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Evaluation of Four Novel Imported and Egyptian Curly and Non-Curly Leafed Parsley Genotypes for Yield and Essential Oil Composition Under The Egyptian Sandy Soil Growing Conditions

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Abstract: Four novel parsley genotypes (Moskurl 2 Petra, Moskurl 2 KRA USA, Gewone Dai 3 Rial 10, and Bravour) were imported from Netherlands to be planted and evaluated along with the Egyptian local variety "Egyptian" in the sandy soil under the Middle Egypt growing conditions. Three of the four introduced genotypes are curly-leafed varieties and one is non-curly leafed "Gewone Dai 3 Rial 10" as well as the Egyptian is a non-curly leafed variety. The aims of this experiment were to evaluate and study the growth characteristics (e.g. plant height, plant fresh and dry weights and fresh yield of leaves/m^2) and some chemical properties of these genotypes (e.g. TSS and essential oil contents, essential oil composition and leaves content of chlorophyll a, b, and carotenoids) after adaptation and growing during the two successive winter seasons of 2013/2014 and 2014/2015. All introduced genotypes grew very well under these conditions and showed a very acceptable vegetative growth, profitable yield and high levels of volatile oils rich in anticancer and flavor responsible compounds and their horticultural and chemical proprieties were compared with those of the Egyptian local variety. The obtained data are very promising for Egyptian parsley growers to produce these new imported varieties in order to meet the increasing demand of parsley fresh and dry processed products with different shapes and different tastes of the Egyptian and foreign markets.

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INTRODUCTION

Parsley plant (*Petroselinum crispum* Mill.) which belongs to family Apiaceae is a biennial crop, native to Europe and Western Asia and is cultivated as an annual crop for its aromatic and attractive leaves (Bailey and Bailey, 1976). There are three main types of parsley, the flat leaf type (ssp *neapolitanum*, Danert) which is popular in Egypt and Arab countries (Aziz *et al*., 2013) and the curly leaf type (ssp *crispum*) cultivated for their foliage, and the turniprooted or 'Hamburg' type (ssp. *tuberosum*) cultivated for its enlarged edible roots (Petropoulos *et al*., 2014). Furthermore, parsley is a popular spice plant known from antiquity. Both parsley roots and leaves are widely used as culinary, medicinal and aromatic plant parts. The fresh or dried leaves are used in food, cosmetic and pharmaceutical industries to produce spice, essential oils and drugs (Lopez *et al*., 1999). In food preparation, the fresh parsley leaves are also used as a garnish and for seasoning. The dried leaves known as parsley flakes are particularly used in the instant food sector as an ingredient to flavor soups and sausages.

Parsley is also a very rich source of vitamins C and E, β-carotene, thiamin, riboflavin and organic minerals (Bąkowski and Michalik 1986; Wills *et al*., 1986; Michalik and Dobrzański, 1987, Kołota, 2011). It is also used as a carminative, diuretic, hypertensive, hypotensive, stomachic, nervine, emmenagogic, abortifacient and nutritive agent (Kreydiyyeh and Usta, 2002). As a traditional medicine for diabetes, parsley has been used in the old world (Noel *et al*., 1997; Yanardag *et al*., 2003). Moreover, the hypoglycemic activity of parsley has been investigated in many studies. Phytochemical screening of parsley has revealed the presence of flavonoids such as apiin, luteolin, and apigenin glycosides (Fejes *et al*., 2000), carotenoids (Francis and Isaksen 1989), ascorbic acid (Davey *et, al*. 1996), tocopherol (Fiad and El Hamidi 1993), volatile compounds (myristicin, apiole), coumarines (bergapten, imperatorin) as reported by Fejes *et al*. (2000), phthalides, furanocoumarins, and sesquiterpenes (Spraul *et al*., 1991).

