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PURPLE CARROT LINES HAS SUPERIOR TECHNOLOGICAL CHARACTERISTICS IN TURKEY

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Abstract. The purple carrot population, which is cultivated commonly in Konya region in Turkey for industrial purposes, was used. Different types of purple carrots were collected in order to have a gene pool, and they were subjected to selection according to the characters studied. The experiment was carried out in a Randomized Blocks Trial Design in a 3-recurrent using 22 inbred lines of purple carrot during 2009–2012. As for average yield, Eregli 1 was the highest (11.54 t·ha^{-1}) whereas Eregli 14 was the lowest (9.27 t·ha^{-1}). A correlation between some physical and chemical quality characteristics was determined. In carrot samples, the amount of dry matter was 12.63–16.30%, total sugar content was 7.13–9.67 g·100 g^{-1}, the amount of β-carotene was 117.17–249.55 μg·g^{-1}, the amount of anthocyanin was 272.0–596.2 μg·g^{-1}, the amount of total phenolic 155.83–206.67 mg·10^{-2} g^{-1} GAE, and antioxidant activity ranged from 31.85 to 44.20%. At the end of the study, the Eregli 9 and Eregli 10 lines were determined as hopeful lines, and Eregli 4 and Eregli 16 lines were determined as being cultivar candidate lines.

Key words: *Daucus carota*, quality characteristics, physical properties, selection, yield

INTRODUCTION

Although carrot farming is widespread in many areas, they are more widely farmed in northern hemisphere [Swingle 1946]. Carrot is among the most important ten vegetables in the world in terms of production areas, production rates and market value [Simon 2000]. 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]. The chemical composition of carrot roots is affected by cultivar and agricultural practices [Majkowska-Gadomska and Wierzbicka 2010].

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Sugar and carotenoid contents in carrot roots are important quality parameters. Sugars are the main storage compounds in carrot; they account for 35–70% of dry weight of the roots and are stored in the vacuoles of the parenchyma [Gajewski et al. 2009]. Growing season and storage conditions affect the content of sugars in carrots [Suojala 2000]. β-carotene accounted for 44–79% of the total carotenes [Simon and Wolff 1987]. Skrede et al. [1997] found that high carotenoid content results in a more reddish and darker colour of the roots. Carotenoid content in carrots increases gradually with the maturation process [Gajewski et al. 2009]. The carotenoid content is enhanced by the large differences in temperature between night and day. Temperature was the most important factor determining chemical quality of carrot, whereas for morphological features like root weight, root length and diameter measurements, light was more important than temperature [Sękara et al. 2012].

The first carrot types cultivated by humans were purple or violet [Gajewski et al. 2009]. Different colored carrot varieties show differences in terms of quality characteristics. Purple carrot population is an important source of anthocyanin. Anthocyanin, which is a powerful colouring item, is used as a colourant in foods and medicine preparation. Anthocyanins are classified among the phenolic compounds, which are called flavonoids [Barczak 2005]. According to Alasalvar et al. [2005] purple coloured carrots contain higher amount of phenolics, mainly anthocyanin, and show higher antioxidant capacity.

It has been reported that purple carrot anthocyanin is used as a natural colourant in jelly, candy, jam, canned foods, and frozen desserts [Ersus and Yurdagel 2007]. Due to the reasons stated above, the importance of the vegetables with economic value has increased, and so have the relevant studies. Nearly 120 000 tons of carrots are grown in 2500 hectares in Eregli, a district of Konya, which has an important place in purple carrot farming in Turkey (TUIK 2014). Overall, 50 000 tons of this is exported to mainly France, Germany, Italy and Denmark, as well as to Japan and Korea in the Far East.

The use of improved seeds in agriculture will bring benefits to agricultural institutions and to the economies of the countries. The purpose of this study is to form a gene pool by collecting different types of purple carrots mainly used in industry and widely grown in Konya and its vicinity, to perform a selection of the types in this pool in terms of characters, and to determine the carrot lines that contain anthocyanin, sugar, antioxidant activity in high amounts, which will be used in the industry.

