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Introduction of Purple and Deep Purple F_1 Carrot Hybrids to Egypt Showed High Antioxidant Activity and High Content of Total Flavonoids and Phenols

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Abstract: For the improvement of carrot cultivation in Egypt and because of the deterioration of the local Egyptian purple carrots, two novel colored (Purple and Deep Purple) F_1 carrot hybrids were introduced for the first time from Netherland to be evaluated and compared to the broadly cultivated yellow Japanese F_1 hybrid (Kuruda) under the Middle Egypt sandy soil growing conditions. The horticultural evaluation showed that the two purple hybrids have elongated thick roots and good vegetative growth and gave a very high yield of roots in two successive winter seasons of 2013/2014 and 2014/2015. The Deep Purple hybrid exceeded the other two hybrids in almost all studied chemical and horticultural characteristics. It showed about three folds of leaves fresh weight/plant, two folds of both root fresh weight/plant and yield/m^2 when compared with Purple and Kuruda hybrids. The chemical analyses declared that the Purple and Deep Purple hybrids have higher contents of all estimated components and the Deep Purple hybrid had the highest values of total flavonoids (about two folds), total phenols (about 5-6 folds), antioxidant activity percentage (7-8 times), and total soluble solids percentage (1.5-2 times) than that of the yellow F_1 hybrid "Kuruda". These newly introduced two Purple and Deep Purple F_1 hybrids may be very promising in production and processing purposes of purple carrots and good materials in carrot breeding programs in Egypt.

INTRODUCTION

Carrot is a unique vegetable crop which belongs to Apiaceae (Umplefera) family and is rich in most of the natural antioxidants (Alasalvar *et al*., 2001; Nicolle *et al*., 2004; Grassmann *et al*., 2007; Sun *et al*., 2009). Umbelliferae cultivated carrots are originated in Afghanistan region (Vavilov, 1951) and are cultivated in China, USA, Russia, Uzbekistan, Ukraine, Turkey, Egypt and India. Early carrots were commonly purple, yellow, or white. From these, modern eastern carrots, with slightly dissected, pubescent, grey-green foliage and purple or yellow roots, and modern western carrots, with deeply dissected, mostly glabrous, yellow-green foliage and orange, yellow, red, or white roots were developed (Small 1978). Recently it is gaining high recognition and economic importance due to its high nutritional value and high concentration of natural antioxidants. Moreover, among vegetables, carrot is the single major source of β-carotene providing 17% of the total vitamin A consumption (Arscott and Tanumihardjo, 2010). Apart from β-carotene, root is a good source of various other lipophilic antioxidants like lycopene and lutein. The consumption of lutein is associated with prevention of age-related macular degeneration (Alves-Rodrigues and Shao, 2004) and reduces the risk of atherosclerosis (Dwyer *et al*., 2001) whereas lycopene consumption is associated with reducing the risk of certain types of cancer and cardiovascular diseases (Rao and Rao, 2007). It is also rich in hydrophilic phenolic antioxidants which are known for wide ranges of health promoting anticancer, anti-atherogenic, anti-inflammatory and antimicrobial properties (Grassmann *et al*., 2007; Sun *et al*., 2009).

Plants are the good sources for the discovery of pharmaceutical compounds and medicines. Natural products could be potential drugs for humans or livestock species and also these products and their analogues can act as intermediates for synthesis of useful drugs (Makkar *et al*, 2009). Plants possess many phytochemicals with various bioactivities including, carotenoids, ascorbic acid, α-tocopherol and polyphenols (Salah *et al*., 1995, Edge *et al*., 1997 and Papas, 2002). Natural antioxidants haven't cause health problems that may arise from the use of synthetic antioxidants which have some harmful side effects (Arouma *et al*., 1992). The increasing interest in powerful biological activity of plant phenols and flavonoids outlined the necessity of determining plants content of these natural beneficial compounds.

