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RELATION BETWEEN HARVESTING STAGE AND VOLATILE OIL CONTENT OF SOME CARROT VARIETIES

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ABSTRACT

Two varieties of carrot plant namely Chantenay Red Cored and Balady selected, were evaluated for their contents of volatile oil percentage and volatile oil yields during two successive seasons 1994/1995 and 1995/1996. The obtained results were as follows:-

The volatile oil content of carrot fresh herb in " Balady Selected " variety was higher than Chantenay Red Cored in the all six growth periods.

The volatile oil percentage of carrot fresh herb of Balady Selected and Chantenay Red Cored raised gradually from 60 till 90 days after sowing and reached to a maximum value. However it was low at the period from 105 to 135 days after sowing for Balady Selected after that period the percentage slightly fluctuated starting from the age 105 days till the end of experiment.

The volatile oil percentage and the volatile oil yield of carrot fresh root of Balady Selected were lower than those of Chantenay Red Cored variety.

The volatile oil percentage of Balady Local carrot seed was higher than that of Chantenay Red Cored and Balady Selected, varieties.

The Chemical composition of volatile oil using gas chromatography (G-C) and gas chromatography spectrometry (i.e. as a tool of compound identification) in the different parts of carrot varieties under study, revealed the presence of more than 10 compounds, some of which were identified as follows: -

a- In the herb :-

The major identified compounds in Balady selected were (β-myrcene (15.14%), limonene (12.83%), cis-trans farnesol (8.40%), β-caryophyllene (7.48%). While the major identified in Chantenay compounds are the followings (β-caryophyllene (17.34%), β-myrcene (15.61%), germacrene (9.35%), trans-ocimene (8.60%).

b-In the root at harvesting stage:-

The major identified compounds in Balady selected were phytole (15.20%), β-caryophyllene (9.51%), terpinolene (7.55%), 2-propanone (7.46%).

The major identified compounds in Chantenay were (β-caryophyllene (25.42%), terpinolene (16.16%), α-farnesene (14.37%), limonene (8.59%).

c- In the fruits (seeds) :-

The major identified compounds in Balady Selected were (β-bisabolene (72.45%), cis iso elemicin (11.75 %), α-caryophyllene (4.35%), β-caryophyllene (2.00%).

The major identified compounds in Chantenay Red Cored selected were (carotol (35.86%), α-farnesene (6.19%), sabinene (5.19%), α-pinene (4.33%).

The major identified compounds in Balady local were (cis trans farnesene (27.29%), β-asarone (17.11%), carotol (14.85%), and caryophyllene oxide (3.39%).

INTRODUCTION

Oil is being used for the flavoring of all kinds of food substitutes and the essential oil of carrot fruits is used in modern perfume compositions, preparation of alcoholic liquors and blending with many types of scents. Also oil of herb has an order and flavor differing from that of carrot (Gnenther, 1962).

Batt *et al.* (1983) reported that effect of the volatile fraction of carrot seed oil (VCSO) and its components on growth and aflatoxin production by *Aspergillus parasiticus* was studied. Geraniol, citral and terpineol prevented the growth of *A. parasiticus* and therefore are considered aflatoxins.

Sayed *et al.* (1986) found that the essential carrot seed oil had marked inhibitory activity against some pathogens at relative high concentration.

Dwivedi *et al.* (1991) suggested that the essential oil of *Daucus carota,* L. may be of use in preventing fungal growth on stored food commodities.

Sharma *et al.* (1994) stated that the carrot seed oil was nearly equitoxic to two insect species i.e. *Aedes aegypti* and *Culex fatigans*. He added that the carrot seed oil exhibited significant toxicity against yellow fever mosquito El-Antaki (1823) and Ibn Sina (1953) reported that carrot fruits have a powerful diuretic, antispasmodic, emenagogue and aphrodisiac effects. It has anti-inflammatory effect in urinary tract and uterine infections, disintegrate urinary calculi and facilitate pregnancy.

Guenther (1962) reported that volatile oil yield varied from 0.4 to 0.8 percent of oil obtained from French carrot seed. He mentioned that the constituents of carrot seed oil were established as:- *t.a*- pinene, *t* - limonene, daucol, asarone, carotol and bisabolene while the essential oil constituents of carrot in herb were *t* - & pinene and carotol.

Gambir *et al.* (1966) found that, aqueous extract of the fruits of "*Daucus carota,* L." has a cholinergic activity on the smooth muscles.

Buttery *et al.* (1968) found that a steam distilled volatile oil obtained from carrot root (*Daucus carota*, L. var. sativa; type Imperator), has been analysed, using gas liquid chromatography separation with characterization by mass and infra red absorpation spectrometry. Major identified components were terpinolene, *r* - bisabolene, *r*- terpinene, caryophyllene, eight other terpenoid hydrocarbons, falcarinol, terpinene- 4-ol, bornyl acetate, *r* - terpineol, myristicin, 2- nonenal, octanal, and eight other oxygenated compounds were also identified.

Seifert *et al.* (1968) studied the composition of carrot seed oil using GLC and found the identities of 23 components. Of these, camphene, *a*-terpinene, terpinene-4-ol, - *a* -terpineol, bornyl acetate, *r* - decanolactone, *B* - selinene, *a* -gurjunene were identified.

Heatherbell (1970) found that 23 compounds including diethyl ether, acetaldehyde, acetone, propnal, methanol, ethanol and (-∞phellandrene which have not previously been reported in raw carrot were positively identified using conventional methods. myristicin, 2-decanal, 4 sesquiterpenes and an aromatic compound (mol. wt. 134) were tentatively

identified. alsa acetaldehyde, sabinene, myrcene, terpinolene and to lesser degree caryophyllene and carotol characterized raw carrot aroma were identified .