The successful commercial use of parsley 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; Moustafa *et al*., 2016). Hence, introduction of novel crop cultivars or hybrids is considered one of the most important and easiest breeding methods (Petropoulos *et al*. 2006; Moustafa *et al*., 2016). In this study, four novel parsley genotypes (three curly-leafed and one non-curly leafed cultivars) were imported from Netherlands for the first time to be planted and evaluated for their yield of fresh and dried leaves and essential oil composition comparing to the Egyptian local non-curly leafed variety "Egyptian" in the sandy soil under the Middle Egypt growing conditions. This will meet the demand of high quality parsley grown under the Egyptian environmental conditions with distinguished aroma and essential oil content from many countries which is high and is increasing a year after another.

MATERIALS AND METHODS

In the sandy soil of the Scientific Farm of Faculty of Agriculture, Minia University, Shousha region, Minia, Egypt, four novel with curled leaves (Moskrul 2 Petra, Moskrul 2 KRA USA, and Bravour) and non-curly-leafed (Gewone Dai 3Rial 10) parsley cultivars were introduced from the Netherland to be evaluated and compared to the broadly cultivated non-curled Egyptian cultivar (Egyptian). Seeds were obtained from the Bejo Zaden b.v. Trambaan 1, 1749 CZ Warmenhuizen, The Netherlands, and with seeds of the Egyptian cultivar 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 in a Randomized Complete Block Design (RCBD). All horticultural practices suitable for parsley cultivation and production were followed according to the instructions of the Egyptian Ministry of Agriculture. Three cuttings were taken from the plants, the first one was 65 days after seeding and the second cutting was one month after the first one and also the third cutting was taken one month after the second one. Horticultural data (e.g., leaves fresh and dry weights/plant (g), shoot and root lengths (cm) as average of 20 plants from each replicate, and fresh yield/m^2 (kg)) were recorded as average of the three cuttings. Also, plant fresh samples from the five cultivars were taken from the second cutting to the Medicinal and Aromatic Plants Research Department, National Research Center, Cairo, Egypt to estimate the essential oil content and to do the gas chromatography (GC) analysis for the obtained essential oil of samples from all studied cultivars.

Horticultural recorded data

Shoots and roots length (cm)

Ten plants from all genotypes at the time of cutting were collected for each replication, the shoots and roots lengths were estimated using a ruler, and then the average was recorded for the three replications.

No. of leaves/plant

Number of leaves of each plant for all genotypes and replications were counted and the average of ten plants (as one replication) was recorded.

Plant fresh weight (g)

All plants previously collected for the three replications of all genotypes were weighed and the average was recorded.

Leaves cutting fresh weight/1m^2 (kg)

One square meter of all parsley genotypes at the time of cutting (as fresh yield) was cut, weighed using a scale and recorded. Each square meter cut of each genotype was considered as a replicate and three replicates were recorded for each genotype.

Leaves cutting dry weight/1m^2 (kg)

All previously collected fresh cuttings per square meter were completely air dried, then weighed and considered as dry weight of one square meter as dry yield.

Dry weight of 100 g fresh leaves (g)

One hundred grams of fresh leaves from all studied genotypes were taken, completely air dried and then weighed and considered as dry weight of 100 g of fresh leaves. This was replicated three times for each genotype.

Humidity (%)

Humidity percentage in fresh parsley plants of all genotypes was calculated as follow:

$$Humidity\ \% = \frac{Plant\ fresh\ weight - Plant\ dry\ weight}{Plant\ fresh\ weight}\ X\ 100$$

The average of ten plants was considered as one replicate and three replicates were recorded for each genotype.

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%.

Chlorophyll a, b and carotenoids content

One gram of fresh leaves per replicate for each parsley genotype was collected, put in glass tubes (slants) and 10 ml of ethanol (70%) were added to each tube. The tubes were shaked gently and then were incubated in a refrigerator for proper time in the dark at 4°C till the complete dissolving of the green and other pigments. Five ml from the solutions were taken and chlorophyll a, b, and carotenoids were estimated using a spectrophotometer at the wave lengths of chlorophyll a, b, and carotenoids and readings were used for the following equations to record the content as mg/g fresh plants according to Francis and Isaksen (1989) and Ritchie (2006):

Chlorophyll (a) = 16.72 x A665.2 – 9.16 x A652.4
Chlorophyll (b) = 34.09 x A652.4 – 15.28 x A665.2
C x+c = (1000 x A470 – 1.63 x Chlorophyll (a) – 104.96 x Chlorophyll (b)/221

A = Absorbance at the described wave length, C x+c = Carotenoids

Essential oil content (%)

Two hundred grams of dried plants from all genotypes were collected and the essential oil was extracted according to Singleton and Rossi (1965).