Free radical reaction occurs in the human body and food systems and free radicals, in the form of reactive oxygen and nitrogen species are integral parts of normal physiology. Over production of these reactive species can occur due to oxidative stress resulted from the imbalance of body antioxidant defense system or free radical formation (Abdel Ati *et al*., 2000). These reactive species can react with biomolecules causing injury and may lead to death (Halliweel, 2008). Antioxidant substances block the action of free radicals which have been implicated in the pathogenesis of many diseases including atherosclerosis, ischemic heart disease, cancer, Alzheimer disease and in the aging process (Aruoma, 1998; Galal *et al*., 2000). Antioxidants are also used to preserve food quality mainly because they prevent the oxidative deterioration of lipids. Natural antioxidants in wine, fruits and vegetables have been studied widely due to their health benefits and commercial values. Besides fruits, other parts of plants such as bark, leaves, fruit peels and roots are also being exploited extensively for their antioxidant properties. For instance, antioxidant studies were conducted in green leafy vegetables such as amaranth, spinach, back choi and kang kong as well as in leaves of guava leaves, blackberry leaves, red raspberry leaves, strawberry leaves, cabbage broccoli, cauliflower and Brussels (Wng *et al*, 2010, Yang *et al*., 2005 and Soengas *et al*., 2011).

The successful commercial use of carrot and also other vegetable crops depends on the choice of open pollinated cultivars or hybrids that are well-adapted to soil and climate conditions at the cultivation site and meets the consumer acceptance (Cruz and Castoldi, 1991; Pereira *et al*., 2015). As the Egyptian purple carrot inbreds' prosperities are deteriorated and is no longer cultivated broadly, in this study, two novel colored carrot F_1 hybrids (Purple and Deep Purple) were introduced for the first time to Egypt and were cultivated and evaluated for their agronomic characteristics, yield and chemical prosperities e.g., their content of total flavonoids, phenols and total soluble solids (TSS) along with their antioxidant activity under the Middle Egypt sandy soil growing conditions. Hopefully, this may improve cultivation and processing purposes of colored carrots in Egypt as it is considered one of the most profitable vegetable crops for Egyptian farmers, processors and traders.

MATERIALS AND METHODS

In the sandy soil of the Scientific Farm of Faculty of Agriculture, Minia University, Shousha region, Minia, Egypt, , two novel colored (Purple and Deep Purple) F_1 carrot hybrids were introduced for the first time from Netherland to be evaluated and compared to the broadly cultivated yellow Japanese F_1 hybrid (Kuruda). Seeds were obtained from the Bejo Zaden b. v. Trambaan 1, 1749 CZ Warmenhuizen, The Netherlands, and were planted in two rows/line (each line was 35cm wide and 350cm long) in small plots (3.0m x 3.5m) in two successive winter seasons of 2013/2014 and 2014/2015. All horticultural practices suitable for carrot cultivation and production were followed according to the instructions of the Egyptian Ministry of Agriculture. Plants were harvested after five months from seed plantation and horticultural data (e.g., leaves fresh weight/plant (g), root fresh weight (g), root length (cm), root diameters (cm), and fresh yield/m^2 (kg)) as average of 20 plants from each replicate were recorded. Also, root samples from the three hybrids were taken to the Food Sciences and Technology Laboratory, Faculty of Agriculture, Minia University, Minia, Egypt and roots content of some chemical properties e.g., total flavonoids (g/100gFW), total phenols (g/100gFW), antioxidant activity (100%), total lipids (100%), ash (100%), and humidity (100%) were estimated as follow:

Determination of total Phenolic compounds

The concentration of phenolic compounds in leaves extract was determined using the spectrophotometric method according to Sing Leton *et al*. (1999).

Determination of flavonoids content

The content of flavonoids in the examined leaves extracts was determined using spectropboiledometric method according to Quettier- Deleu *et al*. (2000). The sample contained 1 ml of aqueous solution of the extract in the concentration of 1 mg/ml and 1 ml of 2% $AlCl_3$ solution dissolved in methanol. The samples were incubated for one hour at room temperature. The absorbance was determined using a spectrophotometer at ʎmax= 415 nm. The samples were prepared in triplicate for each analysis and the mean value of absorbance was obtained. The same procedure was repeated for the standard solution of rutin and the calibration line was construed. Based on the measured absorbance, the concentration of flavonoids was read (mg/ml) on the calibration line; then, the content of flavonoids in extracts was expressed in terms of rutin equivalent (mg of Ru/g of extract).

Evaluation of antioxidant activity (DPPH radical scavenging activity)

The free radical – scavenging activity of each extract was determined as described by Braca *et al*., (2001). Plant leaves extracts were added to 3ml of a 0.004% methanol solution of DPPH. Absorbance at 517nm was measured under constant mixing at room temperature after 30 min and percent inhibitory activity was calculated from:

$$\text{Inhibition}\,(\%) = \frac{(\text{control} - \text{test})}{\text{control}} \times 100$$

Total soluble solids (TSS) determination (100%)

The TSS content in blinded root samples was determined according to the official methods of analysis "AOAC", 1995 using the handheld refractometer model "FG103/113 measuring range 0~ 32%.