MATERIALS AND METHODS

The practise has been constructed in Konya Land Water and Combat Desertification Research Station. Eregli Region in the city of Konya was scanned to determine the purple carrot lines used as plant material in February 2008. The research station that the experiment was conducted in 37°48’17.84” north latidude and 32°30’44.67” east longitude. After the scanning, the carrots that met our selection criteria were collected and registered as 22 lines. Breeding study was carried out according to the method of mass selection. In giving numbers to the lines, the first letter of the district Eregli (E) was taken as the basis and then the registration numbers were added. Since the carrot is a two-year plant, the root production was performed between 2009–2010 (1st growing season data) and 2011–2012 (2nd growing season data). According to the root-to-seed method, the seed production was carried in 2008–2009 and 2010–2011 growing season. The experiment was constructed according to the randomised blocs design in a 3-replicates where in one replication there were grown 500 plants of each line of carrot. The seeds were sown by hand on 11 May 2009 and 14 May 2011. The soil was loamy in texture with a pH value of 8.43%. The organic matter, phosphorus, potassium, iron, copper, and manganese content of the experimental plot were 0.64%, 0.57 $kg \cdot ha^{-1}$, 23.70 $kg \cdot ha^{-1}$, 3.63 ppm, 1.1 ppm, 4.75 ppm soil respectively. Side action consisting of two rows was formed before the first line planting and after the last line planting. A distance of 50 cm was left between the replicates, and a 150 cm distance was left between the rows. During the harvest time, the samples were collected by leaving 50 cm side action. Intercultural operations likes thinning, weeding, irrigation, insects and pest management were done when necessary to facilitate optimum crop growth. The harvest was made on 11 November 2009 and 6 November 2011. Climate data for the years of production were given in Table 1.

Table 1. Climate data for the period of production [Turkish State Meterogical Service 2012]

	Years	May	June	July	August	September	October
Mean temperature (°C)	2009	14.1	20.2	22.4	20.9	16.3	13.9
	2011	13.3	18.6	24.3	21.8	17.9	9.7
Maximum temperature (°C)	2009	20.7	28.2	29.3	28.6	23.7	22.7
	2011	19.5	25.1	31.1	28.7	25.4	16.7
Minimum temperature (°C)	2009	6.4	10.6	14.8	12.2	8.5	5.9
	2011	7.3	11.6	16.5	14.0	9.8	3.0
Sum of rainfall (mm)	2009	39.8	5.6	13.6	0.0	0.3	2.4
	2011	68.2	30.8	0.0	0.4	0.0	6.8

Ten plants from each of replication were measured for root weight (g), root length (cm) and root diameter (mm). To determine the yield to hectare (ha^{-1}) of the lines used in the study, the yield of each population collected from plots were converted to yield to hectare values given in $t \cdot ha^{-1}$.

To determine the dry matter in %, the roots were grated homogenously and a 10 g samples were kept in vacuum oven in 70°C and were dried to the constant weight. The total sugar analysis was performed according to the Loof-Schoorl method, and the results were recorded in $g \cdot 100\ g^{-1}$ [Cemeroglu 1992]. In determining the β-carotene content, 50 ml petrol ether and 50 ml acetone were added into 20 g carrot pulp sample, and then it was passed through a separation funnel. As the last process, the carotene amount was calculated by adding petrol ether to the extract so it became 100 ml in total, and then the absorbance value was read as 452 nm in spectrophotometer [Yanmaz et al. 1995]. The total anthocyanin amount in the roots was measured by using the pH difference method. The extracts were prepared in pH 1.0 and 4.5 solutions, and measured in 533 and 700 nm wavelengths. The total anthocyanin amount was calculated with the [(A520–A700) pH 1.0-(A520–A700) pH 4.5] formula [Giusti et al. 1999]. The determination of total phenolic amount was performed according to the Folin-Ciocalteu colorimetric method, and the results were registered as 10^{-2} g^{-1} GAE fresh carrot [Slinkard and Singelton 1997]. The antioxidant activity analysis was performed according to the DPPH method, and the results were reported as (1.1-diphenyl-2-picrylhydrazyl) percentage of the DPPH inhibited by 1 g fresh carrot l^{-2} ethanol extract ($g \cdot l^{-2}$) [Gyamfi et al. 1999]. The statistical analysis of the data obtained during the study was performed by using the JAMP package programme. The differences between the average values were analysed with the ANOVA test. We also estimated the Pearson correlations among adjusted characteristics.