Chelovskaya and Nikolaev (1972) reported that the essential oil of wild species contain insignificant amount of monoterpenes, while sesquiterpenes account for 7.2 - 25.6 %; *acyclic monoterpenes predominate.* Hilal *et al.* (1975) reported that the percentage of the volatile oil in the fruits of *Daucus carota,* L. grown in Egypt was 1 % and it was noticed to be slightly lower than that reported in the literature. Moreover he revealed that the essential oil consisted of 27 components. The main components were: camphene, *a*-pinene; *B*-pinene, ^{3} carene, myrcene, limonene, *r*- terpinene, *p*-cymene, carotol and daucol. This variation could be attributed mainly to the difference in geographical habitat and he added that the essential oil of fruits of *Daucus carota*, L. contained in general, a low percentage of hydrocarbons, which their amounts did not exceed 10.7 of the total constituents of the oil. (-pinene was the major identified hydrocarbon (3.5 %) followed by *a*-pinene (3.2%) (.cymene (1.6%) ^{3} carene and myrcene (1.4%); *r*- terpinene and limonene, 0.6 % for each. The major constituents of the oil were the sesquiterpene alcohol carotol and daucol (37.2 and 24.5 %) respectively.

Ashraf *et al.* (1977) reported that the yield, physical properties and chemical composition of essential oil from fresh seeds of Pakistani red, blanch and yellow carrots were determined. This results showed yields of 2.1 , 2.0 and 1.3 % respectively, containing 30.2, 28.6 and 10.1 % hydrocarbons and 62.8, 64.9 and 77.5 % carotol. Oil from red and black carrot seed had similar percentage of hydrocarbons fractions, but the black variety contained no-daucol. Overall results indicated that the Pakistani carrot oil is one of the best oils produced anywhere.

Seifert and Buttery (1978) identified the following compounds by GLC and IR Spectra, (humulene, B-farnesene and bisaboliene (0.3- 0.3 - 6.9 relatively % of whole oil respectively.) in carrot root volatile oil.

El-Gendi (1988) reported that the essential oils of carrot seeds for two varieties under studies were fractionated by GLC. There were 16 substances. Of these, most prevalent volatile compounds were Carotol, Daucol, (-Bisabolene.

The aim of this investigation is to evaluate two carrot varies namely Balady Selected and Chantenay Red Cored. The evaluation covered the vegetative growth and the chemical characters in the different parts of both varieties during two seasons of 1994/1995 and 1995/1996 respectively Also, the study will cover the possibility to produce volatile oil from the different parts of carrot plant other than the volatile oil produced from seeds.

MATERIAL AND METHODS

This investigation was carried out in Mallawi Agricultural Research station El- Minia governorate, Egypt. The soil type was loamy clay. Two varieties of carrot (Balady Selected and Chantenay Red Cored) were used in this investigation. The sources of seeds for this study were local production of Balady Selected obtained from Prof. Dr. Abou El- Maarif El- Damarany, Professor of vegetable crops Department of Horticulture, Assuit University and Ohlsens Enke-Denmark Co. for Chantenay Red Cored. The seeds of the two varieties were sown on 15 Sept. in the two seasons of 1995 and 1996 respectively. The plants of the two varieties were harvested in six growth periods. The growth periods were 60, 75, 90, 105, 120 and 135 days after sowing. The experimental design was split plot with six replications. The varieties were in the main plots and the different six growth periods of carrot plants were in the subplots. Each subplot consisted of six ridges, 3 m. long and 60 cm. wide (1/333.33 of feddan). The plants were thinned at the space of 5 cm. between plants. Normal cultural practices of fertilization and irrigation as well as pest control were followed. The sampling was taken every 15 days interval starting after 60 days from sowing till, the growth period of 135 days after sowing. Ten plants were randomly taken from each plot and the following data were recorded:-

The study of the volatile oil in herb, root and seeds (fruits).

1 - Volatile oil percentages and volatile oil yields:-

The volatile oil percentages were determined according to **Guenther** (1962) in the lab. of Midicinal and Aromatic plants Res. Dept. using the volatile oil determination apparatus.

The determination was carried out on the fresh herbs and roots of chantencey Red Cored as well as Balady selected varieties as well as on the dried seed of the two previous varieties in addition to the Balady local variety. One hundred grams were taken from the fresh herbs and root as well as the dried seeds. The samples were prepared before being introduced in the apparatus by cutting into small parts for the fresh samples and crushing for the seeds. The previously prepared sample was introduced in the apparatus and the distillation is carried out for 3 hrs. At the end of distillation the volume of volatile oil is measured and the percentages were calculated. The volatile oil yield/feddan was calculated using the volatile oil percentages and fresh weight of herbs and roots or the weight of the dried seeds.

2- Chemical composition of the volatile oil of carrot plant parts {herb, root, seed (fruits):-

Two methods were followed, viz, the gas liquid Chromatography and gas identification of the volatile oil constituents in herb and roots, of Balady Selected and Chantenay Red Cored carrot varieties and the volatile oil constituents in seeds of Chantenay Red Cored, Balady Selected and Balady Local.1- gas liquid chromatography (G L C):- G-C. The gas liquid chromatography analysis was carried out in laboratory of Cato Aromatic company. The instrument used was Hewlett Packard 5890 Series II Plus gas

chromatograph. Different operating conditions were tried for adopting the possible best resolution of the essential oils under study. Accordingly, the following operating conditions were achieved: HP carbowax 20M, capillary column 50m., i.d. 0.320 mm., initial temperature 60(C 0.710 spring and 0.686 autumn grown carrots).