Lipids content (100%)

Lipids content was determined according to Singleton and Rossi (1965) and results are given as mean values of three replicates.

Ash content (100%)

Ash contents were determined according to Singleton and Rossi (1965) and results are given as mean values of three replicates.

Statistical analysis

All data were subjected to the analysis of variance (ANOVA) and means were compared using the Multiple Range Test (Dunkan's test) and/or the least significant difference (L.S.D.) at 95% confidence degree using the MSTAT-C software version 4.0 (Michigan University, USA) according to Gomez and Gomez (1983).

RESULTS

Horticultural characteristics

The Purple, Deep Purple, and the yellow colored (Kuruda) hybrids were planted and evaluated under the Middle Egypt (Minia governorate) sandy soil growing conditions for their horticultural and field performance characteristics (some of these features are shown in Figure 1) along with their chemical and food quality proprieties. When a cross section was made to the roots of the purple hybrids, the Deep Purple hybrid showed a root with a complete purple color and the Purple hybrid showed a white core in its roots (Figure 1). The Deep Purple hybrid also showed the significant highest values of most of the studied characters and the other two hybrids (Purple and Kuruda) almost differed insignificantly in their horticultural traits as follow:

Figure. 1: Photos show the morphology of the Purple and Deep Purple F_1 carrot hybrids. A): Whole plants of the two hybrids at the age of five months showing roots and shoots. B): Roots and sections in roots of the two hybrids. C): Roots and section in a root of the Deep Purple F_1 hybrid. D): Roots and section in a root of the Purple F_1 hybrid.

Table (1): Morphological characteristics and fresh yield of "Purple", "Deep Purple" and yellow "Kuruda" F_1 foreign carrot hybrids evaluated under the Middle Egypt growing conditions in two successive winter seasons of 2013/2014 and 2014/2015

F_1 hybrids	Leaves fresh weight/plant (g)		Root fresh weight/plant (g)		Root length/plant (cm)		Shoot length/plant (cm)		Top root diameter/plant (cm)		Bottom root diameter/plant (cm)		Middle root diameter/plant (cm)		Fresh yield (kg/m^2)	
	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015
Purple	52.0 B	69.0 B	55.0 B	62.0 B	19.2 A	22.6 A	35.2 B	37.6 AB	1.14 A	1.12 A	1.42 A	1.84 A	1.78 B	2.00 A	12.6 B	14.0 B
Deep Purple	133.0 A	153.0 A	88.6 A	121.0 A	25.8 A	29.1 A	66.0 A	57.2 A	1.26 A	1.40 A	1.84 A	1.74 A	2.66 A	2.82 A	20.4 A	20.7 A
Kuruda	48.0 B	50.0 B	46.6 B	48.4 B	11.8 B	12.4 B	37.8 B	35.6 B	1.50 A	1.20 A	1.86 A	1.82 A	2.08 AB	2.26 A	10.5 B	11.3 B
Mean	**77.67**	**90.67**	**63.4**	**77.13**	**18.93**	**21.37**	**46.33**	**43.47**	**1.30**	**1.24**	**1.71**	**1.80**	**2.17**	**2.36**	**14.51**	**15.32**
L.S.D. at 0.05	53.97	55.32	27.37	37.67	7.17	6.80	9.44	20.86	NS	NS	NS	NS	0.70	NS	2.77	3.15

Table (2): Chemical properties of "Purple", "Deep Purple" and yellow "Kuruda" F_1 foreign carrot hybrids evaluated under the Middle Egypt growing conditions in two successive winter seasons of 2013/2014 and 2014/2015

F_1 hybrids	Total Flavonoids (g/100g fresh weight)		Total Phenols (g/100g fresh weight)		Antioxidant Activity (%)		TSS (%)		Total lipids (%)		Ash (%)		Humidity (%)	
	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015	2013/ 2014	2014/ 2015
Purple	2.57 B	2.55 B	1.57 B	1.64 A	40.9 B	45.3 B	17.0 B	18.0 B	0.38 AB	0.37 AB	1.08 A	1.12 AB	83.2 A	83.0 AB
Deep Purple	3.35 A	3.82 A	1.79 A	1.83 A	47.8 A	51.4 A	21.3 A	22.0 A	0.42 A	0.46 A	1.09 A	1.22 A	80.3 A	79.3 B
Kuruda	1.27 C	1.33 C	0.24 C	0.30 C	5.5 C	6.8 C	15.3 B	14.7 C	0.31 B	0.33 B	1.04 A	1.02 B	84.2 A	85.4 A
Mean	**2.40**	**2.56**	**1.20**	**1.26**	**31.39**	**34.5**	**17.89**	**18.22**	**0.37**	**0.39**	**1.07**	**1.12**	**82.58**	**82.57**
L.S.D. at 0.05	0.29	0.52	0.05	0.19	5.31	4.10	2.34	3.10	0.11	0.11	NS	0.05	NS	3.92

