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RESEARCH ARTICLE

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# Chemical content of the aerial parts essential oil from rosemary, *Rosmarinus officinalis* L. (Lamiaceae) samples collected from Kermanshah province in the west of Iran

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**ABSTRACT**

Rosemary (*Rosmarinus officinalis* L.) is one of the evergreen and fragrant medicinal plants belonging to Lamiaceae (Labiatae). In the present research, the chemical content of the essential oil isolated from its aerial parts (leaf and flower) was investigated. Accordingly, the mature plant was collected in its natural habitats from Kermanshah province in the west of Iran, dried gradually under the shadow (25 ˚C), pulverized, its essential oil isolated, and finally analyzed by Gas Chromatography-Mass Spectroscopy. The results showed that the important compounds were available in the essential oil of this medicinal plant; the number of them reached 147. Run (retention) time for total compounds was determined as 38.358 min. Also, 27 compounds had > 1% share in total volume; among them, alpha-pinene, (-)-bicyclo (peak 4, 5.448 min, 7.50%), bicyclo [2.2.1] heptan-2-one (peak 29, 9.848 min, 5.92%), bicyclo [3.1.1] hept-3-en-2-one (peak 40, 11.771 min, 5.48%), 1,8-cineole 2-oxabicyclo (peak 17, 7.256 min, 4.60%), and acetic acid 1,7,7-trimethyl (peak 45, 14.506 min, 4.29%) were five major constituents, respectively. Moreover, 56 different compounds contained ≤ 0.1% share in total volume and were distinguished as minor compounds. Accordingly, this fragrant medicinal plant has important essential oil constituents which could be considered in medical, pharmacology, and toxicology.



## 1. Introduction

*Rosmarinus officinalis* L. (Figure 1) is a significant medicinal plant from the family Lamiaceae. This perennial plant is woody with fragrant leaves and many volatile compounds, which are originally native for the Mediterranean regions; but also grow in cold climates (Wang et al., 2008). The height of the plant can reach 1.5 m. The leaves are evergreen with 2–4 cm height and 2–5 mm width, above green and below white, with dense, short, and woolly hairs. The plant flowering occurs during the spring and summer seasons under the temperate climates; but can be in constant bloom in warm climates. This plant has white, pink, purple, and deep blue flowers. Rosemary has a suitable tendency to flowering outside its regular season. This plant has a high tolerance to water shortage cause surviving under severe lack of water for long periods (Pintore et al., 2002). Its seed is often difficult to start due to low germination percentage and for this has slow growth relatively; but, can live for 30 years. Rosemary is cultivated in some parts of Iran as an ornamental plant (Dini, 2005).

There are fundamental differences between essential oil and extract, which is necessary to know them. The aromatic compounds obtained by the hydro-distillation method, isolated by volatile mechanisms, are called essential oil. In comparison, when the substances in plant cells are isolated by solvents (water or organic compounds), it is called extract. In general, the extract is a solution that contains all valuable substances inside the cells (tannins, mucilage, vitamins, and minerals); but, the essential oil commonly contains terpene and terpenoids. On the other hand, the extract may have different solvents such as oil, alcohol, and water (Jahanshahi, 2016). Identifying these constituents and understanding their impacts are important aspects of plant science (Isman, 2000; Isman et al., 2008). Essential oils are common in families Myrtaceae, Lauraceae, Lamiaceae, and Asteraceae that rosemary also belongs to Lamiaceae. These compounds mainly have fumigant, repellent, and antifeedant effects and are one of the main

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components in the defense mechanisms of plants against the herbivores for centuries (Bakkali et al., 2008; Rafiee-Dastjerdi et al., 2013; Asadi et al., 2018, 2019, 2022). This research aimed to identify essential oil constituents in the aerial parts of *R. officinalis* as a basic research for its application in the future.

**Figure 1.** Mature plant of *R. officinalis*

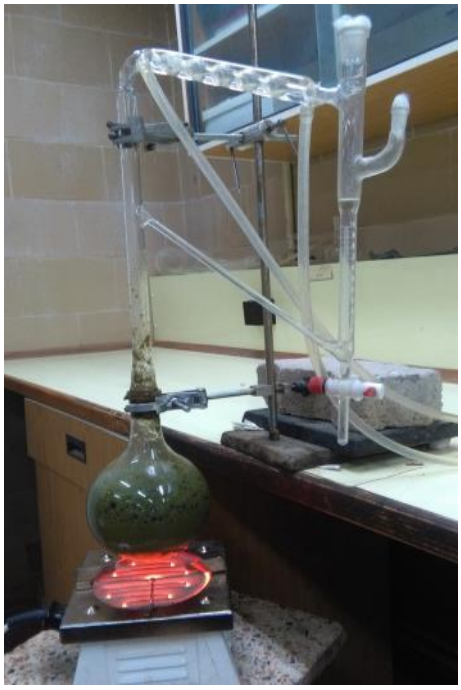

**Figure 2.** Clevenger apparatus for isolation of *R. officinalis* essential oil

## 2. Materials and methods

### *2.1. Identification of species*

Identification of rosemary species was performed by sending its complete specimen to one of the botany experts in Razi University Herbarium (RUHK), Kermanshah, Iran. Accordingly, the species of *R. officinalis* L. was confirmed, and code 1918 was assigned.