Gas chromatography (GC) analysis

The GC-Ms analysis of the essential oil samples from all parsley genotypes was carried out using gas chromatography-mass spectrometry instrument stands at the Department of Medicinal and Aromatic Plants Research, National Research Center, Egypt with the following specifications. Instrument: a TRACE GC Ultra Gas Chromatographs (THERMO Scientific Corp., USA), coupled with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer). The GC-MS system was equipped with a TG-WAX MS column (30 m x 0.25 mm i.d., 0.25 µm film thickness). Analyses were carried out using helium as the carrier gas at a flow rate of 1.0 ml/min and a split ratio of 1:10 using the following temperature program: 40°C for 1 min; rising at 4.0°C/min to 160°C and held for 6 min; rising at 6°C/min to 210°C and held for 1min. The injector and detector were held at 210°C. Diluted samples (1:10 hexane, v/v) of 0.2 µl of the mixtures were routinely injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. Most of the compounds were identified using mass spectra (authentic chemicals, Wiley spectral library collection and NSIT library).

Statistical analysis

All obtained 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 according to Gomez and Gomez (1983) using the MSTAT-C software version 4.0 (Michigan University, USA).

RESULTS

The introduced parsley curly-leafed and non-curly leafed (smooth) genotypes showed different agronomical growth behaviors (Figure 1) and horticultural characteristics along with different and sometimes similar chemical proprieties as described in Tables (1, 2, 3, and 4).

Moskurl 2 Petra **Moskurl 2 KRA USA** **Gewone Dai 3** **Bravour** **Egyptian**

Figure (1): Photo showing the phenotype of whole plants (curled and non-curled leaves and roots) of all introduced and evaluated foreign and Egyptian parsley cultivars two weeks before the first cutting.

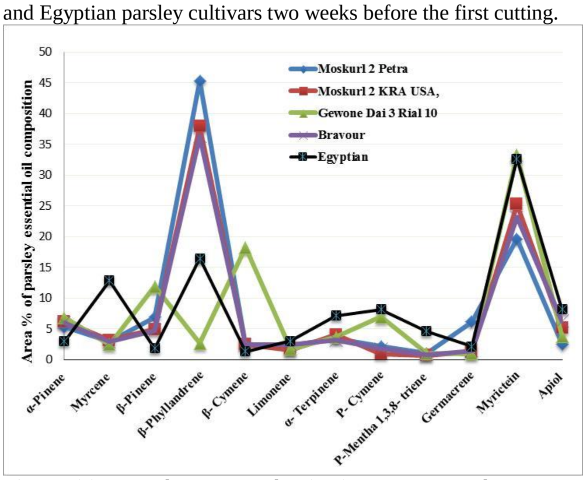

Figure (2): Gas chromatography (GC) mass spectrophotometric analysis of the essential oil fractionation composition extracted from leaves of three foreign curly- **(** Moskurl 2 Petra, Moskurl 2 KRA USA and Bravour) and one non curly-(Gewone Dai 3 Rial 10) leafed parsley cultivars planted, adapted and evaluated under the Middle Egypt growing conditions along with the non-curly leafed Egyptian cultivar.

Horticultural characteristics

Shoot length (cm)

Figure (1) and data presented in Table (1) showed that the non-curly leafed parsley cultivars (Gewone Dai 3 Rial 10 and Egyptian) had bigger vegetative growth and significantly longer shoots (31.0, 32.7 and 29.4, 28.7 cm) comparing to the other evaluated cultivars in the first and second seasons, respectively.

Root length (cm)

The Egyptian cultivar had significant longer roots (28.4 and 27.4 cm) followed by Moskrul 2 KRA USA (22.3 and 22.0 cm) and Moskrul 2 Petra showed the shortest roots (14.0 and 13.0 cm) in the first and second seasons, respectively. On the other hand, Gewone Dai 3 Rial 10 and Bravour had similar root lengths in the two seasons, too (17.0, 17.3 and 17.0, 17.0, respectively) and their values were intermediate between the highest and lowest values of the other cultivars (Table 1) and Figure (1).