Carrot seeds production:-

a) Chantenay seeds production was according to Abd El-Aziz (1991).

b) Balady seeds production :-

They were produced locally from selected plants of this cultivar and planted the stecklings on rows. b as previously mentioned in case of the herbc as previously mentioned.

Statistical analysis:-

Data were subjected to statistical analysis according to Steel and Torrie (1982) and treatments were compared using L.S.D 5% test.

RESULTS

Study of the volatile oils:

1- Percentage volatile oil in fresh herb:

Data presented in Table (1) show the effect of growth periods on the volatile oil percentages in the fresh weight in Balady selected and Chantenay Red C ored v arieties d uring 1 995 a nd 1 996 s easons, T he o bserved r esults show that the volatile oil percentages gradually increased with significant values till the 90 days growth period and then tended to decrease with the advance in growth periods till 135 days in the Balady selected variety. Such a trend was similar in both seasons in most cases with one exception in the last sampling growth period (135 days) where, the values were slightly increased. The mean values of the two seasons showed a similar trend. Also, the values within the growth periods showed similar values in this respect. On the other hand, the Chantenay Red Cored variety exhibited a similar trends as that obtained in case of Balady Selected variety regarding the obtained values in both seasons as well as the mean values of both seasons for each growth periods. In general it can be noticed that volatile oil percentages determined on the fresh weight basis in Chantenay Red Cored variety is slightly higher than that of the Balady Selected.

2- Volatile oil yield in fresh herb:

Data presented in Table (2) show that the volatile oil y ield of fresh herb was of higher values in the second season than in the first season (1833.47 ml/fed) where the obtained values reached (1747.66 ml/fed).

The Balady, Selected exhibited significant values higher than Chantenay Red Cored. The result found were 3026.6 and 553.58 m^1./fed of volatile oil yield of fresh herb in Balady Selected and Chantenay Red Cored.

It could be concluded that the oil y ield of fresh herb was gradually increased in both varieties as the growth period was increased. On the other

hand in Balady Selected, the increment took place till the 90 days after sowing, then oil yield was decreased till the end of experiment.

The interaction between season and growth period; variety and growth period; season, variety and growth period were significant.

Table (1): Mean values of the volatile oil percentage of carrot fresh herb plant for Balady Selected and Chantenay Red Cored varieties during six growth periods in 1994/1995 and 1995/1996 winter seasons.

Variety	Growth period (days)	Seasons		means
		1994/95	1995/96	
Balady Selected	60	0.017	0.017	*0.017*
	75	0.020	0.025	*0.022*
	90	0.028	0.034	*0.031*
	105	0.021	0.021	*0.021*
	120	0.018	0.015	*0.017*
	135	0.012	0.018	*0.015*
Means		*0.019*	*0.022*	*0.021*
Chantenay Red Cored	60	0.020	0.020	*0.020*
	75	0.019	0.020	*0.020*
	90	0.032	0.034	*0.033*
	105	0.024	0.026	*0.025*
	120	0.023	0.026	*0.025*
	135	0.021	0.024	*0.023*
Means		*0.023*	*0.025*	*0.024*
Means		0.021	0.023	

Coefficient of variation	= 17.19 %
L.S.D. 5% Season (S)	= 0.00077
L.S.D. 5% Variety (V)	= 0.0011
L.S.D. 5% growth period (G)	= 0.00134
S x V	N.S.
SxG	N.S.
L.S.D. 5% VxG	= 0.0031
SxVxG	N.S.

Table (2): Mean values of the volatile oil Yield of carrot yield fresh herb plant (cm^3/Fed) for Balady Selected and Chantenay Red Cored varieties during six growth periods in 1994/1995 and 1995/1996 winter seasons.

Variety	Growth period	Seasons		means
	(days)	1994/95	1995/96	
Balady Selected	60	851.23	852.73	*851.97*
	75	1583.74	1967.65	*1775.7*
	90	4014.49	4696.98	*4355.7*
	105	3495.71	3311.43	*3403.6*
	120	4049.39	2978.50	*3513.9*
	135	3589.25	4927.56	*4258.4*
Means		2930.64	3122.47	3026.6
Chantenay Red Cored	60	177.96	192.43	*185.19*
	75	327.65	282.52	*305.09*
	90	646.88	647.07	*646.97*
	105	669.54	617.93	*643.74*
	120	754.21	731.20	*742.71*
	135	799.92	795.61	*797.76*
Means		562.69	544.46	553.58
Means		1746.66	1833.47	

Coefficient of variation	**= 29.97 %**
Season (S)	**N.S.**
L.S.D. 5% Variety (V)	**= 184.43**
L.S.D. 5% growth period (G)	**=307.29**
S x V	**N.S.**
L.S.D. 5% S x G	**= 435.24**
L.S.D. 5% VxG	**= 435.24**
L.S.D. 5% SxVxG	**= 615.53**

3- Percentage volatile oil in root at harvesting stage:-

The data in Table (3) show that the percentage volatile oil in root at harvesting stage in Chantenay Red Cored variety was higher than that of Balady Selected (0.02, 0.017 respectively). Chantenay Red Cored variety comes before Balady selected variety.

4- Volatile oil yield in root at harvesting stage:-

The data in Table (3) showed that the chantenay Red Cored variety is of high volatile oil yield in fresh root at harvesting stage compared with the Balady Selected. The obtained values were significant between Chantenay Red cored and Balady Selected.

In this connection no literature was recorded neither for the volatile oil percentage of herb and roots nor for their oil yields.

