

RESEARCH ARTICLE

Essential oils of Persian Musk rose (*Rosa moschata* Herrm.) as influenced by drying and harvest times

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Abstract

Persian musk rose (*Rosa moschata* Hermm.) is widely used in perfumes and cosmetics industries because of its medicinal properties and pleasant odour. Since synthesis and accumulation of volatile compounds affected by flower harvest time, the current study was conducted to evaluate and monitor the changes of volatiles in the essential oil (EO) of Persian Musk Rose petals harvested at different dates (May 11, May 21 and June 01). GC and GC-MS determined the compositions of EO. In addition, the EOs obtained from fresh and dried flowers harvested at different dates were compared to maximize yield and quality of EO. The highest EO yield was observed in the fresh and dried petals harvested at May11, which was significantly higher than the June samples; however, there was no significant difference between May 11 and May 21 samples. The EO composition at different harvest dates was significantly different in the fresh petals, and the highest phenyl ethyl alcohol (14.3%) was observed at the second harvest date. Monoterpenes increased from 2.4% in the first harvest to 8.5% in the third harvest. Aliphatic hydrocarbons showed an increasing pattern in the petals harvested at May 11 (78.6%) to June (86.4%). Concentration of oxygenated monoterpenes significantly reduced in the EO of the dried petals. After drying, phenylpropanoids reduced at the first and the second harvest dates and increased at the third harvest. However, the concentration of aliphatic hydrocarbons increased at the first and the second harvest dates.

Keywords: Rosa moschata, drying, essential oils, harvest date

Introduction

Rosa has sixteen wild species in Iran of which *R. moschata* Herrm. with the common names of Persian Musk rose, Nastrane Shiraz and Rose Anbar is one of the most strongly scented rose species with characteristic floral scent molecules such as terpenoids, phenylpropanoids/benzenoids and fatty acid derivatives (Mozaffarian 2013; Jandoust & Karami, 2015). Persian Musk rose is distributed in many local regions of Iran; its wild origins are uncertain but are suspected to lie in the western Himalayas (Khosh-Khui 2014, Honarvar et al., 2011). As, Persian Musk rose has not been confirmed clearly in history, but the supposition is that it is a parent of Damask rose (Jandoust & Karami, 2015). In traditional medicine, hydrosol of Persian Musk rose has been used to strengthen heart muscles, stomach, liver, spleen, nerves, and gums and to strengthen intelligence (Honarvar et al., 2011; Jandoust & Karami, 2015). The quantity and composition of the rose oil distilled from the rose petals are strongly affected by the genotypes, the climatic conditions, diurnal variability, storage conditions, the time of rose petals harvesting, and the technology used for processing and distillation (Baydar & Baydar 2005; Carvalho-Filho et al., 2006; Baydaret al., 2008; Barbosa et al., 2011; Sharmaet al., 2012; Karami et al., 2013; Kumar et al., 2013; Jandoust & Karami, 2015). Therefore, in this research, the seasonal variations of EOs of fresh and dried flowers were studied by GC and GC/MS techniques.

Materials and Methods

Plant material

The fresh flowers of Persian Musk rose were collected from College of Agriculture gardens (Shiraz – 59° 35'E, 29°43' N, Altitude 1810 m) during their flowering period (May 11, May 21 and June 01, 2014). A specimen (Collector Number: PC 87-23) has been deposited in the Herbarium of the Faculty of Sciences, Shiraz University.

Analysis of the oil

The aerial parts were air-dried at ambient temperature in the shade and air-dried and fresh flower hydrodistilled by using a Clevenger-type apparatus for 3 h. It was dissolved in*n*-hexane (Merck), dried over anhydrous sodium sulphate and stored at 4°C \pm 2°C.GC analysis was performed using an Agilent gas chromatograph series 7890-A with a flame ionization detector (FID). The analysis was carried out on fused silica capillary HP-5 column (30 m × 0.32 mm *i.d.*; film thickness 0.25 mm). The injector and detector temperatures were kept at 250 °C and 280 °C, respectively. Nitrogen was used as carrier gas at a flow rate of 1 ml/min; oven temperature program was 60-210 °C at the rate of 4°C/min and then programmed to 240 °C at the rate of 20 °C/min and finally held isothermally for 8.5 min; split ratio was 1:50. GC-MS analysis was carried out by use of Agilent gas chromatograph equipped with fused silica capillary HP-5MS column (30 m × 0.25 mm *i.d.*; film thickness 0.25 m) coupled with 5975-C mass spectrometer. Helium was used as carrier gas with ionization voltage of 70 eV. Ion source and interface temperatures were 230 °C and 280 °C, respectively. Mass range was from 45 to 550 *amu*. Oven temperature program was the same given above for the GC.

Identification of Compounds

The constituents of the essential oil were identified by calculation of their retention indices under temperature-programmed conditions for *n*-alkanes (C8-C25) and the essential oil on a HP-5 column under the same chromatographic conditions. Identification of individual compounds made by comparison of their mass spectra with those of the internal reference mass spectra library or with authentic compounds and confirmed by comparison of their retention indices with authentic compounds or with those of reported in the literature. For quantification purpose, relative area percentages obtained by FID were used without the use of correction factors.