RESULTS AND DISCUSSION

In terms of the yield, the difference between the lines was found as statistically significant in 2009–2010 growing season and in 2011–2012 growing season. When table 2 is examined, it can be observed that the average yield of the first growing season is 10.91 $t \cdot ha^{-1}$ and the average yield is of the second growing season is 10.21 $t \cdot ha^{-1}$. The yield values of the 1st growing season change between 8.43 $t \cdot ha^{-1}$ and 12.62 $t \cdot ha^{-1}$; while the yield values of the 2nd growing season change between 9.29–11.19 $t \cdot ha^{-1}$. In China, the total yield of the hybrid Tianhong 1 cultivar, which was obtained with the cross-breeding techniques of the HLBm001 and HLBcms001 male sterile line with inbred line between the years 1996 and 2002, was found as 5.15 $t \cdot ha^{-1}$ [Changzhi et al. 2003]. In a study conducted in Lithuania with 2 hybrid lines and 5 breeding lines, the total lowest yield was found in 1859 F_1 breeding line as 4.97 $t \cdot ha^{-1}$, and the total highest yield was found in 2030 F_1 breeding line as 6.40 $t \cdot ha^{-1}$ [Karkleliene et al. 2008]. It was reported from China that the total yield of the improved Jinhong No. 5 cultivar, which was improved with male sterile technology was 7.50 $t \cdot ha^{-1}$ [Yuanmin et al. 2008]. In a trial study conducted in Lithuania to compare the first hybrid cultivar Svalia of this country in terms of yield and quality parameters with 10 breeding lines, the yield was reported as varying between 4.62 $t \cdot ha^{-1}$ and 6.89 $t \cdot ha^{-1}$, and it was also reported that the lines were very sensitive to environmental conditions [Karkleliene et al. 2009]. When the yield values are compared with the information in the literature, it is clear that the yield of the purple carrot population tested in experiment is higher.

When the yield values are examined, it is observed that the variation coefficient growing season 2009–2010 is high and therefore the difference between the lines in terms of yield is higher as well. In the 2011–2012 growing season, however, it is observed that the difference in terms of the yield decreased in 2011–2012 growing season. In the 1st growing season of the trial study, the fact that there is a difference of 4.19 $t \cdot ha^{-1}$ between the highest and lowest yielding lines shows that our study on this population is very important. The difference between the lines in terms of yield might be due to the genetic properties, and the difference between the years might be due to the environmental conditions. Growing conditions such as heat, moisture of the soil, rainfall, the intensity of the light, and the length of the days are among the major factors that affect the yield [Manosa 2011]. The fact that there are differences between the years as well as between the lines shows that genotype and environmental factors are influential on the yield.

Table 2. Yield, root weight, root length, root diameter and dry matter datas in 2009–2010 and 2010–2011 growing seasons