No. of leaves/plant

Gewone Dai 3 Rial 10 had the significant highest values of average No. of leaves/plant (27.7 and 28.3) followed by the Egyptian cultivar (15.7 and 15.0) in the first and second seasons, respectively and the other three cultivars had the significant lowest values (Table 1).

Single plant fresh weight (g)

This character was almost similar to the shoot length character as the two non curly-leafed Gewone Dai 3 Rial 10 and Egyptian cultivars showed the significant highest values of single plant average fresh weight (45.9, 50.3 g and 46.0, 44.6 g) comparing to those of the other evaluated cultivars which are all curly-leafed (Table 1).

Leaves fresh weight/1m^2 cutting (g)

When a one meter square of fresh leaves from all the evaluated introduced and local parsley cultivars were cut and weighed, the Gewone Dai 3 Rial 10 showed the significant highest values in the two seasons (1450.0 and 1577.3 g/1m^2) comparing to all other cultivars. On the contrary, Bravour showed the significant lowest values in the two seasons, too (830.7 and 865.0 g/1m^2), while the other three cultivars showed almost similar values which is between the highest and lowest values in the two seasons (Table 2).

Dry weight of 1m^2 cutting (g)

Somehow different from the previous character, this character presented in Table (2) declared that the Egyptian and Gewone Dai 3 Rial 10 cultivars showed almost similar (insignificant differences in the first season) with values of (296.4 and 293.9 g/1m^2, respectively) and significant differences in the second season (289.3 and 369.0 g/1m^2, respectively). The other cultivars showed significantly lower values.

Dry weight of 100 g fresh weight (g)

When a hundred grams of fresh cut plants of all cultivated and evaluated parsley cultivars were dried and then weighed, Gewone Dai 3 Rial 10 and Egyptian cultivars almost showed the significant highest values with insignificant differences in the first season (26.5 and 25.3 g, respectively) and significant differences in the second season (27.9 and 24.6 g, respectively) as shown in Table (2). The other cultivars showed values significantly lower than these two cultivars.

Table (1): Performance and horticultural characteristics (shoot and root weights, No. of leaves/plant, and single plant fresh weight) of curled and smooth parsley genotypes planted, adapted and evaluated under the Middle Egypt growing conditions during the two successive winter seasons of 2013/2014 and 2014/2015

Genotypes	**Fresh weight of 1m^2 cutting (g)**		**Dry weight of 1m^2 cutting (kg)**		**Dry weight of 100g fresh plants**	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Moskrul 2 Petra	**1126.7** B	**1136.7**	**258.8** B	**260.7** C	**23.0** B	**22.5** B
Moskrul 2 KRA USA	**1231.7** B	**1297.3** B	**261.3** B	**269.0** BC	**22.7** B	**21.1** C
Gewone Dai 3 Rial 10	**1450.0** A	**1577.3** A	**293.9** A	**369.0** A	**26.5** A	**27.9** A
Bravour	**830.7** C	**865.0** D	**208.**1 C	**210.1** D	**17.8** C	**17.8** D
Egyptian	**1223.3** B	**1143.3** C	**296.4** A	**289.1** B	**25.3** A	**24.6** B
Mean	**1172.7**	**1203.9**	**263.7**	**279.6**	**23.0**	**23.0**
L.S.D. at 0.05	159.4	113.7	14.66	22.02	1.71	1.94

Table (2): Performance and horticultural characteristics (cutting fresh and dry weights/m^2 and dry weight of 100 g fresh weight) of curled and smooth parsley genotypes planted, adapted and evaluated under the Middle Egypt growing conditions during the two successive winter