Results and Discussion

In general, seasonal variation and drying had a significantly effect on the EOs contents and composition of Persian musk rose as discussed more below.

Essential oil content

The EO content of both fresh and dried Persian musk rose flowers extracted during their flowering period (May 11, May 21 and June 01). The highest EO content was observed in the fresh and dried petals harvested at May 11, which was significantly higher than the June samples; however, there was no significant difference between May 11 and May 21 samples.

GC-MS analysis

Seasonal variation

In the current study, at the selected time, EOs were collected for periods of 3hrs and analyzed by GC/MS. In this study, a total number of 79 EOs compounds were detected by GC/MS from FW and DW of R. moschata at different season (Table 1). In overall, identified components in the subsequent season was representing 97.4–99.9 % of total EOs. The major compounds at different season were identified as 1nonadecene (5.90-34.80%), n-heneicosane (18.8-53.8%), n-nonadecane (9.5-34.4) and phenyl ethyl alcohol (0.1-14.27 %). The EO composition at different harvest dates was significantly different in the fresh petals, and the highest phenyl ethyl alcohol (14.27 %) was observed at the second harvest date. Monoterpenes increased from 2.39% in the first harvest to 8.54% in the third harvest. Aliphatic hydrocarbons showed an increasing trend in the petals harvested at May 11 (78.6%) to June (86.4%). The yield and chemical composition of essential oils (EO) from medicinal plants are related to a variety of internal and external factors such as harvest time and postharvest processing, due to spontaneous conversions and their unstable nature. The effect of harvest time on yield and quality of EO has been widely investigated. Baydar & Baydar, 2005 reported that yield and EO composition of *R. damascena* flowers was significantly different on May 8 and 24. They obtained more EO on May 24, which was about 0.04%. Kumar et al., 2013 showed that harvesting R. damascena at different times might affect its EO composition and yield. The highest EO yield in Thymus vulgaris have been reported on December. However, the monoterpenic phenols, thymol and carvacrol were higher after blooming on summer (McGimpsey et al., 2006).

Effects of drying

The EO composition of dried petals was significantly dissimilar than the fresh ones at different harvest dates. Concentration of oxygenated monoterpenes significantly reduced in the EO of the dried petals (Table 1). After drying, phenylpropanoids reduced at the first and the second harvest dates and increased at the third harvest. However, the concentration of aliphatic hydrocarbons increased at the first and the second harvests and decreased at the third harvest date. Number of components and composition of the EO obtained from fresh and dried flowers harvested at different times were different. The GC-MS analyses revealed that Persian Musk rose EO is mainly rich of aliphatic hydrocarbons such as n-nonadecane, nheneicosane, 1-nonadecane, n-tricosene; however, components such as geraniol, citronellol, nerol, comprise lower proportion of the EO. Aliphatic hydrocarbons in fresh petals of EO were about 78.6%, 75.3%, and 86.4% in May 11, May 21 and June. Therefore, aliphatic hydrocarbon increased from first harvest to third harvest. On the other hand, the highest phenyl ethyl alcohol (14.2%), which causes the odor of the rose flowers, was obtained from the fresh tissues harvested in May 21. Hence, it can be concluded that efficiency of EO extraction and quality of EO obtained from flowers harvested on May 21 is significantly higher. Although phenyl ethyl alcohol, or 2-phenylethanol, is the major scent compound of the fresh flower, its content is around 1% in the hydrodistilled rose oil due to the high solubility in residue water or rose water, by-products of hydrodistillation (Baydar et al., 2008). It appears that such investigations are useful for optimizing EO extraction and obtain products with established composition as a market demand. On the other hand, postharvest processing and preserving methods may also influence amount and composition of EO of the harvested material. Drying is widely used for controlling microbial infections, insect pest management and preserving the medicinal plant tissues for long time (Schweiggert et al., 2007). However, drying may influence the amount and composition of essential oil. Barbosa et al., 2006 reported that the citral level in Lippia alba dried leaves was significantly increased, however nerol content showed a significant decrease and geraniol oxidized into geranial after drying. Carvalho-Filho et al., 2006 showed significant changes in the *Ocimum basilicum* L. EO composition during drying.