Lines	Y (t·ha^{-1})		RW (g)		RL (cm)		RD (mm)		DM (%)	
	2009*	2011**	2009	2011	2009	2011	2009	2011	2009**	2011**
E1	12.17ab	10.91ab	152.2	127.9	22.0	19.6	52.3	38.9	13.50hı	12.53ef
E2	10.66ae	11.19a	149.4	137.0	24.5	20.3	42.6	39.0	15.57ac	15.37ac
E4	12.62a	10.66ad	157.8	133.0	24.4	20.9	50.3	40.3	15.07cf	15.00ad
E5	11.61ac	10.68ac	145.1	133.6	23.9	20.9	42.5	38.8	14.40fg	15.23ac
E6	12.00ab	10.06de	149.2	127.1	22.4	20.1	43.6	38.8	13.83gh	15.90ab
E7	10.55ae	10.25ce	131.9	129.6	21.7	21.3	40.3	38.2	15.17be	14.27be
E8	9.58ce	10.19ce	119.8	131.0	23.5	19.8	42.3	39.6	13.17hı	12.10f
E9	11.05ad	9.90ef	138.7	123.7	26.2	19.5	43.7	38.8	16.03ab	16.57a
E10	11.75ac	9.92e	146.6	125.9	23.4	20.3	45.5	36.3	14.77df	15.17ac
E11	11.73ac	9.29f	146.7	125.8	22.9	19.8	51.7	37.3	15.33ad	13.20df
E12	9.52ce	10.32be	135.6	129.8	24.1	19.8	44.3	38.4	15.70ac	14.77ad
E13	11.79ac	10.03e	147.3	129.2	22.9	20.0	44.6	36.6	15.07cf	14.93ad
E14	8.43e	10.12ce	119.6	132.4	20.8	19.9	38.7	40.2	13.03ı	15.80ab
E15	10.66ae	9.86ef	133.3	123.2	25.1	19.6	41.1	35.9	14.47eg	16.13ab
E16	11.51ac	10.05de	143.9	120.7	24.1	20.5	45.0	38.8	14.43eg	13.80cf
E17	9.14de	9.91e	114.2	123.9	23.5	20.1	38.9	37.4	15.50ad	13.73cf
E18	10.87ad	10.03e	129.9	121.0	20.8	19.7	44.1	37.1	16.10a	12.57ef
E19	9.90be	10.27ce	116.0	127.3	19.3	20.7	34.3	41.6	15.43ad	15.30ac
E20	11.26ad	10.39be	140.7	130.6	26.6	20.0	44.4	36.2	13.37hı	16.13ab
E21	11.95ab	10.07de	149.4	130.0	21.8	20.1	45.9	39.5	13.27hı	15.37ac
E22	10.26be	10.35be	142.9	129.3	25.3	20.9	42.8	38.8	14.77df	14.73ad
Avg.	10.91	10.21	138.6	128.2	23.3	20.2	43.8	38.4	14.67	14.70
LSD	0.05 = 2285.3	0.01 = 615.81	ns	ns	ns	ns	ns	ns	0.01 = 0.76	0.01 = 1.85

*, **, ^{ns} – difference between the average values is important at 5 and 1% of error level; ns – not significant; Y – yield; RW – root weight; RL – root lenght; RD – root diameter; DM – dry matter

In the variance analysis performed to determine the differences in the root weight, root length, and root diameter, all of the lines in the growing seasons 2009–2010 and 2011–2012 are observed within the same group, and no statistical differences are determined (tab. 1). The root weights of lines are ranged between 114.2–152.2 g; in 1st growing season, while in 2nd growing season between 120.7–137.0 g. In terms of root weight, the lines of Eregli 2 and 4 taking place in the first rows also took place in the first group in term of total yield. It was reported in earlier studies that the root weight values of carrot cultivars varied between 48.0–182.0 g [Changzhi et al. 2003, Gupta and Verma 2007, Amin et al. 2012].

When the root length values of the lines are considered, it is observed that the average root length of the 1st growing season is 23.3 cm and the average root length of the 2nd growing season is 20.2 cm. The root length of lines are ranged between 19.3–26.2 cm in 1st growing season, while in 2nd growing season between 19.5–21.3 cm. Karkleliene et al. [2009] in their trial study, determined the shortest root length value as 18.0 cm and the highest root length value as 26.8 cm. In Tokat conditions in the study, in terms of root length, the Purple carrot and Cosmic purple statistically took place in the first group and it was reported that the root lengths ranged between 3.1–21.0 cm [Sekerci 2010].

In terms of root diameter, it was identified that the line of Eregli 4 is between the larger root diameter lines. The average root diameter of lines is observed that the average root diameter of the 1st growing season is 43.8 mm and the average root diameter of the 2nd growing season is 38.4 mm. Researchers reported that average root diameter varied between 21.3–45.0 mm [Singh et al. 2002, Vieira et al. 2012]. The highest positive and significant correlation was calculated between yield and root weight (r = 0.68); root diameter (r = 0.58) and in addition between root length and yield (r = 0.30). The results indicated that the larger root weight and root diameter is increased in yield. Similar findings were reported in different studies [Singh et al. 2005, Yadav et al. 2009]. Also root weight and root diameter can be recommended as the most important selection criteria to increase the yield of carrot.

Root weight was positively and significantly correlated with root diameter (r = 0.76), and moderate correlated root length (r = 0.44). Root length showed moderate positive correlation with root diameter (r = 0.42).This was in confirmation with the findings of other scientists [Tewatia et al. 2000, Santos et al. 2005, Vikas et al. 2010].