Table (3): Mean values of the volatile oils percentage of carrot root and yield of carrot root (kg/fed) for Balady Selected, and Chantenay Red Cored in 1994/1995 winter season

Variety	Volatile oil in carrot root in 94/1995	
	%	Yield
Balady Selected	0.017	2,597
Chantenay Red Cored	0.020	3,727
coefficient of variation	= 15.01%	16.68 %
Varieties (V)	= N.S	802.80

5- Percentage volatile oil in Fruits (seeds):

The data in Table (4) show that the local Balady variety is of higher volatile oil percentage in compared with those of the Balady Selected and Chantenay Red Cored. Chantenay Red Cored variety comes after the local Balady variety while the lower oil percentage in the seeds was that of Balady Selected one in this concern.

6- Volatile oil yield in Fruits (seeds):

The data in table (4) show that the Balady Local was Excelled Chantenay Red Cored and Balady Selected. The Balady Local had higher values than Chantenay Red Cored and Balady Selectesd (12047.6, 7048.2 and 6036.8 cm^3./fed. respectively.

Table (4): Total yield of seeds (fruits) (kg/fed) oil percentage and volatile oil yield for Balady Selected, Chantenay Red Cored and Balady Local.

Variety	Seed yield Yield of seeds (fruits) Kg.	Volatile oils	
		%	Yield (kg)
Balady Selected	555	0.128	6,037
Chantenay Red Cored	270	0.223	7,048
Balady Local	768 *	0.273	1,205

* The figure is according to Souror *et al.*, 1963.

Chemical composition of the volatile oil obtained from carrot plant parts (herb, root seeds {fruits}):-

The chemical composition of the volatile oils distilled from the different parts of carrot plant (i.e. herb and roots) in Balady Selected and Chantenay Red Cored also, fruits (seeds) Balady Selected , Chantenay Red Cored and Balady locale ones. The volatile oil samples were subjected to gas liquid chromatography analyses (G.C) and the separated components (peaks) were identified by gas chromatography -mass spectrometry method (GC- MS) (Fig. G C: 1-7) (Fig. G C MS: 8-46).

Table (5): Chemical composition of carrot herb essential oil in Balady Seleected and Chantenay Red Cored.

Constituents	RT.	Balady Selected herb		Chantenay Red Cored herb	
		Peak No.	Area %	Peak No.	Area %
Terpene hydrocarbons					
α-Pinene	4.057	3	0.8327165	3	2.8145682
Camphene	4.655	4	0.0614501	4	0.1486507
β-Pinene	5.337	5	0.2667313	5	0.3852576
Sabinene	5.586	6	0.3750832	6	4.1512065
β-Myrcene	6.493	7	15.14432	7	15.598761
Limonene	7.324	8	12.834037	8	5.2714325
β-Phellandrene	7.530	9	0.6852613	9	0.458093
Cis-Ocimene	8.213	10	0.2991496	10	0.9564645
γ-Terpinene	8.547	11	3.2148556	11	1.2555679
Trans-Ocimene	8.777	12	2.7831544	12	8.5924762
ρ-Cymene	9.239	13	0.3749529	13	0.3325362
Terpinolene	9.644	14	1.1752772	14	0.6788241
Ylangene	17.295	17	0.0895443	18	0.2657008
β-Bourbonene	18.257	18	0.1616616	19	0.3865059
β-Caryophyllene	21.482	22	7.4831629	23	17.335626
α-Caryophyllene	24.040	23	4.2364423	24	1.3416416
β-trans-Farnesene	24.242	24	0.5127795	25	0.4311434
Germacrene D.	25.721	25	1.3635612	26	9.3491996
α-Farnesene	27.382	27	0.8083344	28	0.9086257
Δ- Elemene	28.245	29	1.586126	30	1.0838132
Germacrene B	29.968	30	0.0646021	31	0.4064287
Bicyclo (3.1.1) heptene , 2,6,6-tri methyl-	34.230	32	0.6793645	33	0.5955592
Oxygenated terpens					
2-Propanone	2.547	1	0.0174399	1	3.9330123
Ethyl acetate	2.840	2	1.9609227	2	0.1693687
Cis-3Hexenyl Acetate	10.716	15	0.1357035	15	0.1220232
Nonanal	13.500		----------	16	0.2316841
Menthone	15.934	16	0.2260033	17	0.2963853
2-Hexen-1-ol	18.734	19	0.1113084	20	0.8464211
Linalool	19.315	20	0.2206762	21	0.4242776
Iso-Bronyl acetate	20.590	21	0.8179075	22	0.2582108
cis trans Farnesol	26.441	26	8.4039322	27	1.0827663
Geranyl acetate	27.603	28	6.2256154	29	2.3507671
Geraniol	30.777	31	0.0558235	32	0.2834793
Caryophyllene Oxide	35.424	33	0.4023307	34	1.5458123
Carotol	36.786	34	0.4351397	35	5.9942096
4,7(1H,8H)-Pteridinedione,2-amino	37.305	35	0.5001977	36	0.1161037
Epi-α Bisabolol	43.448	36	0.8990118	37	0.3637291
β-asarone	51.150	37	0.8921869	38	0.1193152
1-Heptadecanol	58.650		----------	39	0.3258719
Phytol	60.595	38	1.6116543	40	2.8117798
Total Area identified			77.948409		93.066827
Unidentified components area %		22.051591		5.976711	
No. of unidentified components		60		54	

Table (6): Chemical composition of carrot root volatile oil in Balady Seleected and Chantenay Red Cored .