Components	RI	May 11		May 21		June	
		FW	DW	FW	DW	FW	DW
α-Pinene	930	t	t	-	-	t	-
Myrcene	988	t	-	-	-	-	-
n-Octanal	1001	-	-	-	-	t	-
<i>p</i> -Cymene	1021	-	t	-	-	t	0.2
trans-Rose oxide	1124	-	-	-	-	t	-
Limonene	1025	t	t	-	-	t	0.2
1,8-Cineole	1028	-	t	-	-	-	-
(Z)-β-Ocimene	1033	t	-	-	-	-	0.3
Benzene acetaldehyde	1040	t	0.2	-	-	t	-
(<i>E</i>)β-Ocimene	1044	t	-	-	-	-	-
dihydro-Tagetone	1048	-	-	-	-	-	3.1
γ-Terpinene	1055	-	t	-	-	-	-
n-Octanol	1066	t	t	-	-	t	-
Linalool	1066	0.1	0.2	-	-	0.1	-
<i>n</i> -Nonanal	1097	0.2	0.7	-	-	0.5	-
Terpinene-4-ol	1174	-	-	-	-	t	-
Phenylethyl alcohol	1110	1.9	1.3	14.3	1.7	0.1	0.8
Camphor	1141	-	t	-	-	-	-
2 <i>E</i>)-None <i>n-</i> 1-al	1155	-	0.3	-	-	t	-
n-Nonanol	1167	t	0.1	-	-	t	0.7
α-Terpineol	1187	t	t	-	-	t	-
n-Dodecane	1196	-	-	-	-	t	-
n-Decanal	1202	0.1	0.5	-	-	0.1	0.5
Citronellol	1225	0.9	0.2	4.1	-	7.6	5.4
Pulegone	1235	-	0.1	-	-	-	-
Neral	1237	0.1	-	-	-	t	-
Geraniol	1251	1.1	0.2	0.4	-	0.7	-
2-Phenylethyl acetate	1253	0.3	0.1	0.3	-	0.2	-
Geranial	1267	0.1	-	-	-	t	-
Nonanoic acid	1267	-	-	-	-	-	6.4
Undecanal	1303	0.1	0.4	-	-	0.1	1.4
Methyl geranate	1320	-	-	-	-	t	-
Citronellyl acetate	1350	-	-	-	-	0.1	-
Eugenol	1353	2.2	1.5	1.2	-	0.4	3.0
Geranyl acetate	1381	-	-	-	-	0.1	-
β-Elemene	1388	-	-	-	-	t	-
n-Decanoic acid	1364	-	0.9	-	-	-	3.0
<i>n</i> -Tetradecane	1396	-	-	-	-	t	-