Genotypes	**Shoot length (cm)**		**Root length (cm)**		**No. of leaves/plant**		**Single plant fresh weight (g)**	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Moskrul 2 Petra	**21.3** B	**22.7** C	**14.0** D	**13.0** D	**10.3** C	**12.0** C	**29.2** B	**30.6** C
Moskrul 2 KRA USA	**19.0** B	**20.0** D	**22.3** B	**22.0** B	**10.0** C	**10.3** C	**22.7** B	**24.0** C
Gewone Dai 3 Rial 10	**31.0** A	**32.7** A	**17.0** C	**17.3** C	**27.7** A	**28.3** A	**45.9** A	**50.3** A
Bravour	**20.3** B	**20.7** CD	**17.0** C	**17.0** C	**10.7** C	**10.7** C	**23.0** B	**23.0** D
Egyptian	**29.4** A	**28.7** B	**28.4** A	**27.4** A	**15.7** B	**15.0** B	**46.0** A	**44.6** B
Mean	**24.2**	**24.9**	**19.7**	**19.3**	**14.9**	**15.3**	**33.4**	**34.5**
L.S.D. at 0.05	3.93	2.12	2.0	2.44	2.28	1.61	6.54	3.95

seasons of 2013/2014 and 2014/2015

Table (3): Laboratory characteristics of curled and smooth parsley genotypes planted, adapted and evaluated under the Middle Egypt growing conditions during the two successive winter seasons of 2013/2014 and 2014/2015

Genotypes	**Humidity (%)**		**Essential oil (%)**		**TSS (%)**	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Moskrul 2 Petra	**77.1** CD	**78.9** B	**0.46** A	**0.46** A	**5.5** AB	**5.8** A
Moskrul 2 KRA USA	**79.0** BC	**80.9** A	**0.37** B	**0.38** BC	**4.8** B	**5.0** B
Gewone Dai 3 Rial 10	**82.6** A	**80.1** A	**0.36** B	**0.34** C	**6.2** A	**6.2** A
Bravour	**76.3** D	**76.3** C	**0.43** A	**0.43** AB	**4.8** B	**4.8** B
Egyptian	**81.0** AB	**80.3** A	**0.20** C	**0.20** D	**6.2** A	**6.3** A
Mean	**79.2**	**79.3**	**0.37**	**0.36**	**5.5**	**5.6**
L.S.D. at 0.05	2.58	1.20	0.06	0.06	0.69	0.52

Table (4): Chlorophyll (a), (b), and carotenoids contents of curled and smooth parsley genotypes planted, adapted and evaluated under the Middle Egypt growing conditions during the two successive winter seasons of 2013/2014 and 2014/2015

Genotypes	**Chlorophyll (a)** mg/g fresh weight		**Chlorophyll (b)** mg/g fresh weight		**Carotenoids** mg/g fresh weight	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Moskrul 2 Petra	**3.48** B	**3.51** B	**3.62** A	**3.73** AB	**4.35** A	**4.33** A
Moskrul 2 KRA USA	**3.67** A	**3.84** A	**3.37** B	**3.47** C	**4.39** A	**4.37** A
Gewone Dai 3Rial 10	**3.65** A	**3.92** A	**3.31** B	**3.28** D	**4.37** A	**4.27** A
Bravour	**3.51** B	**3.45** B	**3.69** A	**3.78** A	**4.37** A	**4.33** A
Egyptian	**3.40** B	**3.48** B	**3.53** AB	**3.58** BC	**4.23** B	**4.19** A
Mean	**3.54**	**3.64**	**3.50**	**3.57**	**4.34**	**4.30**
L.S.D. at 0.05	0.13	0.10	0.24	0.16	0.08	NS

Table (5): Essential oil gas chromatography (GC) mass spectrophotometric analysis showing the chemical composition (%) of the essential oils in leaves of curly- and non curly-leafed parsley cultivars planted, adapted and evaluated under the Middle Egypt growing conditions