Constituents	RT.	Balady Selected root		Chantenay Red Cored root	
		Peak No	Area %	Peak No	Area %
Terpene hydrocarbons					
α-Pinene	4.038	4	0.4343046	4	1.6601441
β-Pinene	5.320	5	0.9657325	5	1.7963761
Sabinene	5.541	6	0.0747601	6	1.4826212
β-Myrcene	6.376	7	0.4998088	7	1.45392
Limonene	7.276	8	3.4442756	8	5.773188
γ-Terpinene	8.529	9	1.3064035	9	4.3494338
ρ-Cymene	9.207	10	3.7866381	10	0.9340234
Terpinolene	9.720	11	7.5466362	11	16.16067
β-Caryophyllene	21.460	14	9.50605	14	25.41982
α-caryophyllene	24.017	15	2.9278379	15	1.8700217
α-farnesene	27.710	17	1.7099614	17	14.369922
Δ- Elemene	28.260	18	3.6455439	18	2.7195049
Iso Pentatriacontane	51.120	22	0.0931549	23	0.1317062
pentatriacontane	54.913	23	0.1279337	24	0.3357744
Oxygenated terpens					
2-Propanone	2.554	1	7.4634181	1	2.7351721
Ethyl acetate	2.847	2	0.4571465	2	0.3650187
Ethanol	3.073	3	0.4218357	3	0.8461589
Menthone	15.902	12	1.4055056	12	0.3742676
Iso bronyl acetate	20.563	13	0.2687301	13	0.5431999
Cis trans fernesol	26.434	16	5.7414664	16	2.2346948
Cumin alcohol	29.949	19	2.4798303	19	0.4876077
Caryophyllene Oxide	35.381	20	3.8616855	20	1.590728
Carotol	36.650	21	0.5979322	21	0.6359357
Gossonorol	46.025		------	22	0.2584589
Phytol	60.374	24	15.19513	25	0.4697682
Total Area identified %			80.961714		88.998132
Unidentified components area %			19.03828		11.001868
No. of unidentified components			82		60

The following are the results obtained from each oils samples as shown in GC chromatograms designated as retention times and relative peak area percentages also, the separated peaks were identified from mass spectrum of each components. The compounds of relative area greater than 1% was considered as major compounds from the compounds identified while those which are lesser than 1% were considered as minor ones.

Table (7): Chemical composition of carrot fruits (seed) volatile oil in Balady Seleected, Chantenay Red Cored and Balady Local.

constituents	RT.	Chantenay Red Cored fruits (seeds)		Balady Selected fruits (seeds)		Balady locale fruits (seeds)	
		Peak No.	Area %	Peak No.	Area %	Peak No.	Area %
Terpene hydrocarbons							
2-Hexene, 4 methyl	2.854	2	0.192214		-------	2	0.0890628
α-Pinene	4.045	4	4.3277205	2	0.23093	4	0.442609
β-Pinene	5.325	5	1.0444989	3	0.38239	5	0.3991415
Sabinene	5.547	6	5.1914337		-------	6	0.114825
β-Myrcene	6.385	7	0.5561699		-------	7	0.5543277
Limonene	7.265	8	1.9734287	4	0.09358	8	1.4153803
γ-Terpinene	8.525	9	0.4183745		-------	9	1.3700889
ρ-Cymene	9.245	10	2.044515		-------	10	3.1433622
Terpinolene	9.638	11	0.0996931		-------	11	1.2930531
β-Garjunene	17.257	13	0.3117099		-------	13	0.3117099
α-Trans Bergamotene	21.209		-------	5	0.58793		-------
β-Caryophyllene	21.295	15	3.078677	6	2.00664	15	2.9398044
β-Cis Farnesene	23.205	16	1.8863662		-------	16	0.2696811
α-Cedrene	23.479		-------	7	0.62635		-------
α-cis Bergamotene	23.824		-------	8	0.12155		-------
α-caryophyllene	23.845	17	0.5317199		-------	17	0.5034332
β-trans-farnesene	24.208	18	4.1786903	9	0.41894	18	0.2619299
Valencene	25.967	19	1.1555405	10	0.29867	19	2.6861018
β- Selinene	26.163	20	0.5429383		-------	20	1.3513948
β-Bisabolene	27.365		-------	11	72.45236		-------
α-Farnesene	27.590	22	6.1868222		-------	22	0.3211025
Δ-Selinene	28.274		-------	12	0.23726		-------
Copaene	28.393		-------	13	0.39159		-------
3-Heptadecen-5-yne, (Z)-	33.335	25	0.2840791		-------	25	0.1466198
4-Tridecen-6-yne, (E)-	35.153	26	0.2457588		-------	26	0.1157193
α-Gurjunene	46.083		-------	17	0.58279		-------
Oxygenated terpens							
2-Propanone	2.560	1	0.1822481	1	0.90319	1	1.1027078
2- Butanol	3.080	3	0.0537178		-------	3	0.3647626
Menthone	15.915	12	0.8036348		-------	12	0.0779578
Linalool	19.290	14	0.5960552		-------	14	0.5515818
Cis -trans Farnesol	26.775	21	3.8087114		-------	21	27.288662
Cumin alcohol	29.968	23	0.147972		-------	23	0.1091754
Benzene,1,4-dimethoxy-	31.534	24	0.0497313		-------	24	0.1211619
Caryophyllene Oxide	35.460	27	2.8150256		-------	27	3.3910867
Carotol	36.885	28	35.863526	14	0.64255	28	14.847551
4,7(1H,8H)-Pteridinedione,	37.520	29	2.1437273		-------	29	0.8129545
Propanal butylhydrasone	40.640	30	0.1218794		-------	30	0.2900065
γ-Decalactone	41.005		-------	15	0.11464		-------
Iso-Spathulenol	41.387	31	0.1776206		-------	31	0.8355901
α- Cis-Santalol acetate	42.313	32	0.1438553		-------	32	0.9357377
Methyl iso Eugenol	42.365		-------	16	1.34675		-------
Spathulenol	42.720	33	0.1029784		-------	33	0.694275
Myristicin	44.438	34	0.7527484		-------	34	0.1564659
Dendrolasin	45.320	35	0.6252234		-------	35	0.0945346
Daucol	45.639	36	1.0501882		-------	36	1.251845
Ledol	45.760	37	0.7232633		-------	37	1.580942
α-Asarone	47.090	38	0.1366135		-------	38	0.7301636
Cis-cis Farnesol	47.360	39	0.1358436		-------	39	1.0944297
Trans iso Elemicin	47.461		-------	18	0.13913		-------
β-Asarone	51.411	40	1.5621558			40	17.109272
Cis iso Elemicin	51.905		-------	19	11.74666		-------
Total Area identified %			86.247055		93.32366		91.170196
Unidentified components area %			13.752945		6.67634		8.829804
No. of unidentified components			66		28		61