Average leaves fresh weight/plant (g)

The average leaves fresh weight varied among the three hybrids and the Deep Purple hybrid showed the significantly heaviest leaves (133.0 and 153.0 g) comparing to the Purple (52.0 and 69.0 g) and Kuruda (48.0 and 50.0 g) hybrids in the two successive seasons, respectively. Differences in values obtained from the Purple and Kuruda hybrids were insignificant (Table 1).

Average root fresh weight/plant (g)

This characteristic is important in carrot production as it shows the marketable part of the plant and is an indicator of the expected yield of roots. As described in Table (1), data showed that the Deep Purple hybrid differed significantly and gave values (88.6 and 121.0 g) of about two times higher than that of the other two hybrids (55.0 and 62.0g for Purple and 46.6 and 48.4 g for Kuruda) in the first and second seasons, respectively.

Average root length/plant (cm)

In this characteristic, the Deep Purple and Purple hybrids differed insignificantly with each other (25.8 and 29.1; 19.2 and 22.6 cm) but significantly with Kuruda hybrid which gave (11.8 and 12.4 cm) in the first and second season, respectively as shown in Table (1) and Figure (1).

Average shoots length/plant (cm)

The Deep Purple hybrid showed big and longer shoots comparing to the other two hybrids (Figure 1) and differed significantly (66.0 cm) in the first season comparing to Purple (35.2 cm) and Kuruda in the two seasons (37.8 and 35.6 cm) and insignificantly with Purple in the second season (57.2 cm for Deep Purple and 37.6 cm for Purple) as shown in Table (1).

Top, middle and bottom root diameter/plant (cm)

Root diameter is a quality trait of carrot cultivars or hybrids and people all over the world vary in their taste concerning this characteristic. As shown in Figure (1) and Table (1), the three hybrids almost gave very similar values of root diameter whether it was measured in the top, middle or bottom of the root and almost differed insignificantly in this characteristic. The Deep Purple hybrid had root diameters ranged from 1.26 to 2.82 cm and the Purple hybrid had values ranged from 1.12 to 2.00 cm, while, Kuruda hybrid showed values of root diameters ranged from 1.20 to 2.26 cm.

Average fresh yield (kg/m^2)

Carrot fresh yield of roots along with roots quality is very important as it is the indicator of the net return which the farmer or producer will get from carrot cultivations. In our experiments, the Deep Purple hybrid significantly varied comparing to the other two hybrids in its average yield/m^2 of roots and gave (20.4 and 20.7 kg/ m^2) comparing to Purple (12.6 and 14.0 kg/ m^2) and Kuruda (10.5 and 11.3 kg/ m^2) hybrids in the first and second season, respectively (Table 1). This production of Deep Purple hybrid is nearly to be double when compared to that of the other two hybrids.

Chemical proprieties of the carrot hybrids

Humidity (%)

Differences in water content (humidity) were almost insignificant among the studied purple and yellow carrot hybrids. However, the Deep Purple hybrid showed the lowest percentages of humidity in the two successive seasons (80.3 and 79.3 %) comparing to (83.2 and 83.0 %) for Purple and (84.2 and 85.4 %) for Kuruda hybrids in the first and second seasons, respectively as described in Table (2).

Total soluble solids percentage (TSS)

The evaluated carrot hybrids varied significantly in their content of the total soluble solids and the Deep Purple hybrid showed the significant highest values (21.3 and 22.0 %) followed by the Purple hybrid (17.0 and 18.0 %), while Kuruda hybrid showed the lowest percentages of the TSS (15.3 and 14.7 %) in the first and second season, respectively (Table 2).

Ash content (%)

The purple hybrids showed significant higher contents of ash comparing to the yellow hybrid. There were insignificant differences between the purple hybrids (1.09 and 1.22 % for Deep Purple) and (1.08 and 1.12 % for Purple), while Kuruda showed values of 1.04 and 1.02 % in the first and second season, respectively (Table 2).