### *2.2. Essential oil isolation*

Mature plants of *R. officinalis* were collected from their natural habitats in different regions of Kermanshah province in the west of Iran, during 2018. Then, the specimens were dried at 25 °C (shadow), moved to the laboratory, and its essential oil was isolated. In the first stage, aerial parts of the plant were pulverized with a grinder, then 50 g of its plant powder was mixed with 500 ml of the

distilled water inside the balloon of the Clevenger apparatus (volume 1 liter) (Figure 2) (Babaee Ghaghelestany et al., 2020). After four hours, the essential oil was given as a green layer. To remove essential oil's water and its purifying, sodium sulfate ($Na_2SO_4$) was applied (Asadi et al., 2019). Finally, the purified essential oil was maintained inside the microtubes (2 ml) covered with aluminum tape in a refrigerator (4 °C) until chemical analysis (Negahban et al., 2007; Samsam Shariat, 2007; Parsia Aref, 2015; Asadi et al., 2018; Babaee Ghaghelestany et al., 2020).

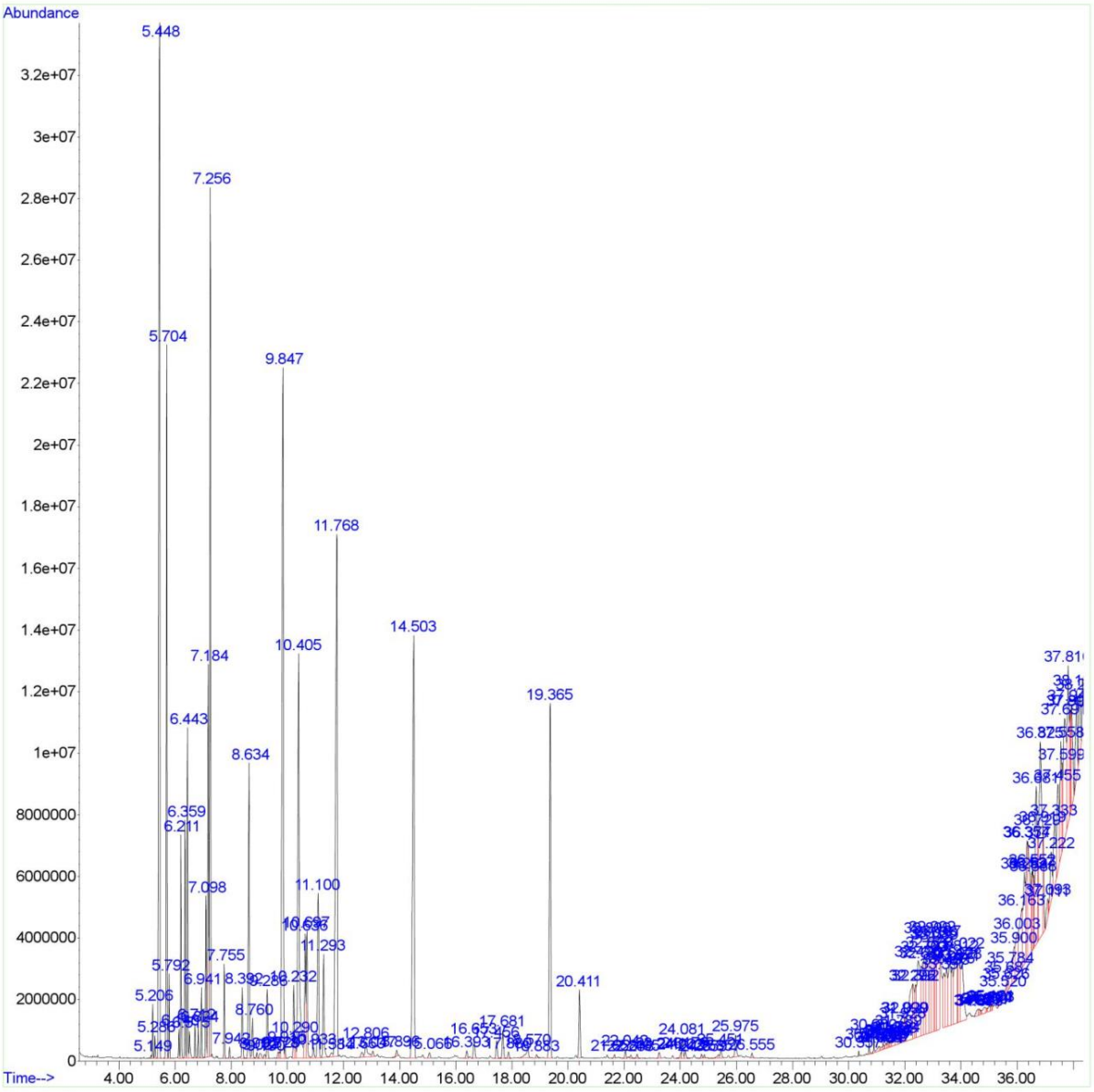


**Figure 3.** Chromatogram of total compounds in *R. officinalis* essential oil

### *2.3. Analyzer device (GC-MS)*

A gas chromatography-mass spectroscopy device in the central laboratory of the University of Mohaghegh Ardabili, Ardabil, Iran, was applied to determine chemical content in the essential oil of *R. officinalis* (Agilent 7980B, the USA). This device could dilute split splitless inlet as its main feature and mass spectroscopy detector to quantitative and qualitative samples' recognition. The ionization system and four-coupled single analyzer were also convenient features of the detector (Babaee Ghaghelestany et al., 2020). After injecting pure essential oil by Hamilton syringe, compounds at different times were gradually detected based on their molar mass. Finally, the analyzer device exhibited the chromatogram (Figure 3).

## 3. Results and discussion

The chromatogram of available chemical constituents in *R. officinalis* essential oil by GC-MS is shown in Figure 3. In the chromatogram, longitudinal (X) and latitudinal (Y) axes showed run (running) time and amount of each compound, respectively. According to the chromatogram, compounds with higher peaks had maximum values and lower values being at minimum.

The results showed that *R. officinalis* essential oil had 147 chemical compounds (Table 1) with a total run time of 38.358 min. The run time in first and last compounds (1,3,6-octatriene,3,7-dimethyl, and alpha-terpinolene cyclohexene) were 5.150 and 38.229 min, respec-