Methyl eugenol 1401 - - - 0.4 - Dodecanal 1405 0.1 0.4 - - 1 0.5 (c)-Caryophyllene 1415 0.8 0.3 - 0.2 - a-Guaine 1434 0.5 - 1.1 - - 0.1 a-Humulene 1449 0.4 0.7 - - 0.2 - Geranyl actone 1443 0.4 0.7 - - 0.1 - Germacrene D 1476 - 2.0 - 0.1 - Germacrene D 1476 - 0.5 - 0.1 - (c)-β-fonone 1482 - 0.5 - 0.1 - 1.2 (f)-β-farmesene 1505 - 0.2 - 0.1 - Tridecanal 1506 - 0.2 - 0.1 - C(p)-Neroliol 1505								
(¢)-Caryophyllene14150.80.30.20.2dihydro-β-Ionone14340.51.11a-Guaiene143411.01.11.0a-Hunulene14490.40.71.00.21.0Geranyl acetone14490.40.71.00.21.0(¢)-β-Farnesene14530.50.11.0(£)-β-farnesene14520.50.11.0(£)-β-farnesene14550.50.11.0(f,E)-G-farnesene15050.20.11.0(f,E)-a-farnesene15050.20.11.0(f,E)-a-farnesene15050.21.01.2(f,E)-a-farnesene15050.21.01.2(f,E)-a-farnesene15050.21.01.2Caryophyllene oxide15770.21.01.2Caryophyllene oxide15811.01.2Caryophyllene oxide15811.01.2Caryophyllene oxide15850.10.21.01.2Caryophyllene oxide15850.10.21.01.2Caryophyllene oxide1.51.01.2 <td>Methyl eugenol</td> <td>1401</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>0.4</td> <td>-</td>	Methyl eugenol	1401	-	-	-	-	0.4	-
dihydro-bionone 1434 0.5 - 1.1 - - α-Guaiene 1434 - - - 0.1 - α-Humulene 1449 0.4 0.7 - 0.2 - Geranyl acetone 1449 0.4 0.7 - - 0.1 - Germacrene D 1476 - - - 0.1 1 - n-Pentadecane 1495 0.5 - - 0.4 - - (E)-β-lonone 1482 - 0.5 - - 0.4 - -Pentadecane 1495 - 0.5 - - 0.1 - (E)-β-lonone 1482 - 0.2 - 0.4 - 1.2 (E)-β-honole 1495 - 0.2 - 0.1 1.2 (E)-β-honole 1555 0.1 0.2 - 1.2 1.4 1.4 -Phenyl	Dodecanal	1405	0.1	0.4	-	-	t	0.5
α-Guaiene14340.10.12α-Humulene14490.40.70.0.20.2Geranyl actone14490.40.70.0.00.2(c)-β-Farnesene14530.50.70.00.10.1Germacrene D14760.70.00.10.10.1(c)-β-Farnesene14950.00.00.10.10.1 <i>n</i> -Pentadecane14950.00.20.10.10.1(c)-β-Farnesene15050.10.20.10.10.1(c)-Nerolidol15600.10.20.10.10.1Caryophyllene oxide15770.20.20.10.10.1Phenylethyl tiglate15810.10.20.10.10.1β-Eudesmol16080.10.20.10.10.1β-Eudesmol16080.10.20.10.10.1β-Eudesmol16680.10.20.10.10.11-Heptadecane16952.41.11.20.10.10.1β-Eudesmol16480.10.30.30.10.10.1β-Eudesmol16952.74.11.61.00.30.1β-Eudesmol16952.74.11.61.00.10.1β-Eudesmol16952.74.11.61.00.10.1β-Eud	(E)-Caryophyllene	1415	0.8	0.3	-	-	0.2	-
α-Humulene14490.2Geranyl actone14490.40.70.8(E)-β-Farnesene14530.5Germacrene D14760.1(E)-β-Ionone14820.1n-Pentadecane14950.1(E,E)-α-Farnesene15050.11.2(f.C)-Nerolidol15601.21.2(f.C)-Nerolidol15601.21.2(f.C)-Nerolidol15601.21.2(f.C)-Nerolidol15601.21.2(f.C)-Nerolidol16681.2 <t< td=""><td>dihydro-β-Ionone</td><td>1434</td><td>0.5</td><td>-</td><td>1.1</td><td>-</td><td>-</td><td>-</td></t<>	dihydro-β-Ionone	1434	0.5	-	1.1	-	-	-
Geranyl actione14490.40.70.8[ξ]-β-Farnesene14530.5Germacrene D1476-2.00.1[ξ]-β-Ionone1482-2.00.1n-Pentadecane1495-0.50.4[(ξ, Γ)-α-Farnesene15050.21.2-1.2[(ξ)-Nerolidol15600.21.22.82-Phenylethyl tiglate15511.11.2-n-Hexadecane15950.10.21.1n-Hexadecane16080.1 <td< td=""><td>α-Guaiene</td><td>1434</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0.1</td><td>-</td></td<>	α-Guaiene	1434	-	-	-	-	0.1	-
(β)-β-Farnesene14530.5Germacrene D14760.10.1-(β)-β-Ionone1482-2.00.10.1-n-Pentadecane1495-0.50.10.10.11.2-1.21.21.21.2 <t< td=""><td>α-Humulene</td><td>1449</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0.2</td><td>-</td></t<>	α-Humulene	1449	-	-	-	-	0.2	-
Germacrene D14760.1-(E)-β-lonone1482-2.00.1-n-Pentadecane1495-0.50.4-(E,E)-α-Farnesene15050.1-1.2(f)-Nerolidol1560-0.20.11.2(E)-Nerolidol1560-0.21.21.2(E)-Nerolidol1560-0.21.21.2Caryophyllene oxide1577-0.2-1.01.21.22-Phenylethyl tiglate15810.11.21.2P-texadecane15950.10.2-0.11.21	Geranyl acetone	1449	0.4	0.7	-	-	-	0.8