RT. : The retantion time for constituents in volatile oil of three carrot variety.

Volatile oil of carrot herb:-

Table (5) shows the chemical composition of herb volatile oil produced from two varieties namely Balady and Chantenay Red Cored as determined by gas chromatography and mass spectrometry methods.
The gas chromatograms and mass spectrometer charts of Balady variety revealed the presence of (98 compounds) from which (38compounds) were identified. The major identified compounds in Balady variety were {β - myrcene (15.14 %), limonene (12.83 %), cis -trans- farnesol (8.40 %), β - caryophyllene (7.48 %), γ- caryophyllene (4.23 %), γ-terpinene (3.21 %), trans-ocimene (2.78 %), ethyl acetate (1.96 %), germacrene D (1.36 %), terpinolene (1.18 %). The identified compounds represented (77.95 %) from total separated components.

The gas chromatograms and mass spectrometer charts of Chantenay Red Cored variety revealed the presence of (94 compounds) from which (40 compounds) were identified. The major identified compounds in Chantenay Red Cored variety were {β-caryophyllene(17.34%), β - myrcene(15.60%),germacrene D (9.35%), trans-ocimene (8.59%), limonene(5.27%),sabinene(4.15%),2- propanone (3.93%), α -pinene (2.81%), α - caryophyllene (1.34%), γ-terpinene (1.26%), cis-trans-farnesol (1.08 %). The identified compounds represented (93.0%) from total separated components. These results matched with those obtained by Guenther (1962).

Volatile oil of carrot root at harvesting stage:-

Table (6) shows the chemical composition of carrot root volatile oil produced from two varieties namely Balady and Chantenay Red Cored as determined by gas chromatography (G-C) and gas chromatography mass spectrometry (G-C-MS) techniques.
The gas chromatograms and mass spectrometer charts of Balady select variety revealed the presence of (106 compounds) from which (24 compounds) were identified. The major identified compounds in Balady variety were phytol (15.20 %), β - caryophyllene (9.51%), terpinolene (7.55%), 2-propanone (7.46%), cis - trans- farnesol (5.74 %), caryophyllene oxide (3.86%), ρ- cymene (3.65%),Δ-elemene (3.65%), limonene (3.44%), α - caryophyllene (2.93 %), α -farnesene (1.71 %), menthone(1.41%), γ-terpinene (1.31%).The identified compounds represented (80.96 %) from total separated components.

The gas chromatograms and mass spectrometer charts of Chantenay Red Cored variety revealed the presence of (85 compounds) from which (25 compounds) were identified. The major identified compounds in Chantenay Red Cored variety were {β - caryophellene (25.42%), terpinolene (16.16%), α -farnesene (14.37%), limonen(5.77%), γ-terpinene (4.35%), 2-propanone (2.74%), Δ - elemene (2.72 %), cis - trans- farnesol(2 .23%), α-caryophyllene (1.87 %), β-pinene (1.80 %), α-pinene (1.66%), caryophyllene oxide (1.59 %), sabinene (1.48 %), β-myrcene (1.45%). The identified compounds represented (88.10 %) from total separated components. The obtained results mostly matched with these obtained by Gambhir *et al.* (1966), Seifert *et al.* (1968), Seifert and Buttery (1978) where some of the

compounds reported by the author as identified compounds in root oil were found while other compounds identified in our sample were not reported by the author. The variation in the identified compound would be due the genetic factors in addition to environment condition.

Volatile oil of carrot seeds:-

Table (7) shows the chemical composition of seeds volatile oil produced from three varieties namely Balady Selected, Chantenay Red Cored and Balady Local as determined by gas chromatography and mass spectrometry methods.

The gas chromatograms and mass spectrometer charts of Balady Selected variety revealed the presence of (47 compounds) from which (19 compounds) were identified. The major identified compounds in Balady Selected variety were {β-Bisabolene (72.45%), cis -iso Elemicin (11.74666 %), α- caryophyllene (4.35%), β- caryophyllene (2.01%), methyl iso elemicin (1.35%). The identified compounds represented (93.32%) from total separated components.

The gas chromatograms and mass, spectrometer charts of Chantenay Red Cored variety revealed the presence of (106 compounds) from which (40 compounds) were identified. The major identified compounds in Chantenay Red Cored variety were {carotol (35.86 %), α- fernesene (6.19%), sabinene (5.19%), α-pinene(4.33%), trans- β -farnesene (4.18%), cis -trans- farnesene (3.81 %), β -caryophyllene (3.08%), caryophyllene oxide (2.82%), 4,7 (1H ,8H)-pteridinedione , 2-amino (2.14%), ρ-cymene (2.04%), limonen (1.97%), cis-β -farnesene (1.89%), β -asarone (1.56 %), valenecene (1.56%), daucol (1.05%), β -pinene (1.04%). The identified compounds represented (86.25%) from total separated components.