**Table 1.** All compounds in *R. officinalis* essential oil with their run time and percentage

| Peak | Compound | Run time (min) | Percentage |
|---|---|---|---|
| 1 | 1,3,6-Octatriene,3,7-dimethyl | 5.150 | 0.01 |
| 2 | Tricyclene tricyclo | 5.208 | 0.21 |
| 3 | Thujene | 5.288 | 0.10 |
| 4 | alpha-Pinene, (-)-bicyclo | 5.448 | 7.50 |
| 5 | Camphene bicyclo [2.2.1] heptan | 5.705 | 3.20 |
| 6 | Bicyclo [3.1.0] hex-3-en-2-ol | 5.791 | 0.32 |
| 7 | Sabinene bicyclo [3.1.0] hexane | 6.140 | 0.11 |
| 8 | (-)-Beta-Pinene 6,6-dimethyl | 6.209 | 0.90 |
| 9 | 3-Octanone | 6.358 | 0.99 |
| 10 | beta-Myrcene 1,6-octadiene | 6.444 | 1.34 |
| 11 | 3-Octanol (cas) n-octan-3-ol | 6.512 | 0.16 |
| 12 | L-Phellandrene 1,3-cyclohexad | 6.712 | 0.15 |
| 13 | 3-Carene | 6.827 | 0.13 |
| 14 | (+)-2-Carene | 6.941 | 0.21 |
| 15 | Benzene, 1-methyl-4-(1-methylethyl) | 7.096 | 0.73 |
| 16 | DL-Limonene cyclohexene | 7.182 | 2.17 |
| 17 | 1,8-Cineole 2-oxabicyclo | 7.256 | 4.60 |
| 18 | gamma-Terpinene 1,4-cyclohexene | 7.754 | 0.39 |
| 19 | Copaene tricyclo | 7.943 | 0.05 |
| 20 | (+)-4-Carene | 8.395 | 0.41 |
| 21 | Linalool L | 8.635 | 1.65 |
| 22 | Filifolone | 8.761 | 0.22 |
| 23 | 1,3-Cyclopentadiene | 8.910 | 0.04 |
| 24 | D-Fenchyl alcohol bicyclo | 9.030 | 0.07 |
| 25 | 1-(1'-Ethoxyethyl) bicyclo [2.1.1] | 9.190 | 0.04 |
| 26 | Chrysanthenone bicyclo [3.1.1] | 9.287 | 0.39 |
| 27 | *trans*-Pinocarveol bicyclo | 9.676 | 0.05 |
| 28 | Bicyclo [3.1.1] hept-3-en-2-ol | 9.728 | 0.04 |
| 29 | Bicyclo [2.2.1] heptan-2-one | 9.848 | 5.92 |
| 30 | *exo*-Methyl camphenilol | 9.917 | 0.07 |
| 31 | Bicyclo [3.1.1] heptan-3-one | 10.231 | 0.43 |
| 32 | Bicyclo [2.2.1] heptan-3-one | 10.289 | 0.12 |
| 33 | Borneol L | 10.403 | 3.80 |
| 34 | Pinocarvone 6,6-dimethyl-2 | 10.638 | 0.82 |
| 35 | 3-Cyclohexen-1-ol, 4-methyl | 10.695 | 0.79 |
| 36 | *p*-Cymen-8-ol | 10.935 | 0.08 |
| 37 | alpha-Terpineol | 11.101 | 1.27 |
| 38 | Estragole | 11.290 | 0.70 |
| 39 | Bicyclo [3.1.1] hept-2-ene-2-ethan | 11.582 | 0.06 |
| 40 | Bicyclo [3.1.1] hept-3-en-2-one | 11.771 | 5.48 |
| 41 | Naphthalene, decahydro-2-methyl | 12.658 | 0.06 |
| 42 | 2-Cyclohexen-1-one, 2-methyl-5 | 12.806 | 0.21 |
| 43 | 1,4-Cyclooctadiene | 13.047 | 0.06 |
| 44 | 2-Cyclohexen-1-one, 3-methyl-6 | 13.894 | 0.03 |
| 45 | Acetic Acid, 1,7,7-trimethyl | 14.506 | 4.29 |
| 46 | Phenol, 2-methyl-5-(1-methylethyl) | 15.067 | 0.05 |
| 47 | alpha-Terpinolene cyclohexene | 16.394 | 0.06 |
| 48 | 2,4-Cycloheptadien-1-one | 16.651 | 0.17 |
| 49 | Bicyclo [4.1.0] heptan-3-ol | 17.458 | 0.13 |
| 50 | alpha-Copaene tricyclo | 17.681 | 0.22 |