(έ)-β-lonone14822.000.1 <i>n</i> -Pentadecane14950.50.4(<i>E,E</i>)-α-Farnesene15050.20.1Tridecanal15060.20.11.2(<i>E,E</i>)-verolidol15001.00.20.11.2(<i>E,P</i> -verolidol15070.10.21.01.2Caryophyllene oxide15770.21.11.21.22-Phenylethyl tiglate15810.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.21.11.21.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.21.11.2	(<i>E</i>)-β-Farnesene	1453	0.5	-	-	-	-	-
n-Pentadecane14950.50.4(<i>E,E</i>)-α-Farnesene15050.20.1Tridecanal15060.20.11.2(<i>E</i>)-Nerolidol15600.21.01.2(<i>E</i>)-Nerolidol15600.21.01.12.82-Phenylethyl tiglate15810.11.11.2n-Hexadecane15950.10.21.01.11.1Ftudesmol16081.01.1 </td <td>Germacrene D</td> <td>1476</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>0.1</td> <td>-</td>	Germacrene D	1476	-	-	-	-	0.1	-
[<i>E,E</i>)-α-Farnesene15050.1-Tridecanal1506-0.20.11.2(<i>E</i>)-Nerolidol15600.20.12.8Caryophyllene oxide1577-0.21.01.12.82-Phenylethyl tiglate15811.01.11.2 <i>n</i> -Hexadecane15950.10.20.1Tetradecanal16080.1β-Eudesmol16450.1a-Eudesmol16480.11-Heptadecene16952.41.11.2-0.42.7(6Z,9E)-Heptadecadiene17191.20.4 <i>n</i> -Heptadecane16952.74.11.61.03.2- <i>n</i> -Heptadecane17170.4 <i>n</i> -Octadecane1758-0.9-0.30.3 <i>n</i> -Ortadecane1795-0.41.70.4<	(<i>E</i>)-β-Ionone	1482	-	2.0	-	-	0.1	-
Tridecanal1506-0.21.2(£)-Nerolidol15600.1-Caryophyllene oxide1577-0.2t2.82-Phenylethyl tiglate15811.01.1-n-Hexadecane15950.10.20.1Tetradecanal16080.1β-Eudesmol16450.1α-Eudesmol16480.1α-Eudesmol16480.11-Heptadecane16952.41.11.2-0.42.7-(6Z,9E)-Heptadecadiene17191.20.4n-Heptadecane16952.74.11.61.03.2(Z,Z)-Farnesol1717n-Doctadecane1795-0.41.00.1n-Nonadecane188634.819.621.37.68.65.9n-Nonadecane189212.716.613.09.52.7.430.41-Eicosene19700.70.30.7-0.3<	<i>n</i> -Pentadecane	1495	-	0.5	-	-	0.4	-
(£)-Nerolidol15600.1Caryophyllene oxide15770.2t2.82-Phenylethyl tiglate15810.1n-Hexadecane15950.10.20.1Tetradecanal16080.1β-Eudesmol16450.1α-Eudesmol16480.11-Heptadecene16952.41.11.20.42.7(6Z,9E)-Heptadecadiene17191.20.4n-Heptadecane16952.74.11.61.003.2n-Heptadecane17170.4(Z,Z)-Farnesol17170.30.3n-Octadecane17950.41.10.6n-Nonadecane186834.819.621.37.68.65.9n-Nonadecane189212.716.613.09.52.7.43.01-Eicosene19700.70.30.70.30.71-Eicosane19990.81.40.94.52.1n-Cotadecanol20736.12.83.001.71.4n-Henciosane19990.8 <t< td=""><td>(<i>E,E</i>)-α-Farnesene</td><td>1505</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0.1</td><td>-</td></t<>	(<i>E,E</i>)-α-Farnesene	1505	-	-	-	-	0.1	-
Caryophyllene oxide1577-0.2t2.82-Phenylethyl tiglate1581t-n-Hexadecane15950.10.20.1-Tetradecanal1608t-β-Eudesmol16450.1-α-Eudesmol16480.1-1-Heptadecene16952.41.11.2-0.12.7(6Z,9E)-Heptadecadiene17191.20.33.2-n-Heptadecane16952.74.11.61.03.2-n-Heptadecane17170.30.3-n-Octadecane1775-0.9-0.30.3-n-Nonadecane1785-0.92.137.68.65.9n-Nonadecane186834.819.62.137.68.65.9n-Nonadecane189212.716.613.09.52.73.042-Phenylethyl phenyl acetate19021-Ficosene19700.70.81.4-0.5-n-Ficosane19990.81.42.83.01.71.4-n-Heneicosane21970.30.60.41.81.5-n-Tricosane22870.	Tridecanal	1506	-	0.2	-	-	-	1.2
2-Phenylethyl tiglate1581ttn-Hexadecane15950.10.2-0.10.10.1Tetradecanal16080.11β-Eudesmol16450.1-α-Eudesmol16480.1-1-Heptadecane16952.41.11.2-0.1-1-Heptadecane16952.74.11.61.03.2-n-Heptadecane17191.20.30.3-n-Ctadecane1775-0.9-0.30.3-n-Octadecane1795-0.9-0.30.3-n-Dotadecane1795-0.41.00.6-n-Nonadecane186834.819.621.37.68.65.9n-Nonadecane186834.819.61.309.527.430.42-Phenylethyl phenyl acetate1902-0.8-0.5-1-Eicosene19700.70.30.7-0.30.52.1n-Eicosane19990.81.4-0.94.52.1n-Heneicosane21970.30.60.41.81.5-n-Tricosane22870.20.2-0.50.8n-Tricosane22961.62.75.1 </td <td>(E)-Nerolidol</td> <td>1560</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>0.1</td> <td>-</td>	(E)-Nerolidol	1560	-	-	-	-	0.1	-