The gas chromatograms and mass spectrometer charts of Balady Local variety revealed the presence of (101 compounds) from which (40 compounds) were identified. The major identified compounds in Chantenay Red Cored variety were {cis -trans- farnesene (27.29%), β-asarone (17.11%), carotol (14.85%), caryophyllene oxide (3.39 %), ρ -cymene (2.04%),β-caryophyllene (3.08%), valenecene (1.56 %), ledol (1.58%), limonen (1.97%), γ-terpinene (1.37 %),β-selinene (1.35%), daucol (1.05%), 2-propanone (2.74%), cis-cis-farnesol (1.09%). The identified compounds represented (91.17%) from total separated components. The data matched mostly with those obtained by Guenther (1962), Hilale *et al.* (1975), Ashraf *et al.* (1977), El-Gendi (1988) and Sharma *et al.* (1994) where some of the identified compounds in our samples were reported by the authors while other compounds that were not detected by the authors were identified the difference in chemical composition is due to the genetic factors and environmental condition.

DISCUSSION

The present investigation was carried out to evaluate two carrot varieties, namely Balady Selected and Chantenay Red Cored. The evaluation covered the vegetative growth and the chemical characters in the different

plant parts of both varieties during the two seasons of 1994/1995 and 1995/1996 respectively. In this connection, we will discuss the uses of the plants (herb, root and seeds) as food and to produce volatile oils (as byproduct), especially from herb and roots which have not been already used in Egypt rather than the seed volatile oil which is usually used as flavoring agent in place of carrot. .

The percentage of volatile oil of carrot herb in the two varieties were increased starting from the first age (60 days after sowing) till (90 days after sowing) then the percentage volatile oil was decreased till the end of experiment.

The best age of volatile oil percentage and yield in Balady Selected and Chantenay Red Cored was (90 days after sowing) in this concern, the percentage were 0.028 and 0.032 in the first season respectively.

The best age of harvesting herb to get the high volatile oil yield was 120 days after sowing while the favourable age for harvesting roots was 105 days after sowing for Balady selected. On the other hand, the Chantenay Red Cored was of best yield in 135 days after sowing while the harvesting stage was 105 days after sowing till the end of experiment according to the desire of consumer.

The percentage of volatile oil of carrot root at harvesting stage in Balady Selected was less than Chantenay Red Cored (0.02% and 0.02 % respectively.)

The best volatile oil yield of root at harvesting stage in Chantenay Red Cored was higher than Balady Selected (3727.400 and 2596.638 cm^3./Fed. respectively).

Comparing the volatile oil percentage and oil yield in carrot seed of Balady Selectd, Chantenay Red Cored and Balady Local led to conclude which variety is the best. The obtained results show that the best variety is that of Balady local owing to its high yield of oil.

With regard to the volatile oil of carrot herb the main terpene hydrocarbon compounds identified in the Balady Selected were β-myrcene (15.14%), limonene (12.83 %) and β-caryophellene (7.48 %) while those identified in Chantenay Red Cored were β-caryophellene(17.34%), β-myrcene (15.60%) and germacrene D (9.35%).The main oxygenated terpenes identified in Balady Selected were cis -trans- farnesol (8.40 %), geranyle acetate (6.23%) and phytol (1.6116543 %), carotol was found minor value (0.44%), while those in Chantenay Red Cored were carotol (5.10),2-propanone (3.93%) and phytol (2.81). Daucol was not detected in the herb oil of both varieties.

With regard to the volatile oil of carrot root, the main terpene hydrocarbon compounds identified in the Balady Selected were β-caryophellene (9.51%), terpinolene (7.55%) and ρ-cymene (3.79%) while those of Chantenay Red Cored were β - caryophellene (25.41981%), terpinolene (16.16%) and α -farnesene (14.37%). The main oxygenated terpenes of Balady Selected were 2-propanone (7.46%), cis trans farnesol (5.74%) and caryophyllene oxide (3.86%), carotol was detected in minor value (0.60%), while those identified in Chantenay Red Cored were 2-

propanone (2.74%), cis tans farnesol (2.23%) and caryophyllene oxide (1.59%). Daucol was not detected in the carrot oil of both varieties.

With regard to the volatile oil of carrot seed, the main terpene hydrocarbon compounds identified in the Chantenay Red Cored were α-fernesene (6.19%), sabinene (5.19%) and α-pinene (4.33%). The terpene hydrocarbons of Balady Selected were β-bisabolene (72.45%) and β-caryophellene (2.01%). The terpene hydrocarbons in Balady Local were ρ-cymene (3.14%), β- caryophellene (2.94%) and terpinolene (1.29%). On the other hand the oxygenated terpenes in seed volatile oil of Chantenay Red Cored were carotol (35.86%), cis trans farnesol (3.81%) and Daucol was detected (1.05%). In the Balady Selected the oxygenated terpenes were cis iso elemicin (11.75%), and methyl iso eugenol (1.35%). Carotol was detected as (0.64%) and daucol was not detected. In the Balady Local the oxygenated terpenes were β- asarone (17.11%),carotol (14.85%) and cis trans farnesol (3.81%). Daucol was detected in (1.25%).