| 51 | Copaene | 17.882 | 0.05 |
| 52 | Bicyclo [3.1.1] hept-2-en-6-one | 18.568 | 0.16 |
| 53 | Benzene, 1,2-Dimethoxy-4 | 18.883 | 0.03 |
| 54 | Caryophyllene | 19.364 | 2.68 |
| 55 | alpha-Humulene | 20.411 | 0.50 |
| 56 | alpha-Selinene | 21.658 | 0.03 |
| 57 | Cyclohexene, 1-methyl-4-(5-methyl) | 22.042 | 0.06 |
| 58 | Benzene, isocyanato | 22.236 | 0.03 |
| 59 | Naphthalene, 1,2,3,5,6,8a | 22.465 | 0.04 |
| 60 | 1 Tricyclo [6.4.0.0 (3,7)] dodecane | 23.243 | 0.05 |
| 61 | Bicyclo [3.2.0] hept-2-ene-6-one | 24.021 | 0.04 |
| 62 | Caryophyllene oxide | 24.079 | 0.14 |
| 63 | 2-(4a, 8-Dimethyl-2,3,4,4a,5,6) | 24.176 | 0.06 |
| 64 | 2-Oxabicyclo [9.1.0] dodeca-3,7-D | 24.760 | 0.03 |
| 65 | beta-Myrcene | 24.857 | 0.02 |
| 66 | *trans-Z*-alpha-Bisabolene epoxide | 25.355 | 0.04 |
| 67 | 10,10-Dimethyl-2,6-dimethylenebi | 25.452 | 0.08 |
| 68 | Cyclooctane, 1,5-dimethyl-2 | 25.973 | 0.19 |
| 69 | di-epi-alpha-Cedrene-(I) | 26.556 | 0.03 |
| 70 | Pyrimidine, 5-methyl-2 | 30.356 | 0.02 |
| 71 | Farnesyl acetone | 30.728 | 0.06 |
| 72 | 1,2-Diphenyl tetramethyl disilane | 30.899 | 0.08 |
| 73 | Isoterpinolene cyclohexene | 31.065 | 0.06 |
| 74 | 4-[2-(Adamantan-1-yloxy)]-ethylamide | 31.105 | 0.03 |
| 75 | Cyclopentanone, 2-(1-adamantyl) | 31.191 | 0.02 |
| 76 | 1,3-Dioxan-2,2-dimethyl-4 | 31.225 | 0.03 |
| 77 | Tricyclo [3.3.1.1 (3,7)] decane | 31.271 | 0.02 |
| 78 | 1-Dodecanone, 2-(imidazol-1-yl) | 31.328 | 0.04 |
| 79 | *trans*-Sabinene hydrate | 31.391 | 0.04 |
| 80 | (6e, 9z)-6-(Dimethyl phenylsilyl) | 31.414 | 0.03 |
| 81 | 1,2-bis (Dimethyl phenylsilyl) ethane | 31.449 | 0.03 |
| 82 | 1-Cyclopropene-1-pentanol | 31.506 | 0.04 |
| 83 | Thymyl acetate 2-isopropyl-5 | 31.632 | 0.08 |
| 84 | 2-Iodoadamantane | 31.723 | 0.11 |
| 85 | 1-Epoxy-2-methyl-3-isobutenyl-1 | 31.792 | 0.09 |
| 86 | N-[2-(Adamantan-1-yloxy)-ethyl] | 31.929 | 0.27 |
| 87 | (+)-2,2,3-Trimethylcyclopent-3 | 31.992 | 0.19 |
| 88 | *p*-Mentha-1(7), 8(10)-dien-9-ol | 32.026 | 0.10 |
| 89 | *m*-Anisic Acid, morpholide | 32.278 | 1.44 |
| 90 | Ethanone, 2-hydroxy-1 | 32.290 | 0.50 |
| 91 | 2-N-Butyladamantane | 32.393 | 0.40 |
| 92 | Cyclononasiloxane, octadecamethyl | 32.478 | 1.57 |
| 93 | 1-Adamantaneethanol tricyclo | 32.650 | 0.92 |
| 94 | 1 Hexasiloxane, tetradecamethyl | 32.702 | 0.86 |
| 95 | Iron, monocarbonyl-(1, 3-butadien) | 32.810 | 1.33 |
| 96 | Cordycepin | 32.879 | 0.75 |
| 97 | 2-Butanone, 4-(dimethyl phenylsil) | 32.993 | 1.18 |
| 98 | Hexasiloxane, tetradecamethyl | 33.033 | 0.44 |
| 99 | Heptasiloxane, hexadecamethyl | 33.091 | 0.75 |