n-Hexadecane15950.10.20.1-Tetradecanal1608t-β-Eudesmol16450.1-α-Eudesmol16480.1-1-Heptadecene16952.41.11.2-0.42.7(6Z,9E)-Heptadecadiene17191.20.33.2-n-Heptadecane16952.74.11.61.03.2-(Z,Z)-Farnesol17170.10.6-Benzyl benzoate1795-0.41.60.10.6-n-Nonadecane1846-2.71.40.10.6-1-Nonadecene186834.819.621.37.68.65.9n-Nonadecane189212.716.613.09.527.430.42-Phenylethyl phenyl acetate1902-0.81-Eicosene19700.70.30.71.4n-Cotadecanol20736.12.83.01.71.4-n-Eicosane19990.81.4-0.50.5-n-Eicosane21970.30.60.41.81.5-n-Tricosane22870.20.2-0.50.8-n-Eicosane22961.62.7<	Caryophyllene oxide	1577	-	0.2	-	-	t	2.8
Tetradecanal1608t-β-Eudesmol16450.1-α-Eudesmol16480.10.1-1-Heptadecene16952.41.11.2-0.42.7(6Z,9E)-Heptadecadiene17191.2n-Heptadecane16952.74.11.61.03.2-(Z,Z)-Farnesol17170.30.3-Benzyl benzoate1795-0.41.00.6-n-Octadecane1795-0.41.00.6-Phenylethyl octanoate1846-2.71.40.10.6-1-Nonadecane188634.819.621.37.68.65.9-n-Nonadecane189212.716.613.09.527.430.4-1-Eicosene19700.70.30.7-0.51-Eicosane19990.81.4-0.94.52.1-n-Cotadecanol20736.12.83.01.71.4-n-Eicosane21970.30.60.41.81.5-n-Eicosane21970.30.60.41.81.5-n-Eicosane21970.30.60.41.81.5-n-Eicosane	2-Phenylethyl tiglate	1581	-	-	-	-	t	-
β-Eudesmol16450.1- α -Eudesmol16480.1-1-Heptadecene16952.41.11.2-0.42.7(6Z,9E)-Heptadecadiene17191.2 <i>n</i> -Heptadecane16952.74.11.61.03.2-(Z,Z)-Farnesol17170.4-Benzyl benzoate1758-0.9-0.30.3- <i>n</i> -Octadecane1795-0.4Phenylethyl octanoate1846-2.7-2.50.4-1-Nonadecene186834.819.621.37.68.65.9 <i>n</i> -Nonadecane189212.716.613.09.527.430.42-Phenylethyl phenyl acetate1902-0.81-Eicosene19700.70.30.7-0.5 <i>n</i> -Eicosane19990.81.4-0.94.52.1 <i>n</i> - <i>n</i> -Heneicosane213721.132.730.953.926.118.8 <i>n</i> -Doctadecanol20736.12.83.01.71.4- <i>n</i> -Eicosane19990.30.60.41.81.5- <i>n</i> -Tricosane21970.30.60.41.85.9	<i>n</i> -Hexadecane	1595	0.1	0.2	-	-	0.1	-
α-Eudesmol 1648 - - - - 0.1 - 1-Heptadecene 1695 2.4 1.1 1.2 - 0.4 2.7 (6Z,9E)-Heptadecadiene 1719 1.2 - - - - - n-Heptadecane 1695 2.7 4.1 1.6 1.0 3.2 - (Z,Z)-Farnesol 1717 - - 0.4 0.4 - Benzyl benzoate 1758 - 0.9 - 0.3 0.3 - n-Octadecane 1795 - 0.4 - 0.4 - - Phenylethyl octanoate 1846 - 2.7 - 0.3 0.3 - 1-Nonadecene 1892 12.7 16.6 13.0 9.5 2.7.4 30.4 2-Phenylethyl phenyl acetate 1902 - 0.8 - - - - - - - - 1.5 1.4	Tetradecanal	1608	-	-	-	-	t	-
1-Heptadecene 1695 2.4 1.1 1.2 0.4 2.7 (6Z,9E)-Heptadecadiene 1719 1.2 n-Heptadecane 1695 2.7 4.1 1.6 1.0 3.2 (Z,Z)-Farnesol 1717 0.4 0.4 Benzyl benzoate 1758 0.4 0.4 . n-Octadecane 1795 0.4 0.4 . Phenylethyl octanoate 1846 2.7 0.1 0.6 . 1-Nonadecene 1846 1.2 2.7 2.5 0.4 . n-Nonadecane 1892 12.7 16.6 13.0 9.5 27.4 30.4 2-Phenylethyl phenyl acetate 1902 - 0.8 1.4 0.5 - . 1-Eicosene 1970 0.7 0.8 0.5 1.5 1.5 . n-Etosane 1999 0.8 1.4 - 0.9 4.5 2.1	β-Eudesmol	1645	-	-	-	-	0.1	-
(6Z,9E)-Heptadecadiene17191.2 <i>n</i> -Heptadecane16952.74.11.61.03.2-(Z,Z)-Farnesol17170.4-Benzyl benzoate1758-0.9-0.30.3- <i>n</i> -Octadecane1795-0.4-0.10.6-Phenylethyl octanoate1846-2.7-2.50.4-1-Nonadecene186834.819.621.37.68.65.9 <i>n</i> -Nonadecane189212.716.613.09.527.430.42-Phenylethyl phenyl acetate1902-0.8-0.51-Eicosene19700.70.30.7-0.30.5 <i>n</i> -Eicosane19990.81.4-0.94.52.1- <i>n</i> -Docosane210321.132.730.953.926.118.8 <i>n</i> -Tricosane22961.62.75.110.57.8- <i>n</i> -Tetracosane22061.62.75.110.55.8- <i>n</i> -Tetracosane2400 <i>n</i> -Tetracosane2400 <i>n</i> -Tetracosane2400 <i>n</i> -Tetracosane2500.6 <td>α-Eudesmol</td> <td>1648</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>0.1</td> <td>-</td>	α-Eudesmol	1648	-	-	-	-	0.1	-