The differences between total dry matter, total sugar, beta carotene, anthocyanin, total phenolics, and antioxidant activity values the lines are statistically significant 2009–2010 and 2011–2012 growing seasons (tabs 2, 3). Among purple carrot lines, total dry matters are ranged between 13.03–16.10% in 1st growing season, while in 2nd growing season between 12.10 and 16.57%. The highest content of dry matter is determined in line Eregli 9 (16.03–16.57%). Fikselova et al. [2010], Gajewski et al. [2010], Karkleliene et al. [2009], Kreutzmann et al. [2008] reported that the dry matter contents of the carrots varied between 7.96% and 14.58%. It is observed that the dry matter values obtained in our study are in accordance with the values reported in the literature.

It is also observed that while the total sugar contents vary between 6.83 g·100 g^{-1} and 10.63 g·100 g^{-1} in the 1st growing season, they vary between 7.27 g·100 g^{-1} and 9.67 g·100 g^{-1} in the 2nd growing season. The sugar content of the carrot is controlled by one single gene. It has been reported that the genetic factor in terms of sugar content is 40–45%. The dry matter and sugar contents in vegetables vary due not only to the soil properties and growing season but also to the amount of the minerals and cultivars of the vegetables [Alasalvar et al. 2001, Barański et al. 2012]. In the 1st growing season of the trial study, three lines have been observed with the highest sugar contents, while in the 2nd growing season, only one of these three lines (Eregli 13) have been among the lines with the highest sugar content. This fact shows the effect of the growing season on the sugar content. Also, it was identified that there was a low correlation between total sugar contents and dry matter (r = 0.16). There was a non-significant negative correlation between total sugar and yield (r = -0.21), and likewise anthocyanin content (r = -0.18).

Among purple carrot lines, β-carotene contents are ranged between 97.77–358.07 μg·g^{-1} in 1st growing season, while in 2nd growing season between 116.83–239.80 μg·g^{-1}. Alasalvar et al. [2001] reported that the carotene content depended on the type of the carrot, its growing conditions, the growing season and the part of the plant where the sample was taken. Although the climate has an important effect on the carotene content, the soil type and genetic factors have also great effects. Fikselova et al. [2010] reported that excessive irrigation and excessive rain decreased the dry matter content and affected the β-carotene content negatively.

tab. 3

Rubatzky et al. [1999] reported that the optimum carotene synthesis was between 15ºC and 21ºC. In the first and second growing seasons of the trial study, the lines with the highest difference in β-carotene content and the fact that July, August, and September were hotter than usual in the second growing season of the study show how important the growing season is for the β-carotene content. These findings support the findings of the studies that report that the β-carotene amount in carrot types in the Konya region vary between years [Bozalan and Karadeniz 2011]. A positive and significant correlation was determined between β-carotene content and total sugar content with r = 0.61. β-carotene was a low correlation with the total dry matter content (r = 0.24) and was a non-significant negative correlation between yield (r = -0.14). Similar association in carrot was also reported by Kidmose et al. [2004].

It is also observed that while the anthocyanin contents of the 1^{st} growing season vary between 223.40–816.57 $\mu g \cdot g^{-1}$, the anthocyanin contents of the 2^{nd} growing season vary between 284.93–461.10 $\mu g \cdot g^{-1}$. The properties of the colouring items in the black carrot were examined in a study and the total anthocyanin content was found as 306 $\mu g \cdot g^{-1}$ [Uysal 2000]. Alasalvar et al. [2005] reported in his study, at the harvest of the anthocyanin content was found as 510 $\mu g \cdot g^{-1}$and then it decreased gradually. Singh et al. [2012] conducted a study with purple, orange, yellow, and white carrots and determined that the highest anthocyanin content was in Purple Dragon with 390–940 $\mu g \cdot g^{-1}$. They also reported that the genotype*application interaction is effective on the enhanced anthocyanin content in carrot. These findings match up with the findings of our study.