| 100 | Isoindole-1,3-dione | 33.188 | 1.42 |
| 101 | Cyclodecasiloxane, eicosamethyl | 33.400 | 0.67 |
| 102 | (3r*, 4s*)-4-(4-Methoxyphenyl) | 33.486 | 0.68 |
| 103 | Pulegone | 33.611 | 0.98 |
| 104 | Methyl 4-(1-hydroxycyclohex-2-en) | 33.674 | 0.58 |
| 105 | *n*-1-Adamantyl-*p*-nitrobenzalimine | 33.812 | 1.17 |
| 106 | N, N'-Ethylenebis [3-methoxy-N) | 33.869 | 0.18 |
| 107 | [Dimethyl-(3-trimethylsilanyloxyl)] | 33.926 | 0.68 |
| 108 | Anhydro 5-hydroxy-3-piperonyl | 34.023 | 1.25 |
| 109 | 1,4-Cyclohexadiene, 1,3,6-tris | 34.601 | 0.08 |
| 110 | *cis*-Ocimene | 34.647 | 0.04 |
| 111 | 3-(4-Morpholino)bicyclo | 34.681 | 0.02 |
| 112 | 3-Methyl-1-phenyltriazene | 34.847 | 0.10 |
| 113 | beta-Selinene naphthalene | 34.899 | 0.02 |
| 114 | *trans*-Decalin, 2-methyl | 35.002 | 0.06 |
| 115 | Methyl isopropyl disulphide | 35.076 | 0.03 |
| 116 | *trans*-verbenol bicyclo [3.1.1] | 35.099 | 0.03 |
| 117 | 2-[(4-Isopropyl-phenylcarbamoyl)] | 35.523 | 0.15 |
| 118 | beta-Phellandrene cyclohexene | 35.626 | 0.08 |
| 119 | Bornyl acetate | 35.688 | 0.13 |
| 120 | 3,4-Methylenedioxy-*n*-ethyl | 35.786 | 0.27 |
| 121 | *Z*-Jasmone | 35.900 | 0.39 |
| 122 | Etracosamethyl cyclododecasiloxan | 36.003 | 0.60 |
| 123 | Acetamide, 2-(adamantan-1-yl) | 36.163 | 1.01 |
| 124 | 6-Phenyl-3, 5-dithioxo-2,3,4,5 | 36.261 | 1.31 |
| 125 | 3-(4-Chlorophenyl)-4,6-dimethoxy | 36.352 | 0.89 |
| 126 | *o*-Anisic acid, 2-adamantyl ester | 36.375 | 1.71 |
| 127 | delta-Cadinene naphthalene | 36.530 | 0.46 |
| 128 | L-Valine, n-(*o*-anisoyl), methyl | 36.553 | 0.40 |
| 129 | Pentasiloxane, dodecamethyl | 36.587 | 0.44 |
| 130 | 1,1,1,5,7,7,7-Heptamethyl-3 | 36.678 | 1.71 |
| 131 | Trichloroacetic acid, 1-adamanty | 36.730 | 0.54 |
| 132 | Bistrimethylsilyl *n*-acetyl | 36.827 | 3.20 |
| 133 | 1,2-Benzisothiazole-3-propanoic | 36.919 | 0.69 |
| 134 | 3,6-Dioxa-2,4,5,7-tetrasilaoctan | 37.090 | 0.20 |
| 135 | Linalool 1,6-octadien-3-ol | 37.113 | 0.05 |
| 136 | 3,5,6,8,9-Tetramethoxy-2-methylpep | 37.222 | 0.58 |
| 137 | 1h-Pyrazole, 4,5-dihydro-5 | 37.331 | 0.82 |
| 138 | Bicyclo [4.3.0] nona-3,7-diene | 37.457 | 1.12 |
| 139 | Octadecamethyl cyclononasiloxane | 37.560 | 0.95 |
| 140 | 1-Amino-1-*o*-chlorophenyl-2 | 37.600 | 0.48 |
| 141 | 1,3-Xylyl-15-crown-4,2,3-pinan | 37.691 | 2.03 |
| 142 | 5,6,8,9-Tetramethoxy-2-methyl | 37.817 | 1.69 |
| 143 | *n*-Adamantan-1-ylmethyl-4 | 37.891 | 0.52 |
| 144 | 9-Borabicyclo [3.3.1] nonane | 37.909 | 0.31 |
| 145 | 4beta-Acetoxy-1beta | 37.943 | 0.90 |
| 146 | Adamantane-1-carboxamide | 38.120 | 0.82 |
| 147 | alpha-Terpinolene cyclohexexene | 38.229 | 0.62 |