n-Heptadecane 1695 2.7 4.1 1.6 1.0 3.2 - (Z,Z)-Farnesol 1717 - - - 0.4 - Benzyl benzoate 1758 - 0.9 - 0.3 0.3 - n-Octadecane 1795 - 0.4 - 0.4 - - Phenylethyl octanoate 1846 - 2.7 - 0.1 0.6 - n-Nonadecene 1846 - 2.7 - 2.5 0.4 - n-Nonadecane 1892 12.7 16.6 13.0 9.5 27.4 30.4 2-Phenylethyl phenyl acetate 1902 - 0.8 1.0 0.5 - - 1-Eicosene 1970 0.7 0.3 0.7 - 0.5 - - n-Eicosane 1997 0.8 1.4 - 0.9 4.5 2.1 n-Doctadecanol 2073 6.1 2.8 3.0 1.7 1.4 - n-Heneicosane 2107	1-Heptadecene	1695	2.4	1.1	1.2	-	0.4	2.7
(Z,Z)-Farnesol17170.4-Benzyl benzoate1758-0.9-0.30.3-n-Octadecane1795-0.4-0.10.6-Phenylethyl octanoate1846-2.7-2.50.4-1-Nonadecene186834.819.621.37.68.65.9n-Nonadecane189212.716.613.09.527.430.42-Phenylethyl phenyl acetate1902-0.80.70.51-Eicosene19700.70.30.7-0.5n-Eicosane19990.81.4-0.94.52.1n-Octadecanol20736.12.83.01.71.4-n-Eicosane21970.30.60.41.81.5-n-Tricosane21970.30.60.41.81.5-n-Tricosane22870.20.20.50.50.5-n-Tetracosane24000.50.5-n-Tetracosane24000.50.5-n-Tetracosane25000.20.40.71.92.9-	(6Z,9E)-Heptadecadiene	1719	1.2	-	-	-	-	-
Benzyl benzoate 1758 - 0.9 - 0.3 0.3 - n-Octadecane 1795 - 0.4 - 0.1 0.6 - Phenylethyl octanoate 1846 - 2.7 - 2.5 0.4 - 1-Nonadecene 1868 34.8 19.6 21.3 7.6 8.6 5.9 n-Nonadecane 1892 12.7 16.6 13.0 9.5 27.4 30.4 2-Phenylethyl phenyl acetate 1902 - 0.8 - 0.5 - - 1-Eicosene 1970 0.7 0.3 0.7 - 0.5 2.1 n-Dctadecanol 1995 - - - 0.5 2.1 n-Dctadecanol 1995 0.7 2.8 3.0 1.7 1.4 2.1 n-Dctadecanol 2073 6.1 2.8 3.0 1.7 1.4 2.1 n-Dctosane 2107 0.3	<i>n</i> -Heptadecane	1695	2.7	4.1	1.6	1.0	3.2	-
n-Octadecane 1795 - 0.4 - 0.1 0.6 - Phenylethyl octanoate 1846 - 2.7 - 2.5 0.4 - 1-Nonadecene 1868 34.8 19.6 21.3 7.6 8.6 5.9 n-Nonadecane 1892 12.7 16.6 13.0 9.5 27.4 30.4 2-Phenylethyl phenyl acetate 1902 - 0.8 - 0.5 - - 1-Eicosene 1970 0.7 0.3 0.7 - 0.3 - - - n-Eicosane 1995 - - - - 0.3 0.7 1.4 2.1 n-Octadecanol 1995 0.7 0.3 0.7 1.4 2.1 - n-Eicosane 1999 0.8 1.4 - 0.9 4.5 2.1 n-Octadecanol 2073 6.1 2.8 3.0 1.7 1.4 - n-Docosane 2197 0.3 0.6 0.4 1.8 1.5 -	(Z,Z)-Farnesol	1717	-	-	-	-	0.4	-
Phenylethyl octanoate1846-2.7-2.50.4-1-Nonadecene186834.819.621.37.68.65.9n-Nonadecane189212.716.613.09.527.430.42-Phenylethyl phenyl acetate1902-0.8-0.51-Eicosene19700.70.30.72.00.35.9Ethyl palmitate19950.32.13.03.1n-Cicosane19990.81.4-0.94.52.1n-Doctadecanol20736.12.83.01.71.4n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-n-Tricosane22870.20.25.110.57.8-n-Tetracosane22061.62.75.110.50.5.n-Tetracosane2400n-Pentacosane25000.20.40.71.92.9-	Benzyl benzoate	1758	-	0.9	-	0.3	0.3	-
1-Nonadecene186834.819.621.37.68.65.9n-Nonadecane189212.716.613.09.527.430.42-Phenylethyl phenyl acetate1902-0.8-0.51-Eicosene19700.70.30.7-0.5Ethyl palmitate19950.32.1n-Eicosane19990.81.4-0.94.52.1n-Octadecanol20736.12.830.91.41.4-n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-n-Tricosane22870.20.25.110.57.8-n-Tetracosane24000.50.5-n-Pentacosane25000.20.40.71.92.9-	<i>n</i> -Octadecane	1795	-	0.4	-	0.1	0.6	-