Peak No.	**RT**	**Name of Peak**	**Area %**				
			Moskurl 2 Petra	**Moskurl 2 KRA USA,**	**Gewone Dai 3 Rial 10**	**Bravour**	**Egyptian**
1	**2.321**	**α-Pinene**	5.299	6.180	6.805	6.012	2.932
2	**2.673**	**Myrcene**	2.949	3.113	2.434	2.910	12.811
3	**2.836**	**β-Pinene**	6.891	4.929	11.863	4.721	1.792
4	**3.252**	**β-Phyllandrene**	45.305	37.865	2.6378	36.223	16.42
5	**3.587**	**β- Cymene**	2.267	2.426	18.229	2.369	1.310
6	**4.573**	**Limonene**	2.273	1.551	1.668	2.451	3.022
7	**4.946**	**α- Terpinene**	3.470	4.039	3.658	3.109	7.133
8	**6.318**	**P- Cymene**	2.101	0.937	6.922	1.728	8.126
10	**8.795**	**1,3,8 *P*-Menthatriene**	0.9906	0.667	1.001	0.814	4.580
11	**10.373**	**Germacrene**	6.094	1.239	0.893	1.413	2.124
13	**12.714**	**Myrictein**	19.611	25.222	33.257	23.164	32.65
14	**15.516**	**Apiol**	2.513	5.087	3.785	6.231	8.120

Humidity (%)

The humidity percentage was obviously significant smaller in curly-leafed parsley cultivars than in smooth or non-curly-leafed ones. Gewone Dai 3 Rial 10 and Egyptian cultivars which have non curled leaves showed the highest humidity contents more than (80%) and the other cultivars with curled leaves had (from 76.3 to 80.9 %) in their leaves. Bravour showed the significant lowest values (76.3 and 76.3 %) in the two growing seasons (Table 3).

Total soluble solids (TSS) determination (100%)

Three cultivars (Egyptian, Gewone Dai 3 Rial 10 and Moskrul 2 Petra) showed the significant highest values of total soluble solids (TSS) in their fresh leaves in the two seasons (6.2 and 6.3, 6.2 and 6.2, and 5.5 and 5.8 %, respectively) as shown in Table (3). On the contrary, both Moskrul 2 KRA USA and Bravour cultivars showed the significant lowest TSS values (4.8 and 5.0, 4.8 and 4.8 %, respectively). This means cultivars with non-curled leaves (Except for Moskrul 2 Petra) had higher values of TSS than cultivars with curled leaves.

Essential oil content as oil yield (%)

Data in Table (3) showed that the foreign parsley cultivars (curled and non-curled) contained higher essential oil content than the Egyptian cultivar and cultivars with curled leaves showed higher essential oil values than those with non-curled leaves. Both Moskrul 2 Petra and Bravour contain the significant highest oil values in their fresh leaves in the two seasons (0.48, 0.46 % and 0.43, 0.43 %, respectively), while the Egyptian cultivar showed the significant lowest values (0.20 and 0.20 %) in the two seasons.

Chlorophyll a, b and carotenoids content (mg/g fresh weight)

Table (4) is presenting values of Chlorophyll a, b and carotenoids in fresh leaves of all evaluated parsley cultivars. Data presented in this table showed that the two foreign cultivars (Moskrul 2 KRA USA and Gewone Dai 3 Rial 10) had the significant highest values of chlorophyll a in the first and second seasons, respectively (3.67, 3.65 and 3.84, 3.92 mg/g fresh weight). The other three cultivars had lower values of chlorophyll a content than those two cultivars and there were insignificant differences among the three cultivars (Moskrul 2 Petra, Bravour and Egyptian). On the contrary, fresh leaves of Bravour contained the highest values of chlorophyll b (3.69 and 3.78 mg/g fresh weight) in the first and second season, respectivey with significant and/or insignificant differences with the other cultivars. Regarding the carotenoids content in fresh leaves of all tested cultivars, data showed that there were almost insignificant differences among all parsley cultivars (Table 4).

Essential oil gas chromatography (GC) mass spectrophotometric analysis

Data in Table (5) and Figure (2) describing the oil biosynthesis composition of the foreign imported and Egyptian parsley cultivars showed that the Egyptian which is non-curly leafed cultivar represented the most abundant fractions responsible for the preferred parsley aroma including myrecene (12.811%), 1,3,8-*p*-menthatriene (4.580%) and myristicin (32.650%) and also the highest percentages of limonene (3.022%), *p*- cymene (8.126%), α-terpinene (7.133%) and apiol (8.120%) comparing to all curled or non-curled foreign cultivars. However, the curled cultivars were higher in ß-phyllandrene (45.305% for Moskurl 2 Petra "which had the highest percentage (6.094) of germacrene, too", 37.865% for Moskurl 2 KRA USA and 36.223% for Bravour). The non-curled cultivar Gewone Dai 3 Rial 10 showed the highest percentage of α-pinene (6.805%), ß-pinene (11.863%), ß-cymene (18.229%) and also myrictein (33.257% and almost similar to the Egyptian cultivar).