tively. According to Table 2, twenty-seven compounds occupied more than 1% of essential oil volume which was distinguished as dominant components; among them, alpha-pinene, (-)-bicyclo in peak 4 (5.448 min with 7.50%), bicyclo [2.2.1] heptan-2-one in peak 29 (9.848 min with 5.92%), bicyclo [3.1.1] hept-3-en-2-one in peak 40 (11.771 min with 5.48%), 1,8-cineole 2-oxabicyclo in peak 17 (7.256 min with 4.60%), and acetic acid 1,7,7-trimethyl in peak 45 (14.506 min with 4.29%) were five major of them, respectively (Table 2). By comparing percentage for each compound on total

volume, it was found that 1,3,6-octatriene,3,7-dimethyl in peak 1 (5.150 min with 0.01%) given in Table 3 were minor constituent in the essential oil. It can be approximately said that the detector has distinguished twenty-seven major compounds in primary to final peaks; moreover, the minor components were observed in the middle. With closely looking at constituents of the essential oil, there were 120 different compounds with shares of ≤ 1% in total volume, which altogether contained 32.96% of the essential oil volume; nevertheless, twenty-seven dominant compounds occupied 67.04% of total volume, indicating most of the essential oil volume was filled by them (Table 2).

**Table 2.** Twenty-seven dominant compounds in the essential oil of *R. officinalis*

| Peak | Compound | Run time (min) | Percentage |
|---|---|---|---|
| 4 | alpha-Pinene, (-)-bicyclo | 5.448 | 7.50 |
| 29 | Bicyclo [2.2.1] heptan-2-one | 9.848 | 5.92 |
| 40 | Bicyclo [3.1.1] hept-3-en-2-one | 11.771 | 5.48 |
| 17 | 1,8-Cineole 2-oxabicyclo | 7.256 | 4.60 |
| 45 | Acetic acid, 1,7,7-trimethyl | 14.506 | 4.29 |
| 33 | Borneol L | 10.403 | 3.80 |
| 5 | Camphene bicyclo [2.2.1] heptan | 5.705 | 3.20 |
| 132 | Bistrimethylsilyl *n*-acetyl | 36.827 | 3.20 |
| 54 | Caryophyllene | 19.364 | 2.68 |
| 16 | DL-Limonene cyclohexene | 7.182 | 2.17 |
| 141 | 1,3-Xylyl-15-crown-4,2,3-pinan | 37.691 | 2.03 |
| 126 | *o*-Anisic acid, 2-adamantyl ester | 36.375 | 1.71 |
| 130 | 1,1,1,5,7,7,7-Heptamethyl-3 | 36.678 | 1.71 |
| 142 | 5,6,8,9-Tetramethoxy-2-methyl | 37.817 | 1.69 |
| 21 | Linalool L | 8.635 | 1.65 |
| 92 | Cyclononasiloxane, octadecamethyl | 32.478 | 1.57 |
| 89 | *m*-Anisic acid, morpholide | 32.278 | 1.44 |
| 100 | Isoindole-1,3-dione | 33.188 | 1.42 |
| 10 | beta-Myrcene 1,6-octadiene | 6.444 | 1.34 |
| 95 | Iron, monocarbonyl-(1,3-butadien) | 32.810 | 1.33 |
| 124 | 6-Phenyl-3,5-dithioxo-2,3,4,5 | 36.261 | 1.31 |
| 37 | alpha-Terpineol | 11.101 | 1.27 |
| 108 | Anhydro 5-hydroxy-3-piperonyl | 34.023 | 1.25 |
| 97 | 2-Butanone, 4-(dimethyl phenylsil) | 32.993 | 1.18 |
| 105 | *n*-1-Adamantyl-*p*-nitrobenzalimine | 33.812 | 1.17 |
| 138 | Bicyclo [4.3.0] nona-3,7-diene | 37.457 | 1.12 |
| 123 | Acetamide, 2-(adamantan-1-yl) | 36.163 | 1.01 |
| | Total volume | | 67.04 |

Rosemary is a valuable medicinal plant that has been studied in different aspects. I reviewed some studies on the essential oil of its samples collected from different regions worldwide. The reasons for the differences or similarities have also been explained. Soliman et al. (1994) analyzed the essential oil of this medicinal plant from Egypt with GC-MS and stated that 43 components were available in sample 1, which represented 82% of total volume, while verbenone (12.3%), camphor (11.3%), bornyl acetate (7.6%), and limonene (7.1%) were significant. Moreover, in their sample II, thirty-seven components occupied 86% of the total volume, and camphor (14.9%), alpha-pinene (9.3%), and 1,8-cineole (9.0%) were dominant. The results in each sample differed from another, and this subject indicated the effects of maintenance and sampling conditions on the changes of secondary metabolites in plants. Touafek et al. (2004) investigated the chemical properties of the essential oil of *R. officinalis* from Algerian Sahara and concluded that thirty compounds represented 98.2% of the essential oil volume while 1,8-cineole (29.5%), 2-ethyl-4,5-dimethylphenol (12.0%), and camphor (11.5%) were significant. Their results, to some extent, were similar to the previous study in Egypt, indicating the impact of similar environmental conditions (two countries from Africa) on the composition of the essential oil. Santoyo et al. (2005) studied the chemical composition of *R. officinalis* essential oil by supercritical fluid extraction and stated that in comparison with chromatography-mass spectroscopy analysis, fractions resulted in