In both growing seasons of study, the content of the highest the total phenolics and antioxidant activity are obtained from Eregli 17 lines. Among purple carrot lines, total phenolic matter and antioxidant activity are ranged between 146.37–208.67 $mg \cdot 10^{-2}$ g^{-1} GAE; 26.27–47.50% in 1^{st} growing season, while in 2^{nd} growing season between 142.67–204.67 $mg \cdot 10^{-2}$ g^{-1} GAE; 30.90–40.90%. A strong relation between the purple color density and phenolic matter content was determined [Nicole et al. 2004]. 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 is observed that the lines that have high phenolic matter content also have high antioxidant activity. A high correlation was determined between the antioxidant activity and total phenolic matter content with r = 0.62. A similar relation was determined in other studies [Song et al. 2010, Bozalan and Karadeniz 2011]. In the present study, antioxidant activity was negative and significantly associated with β-carotene (r = -0.45), and sugar contents (r = -0.37). Moreover, the relationship between antioxidant activity and anthocyanin content was found positive but non-significant (r = 0.18). However, there was a non-significant negative correlation between total phenolic matter and β-carotene (r = -0.25); sugar content (r = -0.23).

CONCLUSIONS

1. The significant differences are determined between inbred lines of purple carrot in yield and quality characteristics.

2. A strong positive and significant correlation has been determined between yield and root weight/root diameter. The root weight and root diameter, which are among

morphological features, can be used as a selection criteria in order to increase the yield in the breeding program.

3. Among β-carotene content with total sugar and antioxidant activity with total phenolic matter are positive correlated. Eregli 17 is the line with the highest antioxidant activity and phenolic matter, and Eregli 13 is a line having the highest total sugar.

4. In our study, 4 lines with superior characteristics have been determined as being hopeful. These lines are Eregli 4, Eregli 9, Eregli 10, and Eregli 16. The lines in Eregli 4 and Eregli 16 have especially been observed as remarkable lines in terms of our selection criteria.

5. If the characteristics that are desired by the consumers and processing industry are achieved by the plant breeders, purple carrot will be preferred more. Because the interest in carrots of containing different bioactive compounds is increased every day.

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REFERENCES

Alasalvar, C., Grigor, J.M., Zhang, D., Quantick, P.C., Shahidi, F. (2001). Comparison of volatiles, phenolics, sugars, antioxidant vitamins, and sensory quality of different colored carrot varieties. J. Agric. Food Chem., 49, 1410–1416.

Alasalvar, C., Al-Farsi, M., Quantick, P.C., Wiktorowicz, R. (2005). Effect of chill storage and map on antioksidant activity, anthocyanins, carotenoids, phenolics and sensory quality of ready to eat shreded orange and purple carrots. Food Chem., 89, 69–76.

Amin, A., Dhillon, T.S., Mir, H., Shah, M.A. (2012). Assessment of genetic diversity in carrot germplasms. SAARC, J. Agric., 10, 9–20.

Barański, R., Allender, C., Chodacka, M.K. (2012). Towards better tasting and more nutritious carrots: carotenoid and sugar content variation in carrot genetic resources. Food Res. Inter., 47, 182–187.

Barczak, A.B. (2005). Acylated anthocyanins as stable, natural food colorants. J. Food Sci. Nutr., 14, 107–116.

Bozalan, N.K., Karadeniz, F. (2011). Carotenoid profile, total phenolic content, and antioxidant activity of carrots. Inter. J. Food Proper., 14(5), 1060–1068

Changzhi, G., Lirong, Y., Zihoo, G., Lei, C., Liya, W. (2003). Selection of a new carrot F1 hybrid Tianhong No.1. China Veg., 2, 21–22.

Cemeroglu, B. (1992). Fruit and vegetable processing ındustries basic analysis methods. Biltav University Books Series, 02–2, Ankara.

Ersus, S., Yurdagel, U. (2007). Microencapsulation of anthocyanin pigments of black carrot by spray drier. J. Food Engin., 80, 805–812.

Fikselova, M., Marecek, J., Mellen, M. (2010). Carotenes content in carrot roots as affected by cultivation and storage. Veg. Crops Res. Bull., 73, 47–54.

Gajewski, M., Szymczak, P., Elkner, K., Dabrowska, A., Kret, A., Danilcenko, H. (2007). Some aspects of nutritive and biological value of carrot cultivars with orange, yellow and purple coloured roots. Veg. Crops Res. Bull., 67, 149–161.

Gajewski, M., Szymczak, P., Bajer, M. (2009). The accumulation of chemical compounds in storage roots by carrots of different cultivars during vegetation period. Acta Sci. Pol. Hortorum Cultus, 8(4), 69–78.