n-Nonadecane189212.716.613.09.527.430.42-Phenylethyl phenyl acetate1902-0.8-0.51-Eicosene19700.70.30.7-0.5Ethyl palmitate19950.32.1n-Eicosane19990.81.4-0.94.52.1n-Octadecanol20736.12.83.01.71.4-n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-1-Tricosene22870.20.2-0.50.8-n-Tetracosane22061.62.775.110.57.8-n-Tetracosane22000.20.40.71.92.9-	Phenylethyl octanoate	1846	-	2.7	-	2.5	0.4	-
2-Phenylethyl phenyl acetate1902-0.8-0.51-Eicosene19700.70.30.7-0.5Ethyl palmitate19950.33.3-n-Eicosane19990.81.4-0.94.52.1n-Octadecanol20736.12.83.01.71.4-n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-1-Tricosene22870.20.25.110.57.8-n-Tetracosane24000.50.5-n-Pentacosane25000.20.40.71.92.9-	1-Nonadecene	1868	34.8	19.6	21.3	7.6	8.6	5.9
1-Eicosene19700.70.30.7-0.5-Ethyl palmitate19950.3-n-Eicosane19990.81.4-0.94.52.1n-Octadecanol20736.12.83.01.71.4-n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-1-Tricosene22870.20.2-0.50.8-n-Tetracosane22961.62.75.110.57.8-n-Pentacosane25000.20.40.71.92.9-	<i>n</i> -Nonadecane	1892	12.7	16.6	13.0	9.5	27.4	30.4
Ethyl palmitate19950.3-n-Eicosane19990.81.4-0.94.52.1n-Octadecanol20736.12.83.01.71.4-n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-1-Tricosene22870.20.25.110.57.8-n-Tetracosane24000.40.50.5-n-Pentacosane25000.20.40.71.92.9-	2-Phenylethyl phenyl acetate	1902	-	0.8	-	0.5	-	-
n-Eicosane19990.81.4-0.94.52.1n-Octadecanol20736.12.83.01.71.4-n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-1-Tricosene22870.20.2-0.50.8-n-Tricosane22961.62.75.110.57.8-n-Tetracosane24000.40.71.92.9-	1-Eicosene	1970	0.7	0.3	0.7	-	0.5	-
n-Octadecanol20736.12.83.01.71.4-n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-1-Tricosene22870.20.22.75.110.57.8-n-Tricosane24000.50.5n-Tetracosane24001.92.9-	Ethyl palmitate	1995	-	-	-	-	0.3	-
n-Heneicosane210321.132.730.953.926.118.8n-Docosane21970.30.60.41.81.5-1-Tricosene22870.20.2-0.50.8-n-Tricosane22961.62.75.110.57.8-n-Tetracosane24000.50.5-n-Pentacosane25000.20.40.71.92.9-	n-Eicosane	1999	0.8	1.4	-	0.9	4.5	2.1
n-Docosane21970.30.60.41.81.5-1-Tricosene22870.20.2-0.50.8-n-Tricosane22961.62.75.110.57.8-n-Tetracosane24000.50.5-n-Pentacosane25000.20.40.71.92.9-	n-Octadecanol	2073	6.1	2.8	3.0	1.7	1.4	-
1-Tricosene22870.20.2-0.50.8-n-Tricosane22961.62.75.110.57.8-n-Tetracosane24000.50.5-n-Pentacosane25000.20.40.71.92.9-	<i>n</i> -Heneicosane	2103	21.1	32.7	30.9	53.9	26.1	18.8
<i>n</i> -Tricosane22961.62.75.110.57.8- <i>n</i> -Tetracosane24000.50.5- <i>n</i> -Pentacosane25000.20.40.71.92.9-	<i>n</i> -Docosane	2197	0.3	0.6	0.4	1.8	1.5	-
<i>n</i> -Tetracosane24000.50.5- <i>n</i> -Pentacosane25000.20.40.71.92.9-	1-Tricosene	2287	0.2	0.2	-	0.5	0.8	-
<i>n</i> -Pentacosane 2500 0.2 0.4 0.7 1.9 2.9 -	<i>n</i> -Tricosane	2296	1.6	2.7	5.1	10.5	7.8	-
	n-Tetracosane	2400	-	-	-	0.5	0.5	-
Total 97.4 98.5 99.3 98.9 99.9 99.8	<i>n</i> -Pentacosane	2500	0.2	0.4	0.7	1.9	2.9	-
	Total		97.4	98.5	99.3	98.9	99.9	99.8

*RI: Retention indices analysed on HP-5; " – ": not detected; t: trace amount; DW: Dry weight; FW: Fresh weight

Conclusion

In general, it is clear that during seasonal variation and emission timing, Persian musk rose EOs varied significantly over time. GC/MS analysis was performed to define both similarities and differences across different seasons and fresh and dried flower in Persian Musk rose. Therefore, drying of plant material and seasonal variations of EOs has essential function and application in agriculture. Consequently, it can be concluded that efficiency of EO extraction and quality of EO obtained from flowers of this plants harvested on May 21 is significantly higher than other harvest times.

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