DISCUSSION

In our study the parsley cultivars varied in their growth behavior, yield of fresh leaves and essential oil yield. The non-curled cultivars (Egyptian and Gewone Dai 3 Rial 10) gave the highest yield from fresh leaves and this is very preferred in the Egyptian market as Egyptian people demand for non-curled fresh leaves of parsley. On the other hand, the curled cultivars gave the highest yield from essential oil percentages gained from dried leaves. The fresh parsley leaves are used as a garnish and for seasoning in food industry but the dried leaves known as parsley flakes are used in the instant food sector as an ingredient to flavor soups and sausages (Simon and Quinn, 1988; Aziz *et al*., 2013; Sabry *et al*., 2014). This means the non-curled imported cultivar "Gewone Dai 3 Rial 10" will be used the same way of that of the Egyptian cultivar as fresh green leaves. The other curly-leafed cultivars are very promising in parsley exportation as dry leaves which will be very profitable for Egyptian parsley growers. Parsley like many other herbs is highly seasonal in nature. In order to preserve this seasonal and highly perishable plant and make it available to consumers all year round at low prices, it is subjected to post-harvest technological treatments such as drying and freezing. Drying is one of the oldest methods of food preservation and represents very important aspect of food processing (Doymaz *et al*., 2006). Natural drying (drying in the shade) and hot air drying are still most widely used methods to produce dried parsley flakes, because of their low cost. Natural drying has many disadvantages due to the inability to handle the large quantities and to achieve consistent quality standards (Soysal and Öztekin 2001). The freezing of parsley leaves, particularly as pressed cubes, ensures their easy, rapid, and wide application at home and in restaurants. Leaves harvested mainly from tuber rooted parsley provide significantly lower yield compared to leafy parsley (Kmiecik and Lisiewska 1999).

New cultivars and hybrids introduction to different environments and adaptation to new environmental conditions is very beneficial in crops breeding. The germplasm collection could serve as an important source of genetic material for plant breeding and selection based on different growth and yield characteristics and also upon known comparative relationships among essential oil constituents.In this respect, Bernath (1986) found that the composition of essential oil in different plant crops particularly parsley is affected by genotype, environmental conditions and cultural systems. Masanetz and Grosch, (1998) reported that the aroma of curly leaf parsley was derived from a mixture of seven constituents, including myrcene, 1,3,8-*p*-menthatriene and myristicin and Mangkoltriluk *et al*. (2005) suggested that 1,3,8-p menthatriene was important for the odor of parsley leaves. In our study, results showed that leaves of the Egyptian parsley cultivar contained the highest percentages of these components. Furthermore, myristicin is known as anticancer and other diseases and all studied cultivars are rich in this component, particularly Gewone Dai 3 Rial 10 and the Egyptian cultivars. In which, myristicin can be extracted and collected with high amounts from these two cultivars and can be used in this purpose, too.

CONCLUSION

The new parsley genotypes which were imported from Netherlands and introduced to our area of the Middle Egypt and cultivated in the sandy soil were well adapted to these conditions, showed very acceptable vegetative growth, high yield of fresh and dry leaves and essential oil. Their essential oil composition contains components responsible for cancer curing (anticancer compounds) and other diseases curing chemical compounds as aforementioned discussed. Moreover, some of these foreign cultivars contained the parsley preferred flavor compounds however; the Egyptian cultivar exceeded them in some of these compounds level. These cultivars with these characteristics may enrich parsley cultivation and production in The Middle Egypt and enhance fresh and dry parsley products suitable for exportation. Furthermore, these imported genotypes will be a good material for our next breeding program to begin a hybridization technique and obtain hybrids with mixed characteristics as we wish and expect.

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