Total lipids content (%)

Carrot hybrids showed significant differences in their content of total lipids as shown in Table (2). Tissues of the Deep Purple hybrid contained the significant highest values (0.42 and 0.46 %) comparing to Kuruda hybrid (0.31 and 0.33 %) and differed insignificantly with the Purple hybrid (0.38 and 0.37 %) in the first and second season, respectively.

Total flavonoids (g/100g fresh weight)

The three studied and evaluated hybrids differed significantly among each other in their content of total flavonoids percentages and the Deep Purple hybrid contained the highest values (3.35 and 3.82 g/100g fresh weight) followed by the Purple hybrid (2.57 and 2.55 g/100g fresh weight) and those of

Kuruda (1.27 and 1.33 g/100g fresh weight). That means the purple hybrids contained almost double percentages of those of the yellow hybrid (Table 2).

Total phenols (g/100g fresh weight)

As shown in Table (2), tissues of both the Deep Purple and Purple hybrids contained amounts of total phenols which are about six times those of the yellow hybrid (Kuruda). Tissues of the Deep Purple hybrid contained 1.79 and 1.83 g/100g fresh weight of total phenols, while the Purple hybrid's tissues contained 1.57 and 1.64 g/100g fresh weight and both of these two hybrids exceeded that of the yellow hybrid (0.24 and 0.30 g/100g fresh weight) in the first and second season, respectively.

Antioxidant activity (DPPH radical scavenging activity), (%)

Interestingly, the Deep Purple hybrid showed an antioxidant activity of about 8 times (47.8 and 51.4 %) than that of the yellow hybrid (5.5 and 6.8 %) and the Purple hybrid showed an antioxidant activity of about 7 times (40.9 and 45.9 %) than that of Kuruda hybrid in the first and second season, respectively (Table 2).

DISCUSSION

Carrot was chosen in this study because of its importance as it is widely grown for use both fresh and processed and it provides an excellent source of vitamin A and fibers in the diet. Economically, carrot ranks among the ten most important vegetables, exceed by potato, lettuce, tomato, onion, celery and sweet corn. The domestic carrot is closely related to and readily crosses with the highly diverse and widely adapted wild carrot known as Queen Anne's Lace. In nature, the wild carrot has an annual or winter annual life cycle. Domestic cultivars have been selected for non-bolting and therefore behave as biennials or winter annuals.

Breeding of carrots is focused on improving yield, visible characteristics such as color, shape, smoothness and resistance to some common diseases along with non-bolting traits. However, sometimes the total yield is not as important as uniformity especially when carrot roots are eaten at the immature stage. In our study, we focused on both quality characteristics and yield of the carrot hybrids evaluated and acclimatized under the Middle Egypt growing conditions. Over the last two centuries, the most important breeding methods have been mass selection and pedigree selection within the different populations of orange-colored carrots. This has resulted in a great number of open-pollinated carrot varieties. The yield of' marketable carrots is the most important economic factor. All open pollinated varieties suffer from inbreeding depression and a limited degree of uniformity, and hybrid breeding of carrot has been started intensively to improve uniformity. In addition, hybrid breeding provides a rather high level of safety against uncontrolled reproduction. Moreover, the synthetic hybrids have been tested in comparison to open pollinated varieties and adapted hybrid varieties. For improving yield, the development of synthetics hybrids seems to be a successful approach, connected with rather low breeding costs. In Europe, Frimmel and Lauche (1938) were the first to recommend the breeding of F_1 carrot hybrids; however, the lack of a system of producing hybrid seed in large quantities prevented the introduction of this method.

The successful commercial use of carrot depends on the choice of cultivars that are well-adapted to soil and climate conditions at the cultivation site and meets the consumer acceptance (Pereira *et al*., 2015). Egyptian people are very familiar with the red and purple carrots and the Egyptian purple open pollinated varieties were very preferred by Egyptian people for many decades before the deterioration of these varieties. Hence, the choice of genotypes for extensive ranges of environments on the basis of their mean yield, i.e., without considering the specific adaptation of each genotype in each environment, is a decision that facilitates the work of plant breeders. However, for productive characteristics where the effects of the genotype-environment interaction are important, this practice can cause large losses, because these interactions are not defined for each specific environment. This is one reason why it can be difficult to select genotypes for regions that have different soil and climatic features (Cruz and Castoldi, 1991).