**Table 3.** Fifty-six constituents in *R. officinalis* essential oil had the lowest percentage (≤ 0.1 in total)

| Peak | Compound | Run time (min) | Percentage |
|---|---|---|---|
| 3 | Thujene | 5.288 | 0.10 |
| 88 | p-Mentha-1(7), 8(10)-dien-9-ol | 32.026 | 0.10 |
| 112 | 3-Methyl-1-phenyltriazene | 34.847 | 0.10 |
| 85 | 1-Epoxy-2-methyl-3-isobutenyl-1 | 31.792 | 0.09 |
| 36 | *p*-Cymen-8-ol | 10.935 | 0.08 |
| 67 | 10,10-Dimethyl-2,6-dimethylenebi | 25.452 | 0.08 |
| 72 | 1,2-Diphenyl tetramethyl disilane | 30.899 | 0.08 |
| 83 | Thymyl acetate 2-isopropyl-5 | 31.632 | 0.08 |
| 109 | 1,4-Cyclohexadiene, 1,3,6-tris | 34.601 | 0.08 |
| 118 | beta-Phellandrene cyclohexene | 35.626 | 0.08 |
| 24 | D-Fenchyl alcohol bicyclo | 9.030 | 0.07 |
| 30 | *exo*-Methyl camphenilol | 9.917 | 0.07 |
| 39 | Bicyclo [3.1.1] hept-2-ene-2-ethan | 11.582 | 0.06 |
| 41 | Naphthalene, decahydro-2-methyl | 12.658 | 0.06 |
| 43 | 1,4-Cyclooctadiene | 13.047 | 0.06 |
| 47 | alpha-Terpinolene cyclohexe | 16.394 | 0.06 |
| 57 | Cyclohexene, 1-methyl-4-(5-methyl) | 22.042 | 0.06 |
| 63 | 2-(4a, 8-Dimethyl-2,3,4,4a,5,6) | 24.176 | 0.06 |
| 71 | Farnesyl acetone | 30.728 | 0.06 |
| 73 | Isoterpinolene cyclohexene | 31.065 | 0.06 |
| 114 | *trans*-Decalin, 2-methyl | 35.002 | 0.06 |
| 19 | Copaene tricyclo | 7.943 | 0.05 |
| 27 | *trans*-Pinocarveol bicyclo | 9.676 | 0.05 |
| 46 | Phenol, 2-methyl-5-(1-methylethyl) | 15.067 | 0.05 |
| 51 | Copaene | 17.882 | 0.05 |
| 60 | 1 Tricyclo [6.4.0.0 (3,7)] dodecane | 23.243 | 0.05 |
| 135 | Linalool 1,6-octadien-3-ol | 37.113 | 0.05 |
| 23 | 1,3-Cyclopentadiene | 8.910 | 0.04 |
| 25 | 1-(1'-Ethoxyethyl) bicyclo [2.1.1] | 9.190 | 0.04 |
| 28 | Bicyclo [3.1.1] hept-3-en-2-ol | 9.728 | 0.04 |
| 59 | Naphthalene, 1,2,3,5,6,8a | 22.465 | 0.04 |
| 61 | Bicyclo [3.2.0] hept-2-ene-6-one | 24.021 | 0.04 |
| 66 | *trans-Z*-alpha-Bisabolene epoxide | 25.355 | 0.04 |
| 78 | 1-Dodecanone, 2-(imidazol-1-yl) | 31.328 | 0.04 |
| 79 | *trans*-Sabinene hydrate | 31.391 | 0.04 |
| 82 | 1-Cyclopropene-1-pentanol | 31.506 | 0.04 |
| 110 | *cis*-Ocimene | 34.647 | 0.04 |