Gajewski, M., Szymczak, P., Danilcenko, H. (2010). Changes of physical and chemical traits of roots of different carrot cultivars under cold store conditions. Veg. Crops Res. Bull., 72, 115–127.

Gıustı, M.M., Rodrıguez-Saona, L.E., Wrolstad, R.E. (1999). Molar absorptivity and color characteristics of acylated and non-acylated pelargonidin-based anthocyanins. J. Agric. Food Chem., 47, 4631–4637.

Gupta, A.J., Verma, T.S. (2007). Studies on genetic variability and selection parameters in europen carrot. Hayrana J. Hort. Sci., 36, 166–168.

Gyamfi, M.A., Yonamine, M., Aniya, Y. (1999). Free radical scavenging action of medical herbs from ghane: Thonningia sanguinea on experimentally induced liver injuries. General. Pharmacol., 32, 661–667.

Holley, S.L., Edwards, C.G., Thorngate, J.H., Fellman, J.K., Matiinson, D.S., Sorensen, E.J., Dougherty, R.H. (2000). Chemical characterization of different lines of roots. J. Food Qual., 23, 487–502.

Karkleliene, R., Dambrauskiene, E., Radzevicius, A. (2008). Evaluation of the morphological, physiological and biochemical parameters of edible carrot. Biologija, 54, 101–104.

Karkleliene, R., Radzevieius, A., Bobinas, C. (2009). Productivity and root-crop quality of Lithuanian carrot breeder lines. Proc. Latvian Acad. Sci., sect. B 63, 63–65.

Kidmose, U., Hansen, S.L., Christensen, L.P., Edelenbos, M., Larsen, E., Nørbæk, R. (2004). Effects of genotype, root size, storage and processing on bioactive compounds in organically grown carrots. J. Food Sci., 69, 388–394.

Kreutzmann, S., Thybo, A.K., Edelenbos, M., Christensen, L.P. (2008). The role of volatile compounds on aroma and flavour perception in coloured raw carrot genotypes. J. Food Sci. Tech., 43, 1619–1627.

Majkowska-Gadomska, J., Wierzbicka, B. (2010). The yield and nutritive value of selected carrot cultivars with orange and purple colored storage roots. Acta Sci. Pol. Hortorum Cultus, 9(4), 75–84.

Manosa, N.A. (2011). Influence of temperature on yield and quality of carrots. M. Thesis, University of The Free State Bloemfontein, South Africa.

Nicole, C., Simon, G., Rock, E., Amouroux, P., Remesy, C. (2004). Genetic variability influences carotenoid, vitamin, phenolic and mineral content in white, yellow, purple, orange and dark-orange carrot cultivars. J. Am. Soc. Hort. Sci., 129, 523–529.

Rubatzky, V.E., Quiros, C.F., Simon, P.W. (1999). Carrots and related vegetable umbelliferae. Cabi Publishing, New York, 287 p.

Santos, C.A.F., Senalik, D., Simon, P.W. (2005). Path analysis suggests phytoene accumulation is the key step limitingthe carotenoid pathway in white carrot roots. Gen. Mol. Biol., 28(2), 287–293.

Sekerci, Ş. (2010). Determınatıon of plant and phytochemical characteristics of colored carrots. M. Thesis, Gazi Osmanpasa University, Turkey.

Sękara, A., Kalisz, A., Cebula, S., Grabowska, A. (2012). The quality and processing usefulness of chosen polish carrot cultivars. Acta Sci. Pol. Hortorum Cultus, 11(5), 101–112.

Skrede, G., Nilsson, A., Baardseth, P., Rosenfeld, H.J., Enersen, G., Slinde, E. (1997). Evaluation of carrot varieties for production of deep fried carrot chips. Food Res. Internat., 30, 73–81.

Slinkard, K., Singelton, V.L. (1997). Total phenolic analysis, automation and comparison with manual methods. A. J. Enol. Viticult., 28, 49–55.

Simon, P.W., Wolff, Y. (1987). Carotenes in typical and dark orange carrots. J. Agric. Food Chem., 35, 1017–1022.

Simon, P.W. (2000). Domestication, historical development and modern breeding of carrot. Plant Breed. Rev., 19, 157–190.

Singh, J., Singh, B., Kalloo, G. (2002). Root morphology and carotene content in asiatic and european carrots. Indian J. Agric. Sci., 72, 225–227.