Back to the history, Khalil *et al*. (2015) reported that traditionally, *Daucus carota* was employed by the Ancient Egyptians as a stimulant, carminative and diuretic, concurrently its decoction was used for curing infantile diarrhea and as an anthelmintic agent (Van Wyk and Wink, 2004). Recently, it was shown that *Daucus carota* encompass multiple active constituents such as flavonoids (El-Sayed *et al*., 1994); Singab *et al*. 1995), essential oils (Kilibarda *et al*. 1996), polyacetylenes (Lund *et al*. 1992; Degen *et al*. 1999) and phenylpropanoids (Douds *et al*. (1996). Khalil *et al*. (2015) found that the anti-inflammatory activity of the essential oils was clearly observed through their abilities to suppress soybean 5-LOX and inhibition of prostaglandin E2 production. The Purple and Deep Purple hybrids used in our study showed high contents of most of these components in their tissues and this reflects their importance in medicinal and nutritional usage capabilities. Stintzing and Carle (2004) reviewed the role of anthocyanins in plants and concluded that in the carrot root, anthocyanins might play a role as monosaccharide transporters or osmotic adjusters that protect plant cells from drought and cold temperatures. Alasalvar *et al*. (2001) studied the carotenoid levels and consumer preference for orange and purple carrots and in their study, purple carrots had more than twice the α- and β-carotene present in orange carrots and were perceived by consumers to be sweeter than orange carrots, although total sugars and calculated relative sweetness was lower for purple than for orange carrots. Moreover, high antiradical activity of purple-yellow and purple-orange carrots was previously reported by Sun *et al*. (2009), who measured such activity by DPPH and ABTS methods. Also Gajewski *et al*. (2007) found higher antioxidant capacity in methanolic extracts from purple carrots than in extracts from orange and yellow carrots. This is matching with our results in which purple carrot F_1 hybrids contained higher levels of total phenols and higher percentages of antioxidant activity comparing to the evaluated Japanese yellow F_1 hybrid "Kuruda". Leja *et al*. (2013) evaluated 35 carrot cultivars and found in their results that red carrots showed higher antioxidant activity than orange, yellow and white carrots and in the season of lower rainfall they accumulated higher amounts of phenolic compounds. They added that carrots of Asian origin belonging to Eastern gene pool were more often purple or red and richer in phenolics and had higher antiradical activity than those from the Western gene pool with mainly orange roots.

The evaluated Purple and Deep Purple F_1 carrot hybrids contained high levels of pigments (data are not shown but it is obviously seen in Fig 1). Colored carrots are a significant or potential source of dietary nutrients in the form of plant pigments, including carotenoids, anthocyanins, and other flavonoids. The health benefits of these compounds, including protection against certain forms of cancer, reduction of the risk of cardiovascular disease, and scavenging of free radicals (reviewed by van den Berg *et al*. 2000 and Stintzing and Carle 2004), have led to consumer interest in natural products rich in carotenoids and anthocyanins. This gives an importance of our hybrids used in this study.

From all these promising results we are going to begin a breeding program between these Purple and Deep Purple foreign carrot hybrids and the Egyptian purple inbreds because the Egyptian purple inbreds contain high levels of sugars and were very preferred by Egyptian people. Unfortunately, most of the Egyptian purple carrot inbreds are deteriorated. That's why this breeding program is very crucial in carrot breeding and production in Egypt. Hope we can produce good F_1 purple hybrids which meet the Egyptian taste and enrich the carrot cultivation and processing industries again.

CONCLUSION

Two (Purple and Deep Purple) F_1 carrot hybrids were imported, cultivated and evaluated for their horticultural characteristics and chemical proprieties comparing with the broadly cultivated yellow Japanese F_1 carrot hybrid (Kuruda) under the sandy soil conditions of the Middle Egypt. The purple hybrids were adapted to the Middle Egypt growing conditions and showed most of the highest values of all studied characters (e.g., yield/m^2, total flavonoids, total phenols, total lipids, ash content, and antioxidant activity) when compared with Kuruda yellow hybrid. The Deep Purple hybrid exceeded the other two hybrids in almost all estimated characters. These two hybrids are very promising carrot hybrids and will compensate the deterioration of the Egyptian red carrots. These promising purple hybrids will be used in a breeding program to improve the proprieties and productivity of the deteriorated purple Egyptian carrot inbreds.

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