastosowano osiem odmian marchwi o różnej barwie, określając ich cechy chemiczne i sensoryczne. Stwierdzono, że odmiany o pomarańczowym korzeniu są preferowane w porównaniu z odmianami o innej barwie jeśli chodzi o barwę, soczystość, smak i gorzkawy posmak. Określono korelację między niektórymi cechami chemicznymi i sensorycznymi. Największą zawartość fenoli stwierdzono w marchwi Purple (163,52 mg 10<sup>-2</sup> g<sup>-1</sup> GAE) i Bolero (pomarańczowa) (155,90 mg 10<sup>-2</sup> g<sup>-1</sup> GAE). W odmianie Maestro (pomarańczowa) stwierdzono największe działanie antyoksydacyjne (45,91% inhibicji), zawartość suchej masy (16,77%), całkowitą zawartość cukrów (8,27 g 10<sup>-2</sup> g<sup>-1</sup>) i β karotenu (183,01 μg g<sup>-1</sup>). Stwierdzono, że w kategoriach cech sensorycznych odmiany pomarańczowe były lepiej oceniane od odmian o innej barwie.

**Słowa kluczowe:** *Daucus carota*, jakość sensoryczna, β karoten, działanie antyoksydacyjne

Accepted for print: 5.07.2016

For citation: Kiraci, S., Padem, H. (2016). Determination of the chemical and sensory characteristics of some carrot varieties grown in Turkey. *Acta Sci. Pol. Hortorum Cultus*, 15(6), 139–147.