Owing to that the volatile oil of seed is usually distilled and used, it would be preferable to make a comparison between seed volatile oil and those obtained from either of the herb volatile oil or root oil. Comparing the seed volatile oil with that of herb volatile oil it could be observed that only the Chantenay Red Cored herb volatile oil which carotol is found in lower value (5.99%) (i.e. carotol is one of the two main components of seed volatile oil). Consequently the Chantenay Red Cored herb oil may be considered as an oil of closer value to carrot seed oil in this concern.

Comparing seed volatile oil with the carrot root volatile oil of the two varieties it could observed that the root volatile oils of both varieties are different to the seed volatile oils except of that Balady Selected root oil which contained carotol in minor value. In fact, the main part used of carrot plant is the root which is used in the different purposes previously mentioned. Logically, the volatile oil that would be used instead of a plant part, must be obtained from the same part. In this concern, we may consider the volatile oil obtained from the root as the true substituent of carrot. Although this oil is different from that of the seed. Accordingly, it could be said that, Such an oil should be used as substuent to be used instead of carrot root to get the flavour and aroma characteristic of carrot. Any way, the volatile oils of herb and roots of carrot need more researches from the point of view of food technology, medicine and cosmetics.

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العلاقة بين مرحلة الحصاد ومحتوى الزيت الطيار لبعض أصناف الجذر

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أجرى هذا البحث فى محطة البحوث الزراعية بملوي – محافظه المنيا ــ مصر بهدف دراسة وتقييم نسبه الزيت الطيار في العرش والجذر لصنفي الجذر البلدي المنتخب وشنتناي رد كور ونسبة الزيت الطيارة في البذرة شنتناي رد كور والبلدي المنتخب والبلدي المحلـــي.صممت التجربة على أساس القطع المنشقه في ٦ مكررات. وضعت الأصناف في القطع الرئيسية والأعمار في القطع المنشقة.

فصلت المركبات الكيميائيه للزيت الطيار من الأجزاء المختلفه للجزر (عرش وجذر) لكل من الصنفين البلدى المنتخب والشنتناى رد كورد والثمار (البذور) للصنف البلدى المنتخب والشنتناى رد كورد والبلدى المحلى بجهاز التحليل الكروماتوجرافى الغازى وجهاز التحليل الكروماتوجرافى الغازى المتصل بجهاز طيف الكتله ويمكن تلخيص النتائج فيما يلى:-

ا- مركبات الزيت الطيار فى العرش:-

وجد (٩٨ مركب) من المركبات الكليه فى الزيت الطيار فى الصنف البلدى، تم التعرف على (٣٨ مركب) منها المركبات الرئيسيه التى تم التعرف عليها هى بيتا – ميرسين (١٥,١٤%) وليمونـــين ١٢,٨٣%) وسيس ترانس فارنيول (٨,٤٠%) وبيتا كاريوفلين (٧,٤٨ %).

وجد ٩٤ مركب من المركبات الكليه فى الزيت الطيار فى الصنف الشنتناى رد كورد، تم التعرف على ٤٠ مركب منها المركبات الرئيسيه التى تم التعرف عليها هى بيتا كاريوفلين (١٧,٣٤ %) وبيتا ميرسين (١٥,٦٠%) وجيرماسيرين (٩,٣٥ %) وترانس–أوسيمين (٨,٥٩ %) وتمثل المساحه الكليه للمركبات التى تم التعرف عليها هى (٦٤,٥٦ %) للصنف البلدى المنتحب و (٧٧,٠٧ %) للصنف الشنتناى رد كورد.

ب- مركبات الزيت الطيار فى الجذور:-

وجد (١٠٦ مركب) من المركبات الكليه فى الزيت الطيار فى الصنف البلدى المنتخب تم التعرف على ٢٤ مركب منها.

المركبات الرئيسيه التى تم التعرف عليها هى:-

فيتول (١٥,٢٠ %) وبيتا–كاريوفلين (٩,٥١ %) و تيربينولين (٧,٥٥ %) و٢–بروبانون (٧,٤٦ %).

وجد (٨٥ مركب) من المركبات الكليه فى الزيت الطيار فى الصنف الشنتناى رد كورد تم التعرف على ٢٥ مركب منـــــــــــها:-

المركبات الرئيسيه التى تم التعرف عليها هى:-

بيتا–كاريوفليين (٢٥,٤٢ %) وتيربينولين (١٦,١٦ %) وألفا–فارنيسين (١٤,٣٧ %) والليمونين (٨,٥٩%) وتمثل المساحه الكليه للمركبات التىتم التعرف عليها هى (٧٣,٩٦ %) للصنف البلدى المنتخب و (٨٨,١٠ %) للصنف الشنتناى رد كورد.

ج- مركبات الزيت الطيار فى الثمار (البذور):-

وجد (٤٧ مركب) من المركبات الكليه فى الزيت الطيار فى الصنف البلدى المنتخب تم التعرف على (٢١ مركب) منها.

المركبات الرئيسيه التى تم التعرف عليها هى:-

بيتا–بيزابولين (٧٢,٤٥ %) وسيس ايزواليميسين (١١,٧٥ %) و الفا–كاريوفليين (٤,٣٥ %) وبيتا–كاريوفليين (٢,٠١ %)

وجد (١٠٦ مركب) من المركبات الكليه فى الزيوت الطياره فى الصنف الشنتناى رد كورد تم التعرف على (٤٠ مركب) منها.

المركبات الرئيسيه التى تم التعرف عليها هى:-

كاروتول (٣٥,٨٦ %) والفا–فارنيزين (٦,١٩ %) و سابينين (٥,١٩ %) والفا–باينين (٤,٣٣ %).

وجد (١٠١ مركب) من المركبات الكليه فى الزيوت الطياره فى الصنف البلدى المحلى تم التعرف على (٢٧ مركب) منها.