Singh, B., Pandey, S., Pal, A.K., Singh, J., Rai, M. (2005). Correlation and path coeffıcient analysis ın asiatic carrot. Veg. Sci., 32(2), 136–139.

Singh, D.P., Beloy, J., Mcinerney, J.K., Day, L. (2012). Impact of boron, calcium and genetic factors on vitamin C, carotenoids, phenolic acids, anthocyanins and antioxidant capacity of carrots. Food Chem., 132, 1161–1170.

Song, W., Derito, C.M., Liu, M.K., He, X., Dong, M., Liu, R.H. (2010). Cellular antioxidant activity of common vegetables. J. Agric. Food Chem., 58, 6621–6629.

Suojala, T. (2000). Variation in sugar content and composition of carrot storage roots at harvest and during storage. Sci. Hort. 8, 1–19.

Swingle, D.B. (1946). A textbook of systematic botany. Mcgraw-Hill Book Company, Inc., Newyork, 323 p.

Tewatia, A.S., Dudi, B.S., Dahiya, M.S. (2000). Correlation and path coefficient analysis in carrot at different dates of sowing. Haryana J. Horti. Sci., 29, 217–220.

TUIK (2014). Crop production statistics, Turkish Statistical Institute, Ankara.

Turkish State Meterogical Service 2012, Ankara.

Vieira, J.V., Silva, G.O., Boiteux, L.S. (2012). Genetic parameter and correlation estimates of processing traits in half-sib progenies of tropical-adapted carrot germplasm. Hortic. Bras., 30, 7–11.

Vikas, A., Kanwar, H.S., Kanwar, M.S., Anshul, S. (2010). Estimation of genetic variation and correlation in european carrots. SKUAST-J, 9(2), 150–155

Uysal, V. (2000). The exraction of coloring matters (antocyanins) in black carrot and determination of their properties. M. Thesis, Ege University, Turkey.

Yadav, M., Tirkey, S., Singh, D.B., Chaudhary, R., Roshan, R.K., Pebam, N. (2009). Remove from marked records genetic variability, correlation coefficient and path analysis in carrot. Indian J. Hort., 66(3), 315–318.

Yanmaz, R., Agaoglu, Y.S., Halloran, N., Kasım, M.U. (1995). Effects of different storage methods of storage life of carrots. Ankara U, Dept Hort. Ankara.

Yuanmin, C., Yong, W., Yanping, Z. (2008). A new carrot F_1 hybrid – 'Jinhong No. 5'. China Veg., 4, 40–41.

LINIE PURPUROWEJ MARCHWI MAJĄCE LEPSZE CECHY TECHNOLOGICZNE W TURCJI

Streszczenie. Użyto populacji marchwi purpurowej, która jest powszechnie uprawiana w rejonie Konya w Turcji dla celów przemysłowych. Zebrano różne typy marchwi czerwonej dla puli genów. Poddano je selekcji ze względu na badane cechy. Doświadczenie przeprowadzono w latach 2009–2012 w układzie prób losowanych bloków w 3 powtórzeniach przy użyciu spokrewnionych linii marchwi purpurowej. Eregli 1 miał najwyższy (11,54 $t \cdot ha^{-1}$), a Eregli 14 najniższy plon (9,27 $t \cdot ha^{-1}$). Określono korelację między niektórymi cechami fizycznymi i chemicznymi. W próbkach marchwi ilość suchej masy wynosiła 12,3–16,30%, całkowita zwartość cukrów 7,13–9,67 $g \cdot 100\ g^{-1}$, ilość β-karotenu 117,17–249,55 $\mu g \cdot g^{-1}$, ilość antocyjaniny 272,0–596,2 $\mu g \cdot g^{-1}$, całkowita ilość fenoli 155,83–206,67 $mg \cdot 10^{-2} g^{-1}$ GAE, natomiast działanie antyoksydacyjne wynosiło od 31,85 do 44,20%. Przy końcu badania linie Eregli 9 i Eregli 10 określono jako linie dające nadzieję, natomiast Eregli 4 i Eregli 16 jako linie kandydujące na odmiany.

Słowa kluczowe: *Daucus carota*, cechy jakości, cechy fizyczne, selekcja, plon

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