| 44 | 2-Cyclohexen-1-one, 3-methyl-6 | 13.894 | 0.03 |
| 53 | Benzene, 1,2-dimethoxy-4 | 18.883 | 0.03 |
| 56 | alpha-Selinene | 21.658 | 0.03 |
| 58 | Benzene, isocyanato | 22.236 | 0.03 |
| 64 | 2-Oxabicyclo [9.1.0] dodeca-3,7-D | 24.760 | 0.03 |
| 69 | di-*epi*-alpha-Cedrene-(I) | 26.556 | 0.03 |
| 74 | 4-[2-(Adamantan-1-yloxy)]-ethylamide | 31.105 | 0.03 |
| 76 | 1,3-Dioxan-2,2-dimethyl-4 | 31.225 | 0.03 |
| 80 | (6e, 9z)-6-(Dimethyl phenylsilyl) | 31.414 | 0.03 |
| 81 | 1,2-bis (Dimethyl phenylsilyl) ethane | 31.449 | 0.03 |
| 115 | Methyl isopropyl disulphide | 35.076 | 0.03 |
| 116 | *trans*-Verbenol bicyclo [3.1.1] | 35.099 | 0.03 |
| 65 | beta-Myrcene | 24.857 | 0.02 |
| 70 | Pyrimidine, 5-methyl-2 | 30.356 | 0.02 |
| 75 | Cyclopentanone, 2-(1-adamantyl) | 31.191 | 0.02 |
| 77 | Tricyclo [3.3.1.1(3,7)] decane | 31.271 | 0.02 |
| 111 | 3-(4-Morpholino)bicyclo | 34.681 | 0.02 |
| 113 | beta-Selinene naphthalene | 34.899 | 0.02 |
| 1 | 1,3,6-Octatriene, 3,7-dimethyl | 5.150 | 0.01 |

the detection of 33 compounds in the essential oil while the main components were alpha-pinene, 1,8-cineole, camphor, verbenone, and borneol, which occupied 80% of the total volume. Martínez et al. (2009) performed GC-MS analysis of rosemary essential oil from its aerial parts and reported that the major compounds were alpha-pinene (14.10%), camphene (11.47%), beta-pinene (12.02%), myrcene (3.31%), alpha-phellandrene (7.87%), eucalyptol (8.58%), 2-bornanone (3.42%), camphor (8.75%), isoborneol (3.48%), borneol (4.85%), and borneol acetate (6.49%). Hussain et al. (2010) studied *R. officinalis* essential oil in Pakistan and stated that GC-MS analysis revealed major components as 1,8-cineol (38.5%), camphor (17.1%), alpha-pinene (12.3%), limonene (6.23%), camphene (6.00%), and linalool (5.70%). Their results were somewhat in agreement with my results. One of the main reasons for this position is the geographical similarities between the two countries (Iran and Pakistan); of course, the studied plant parts were effective

in this regard. Boutekedjiret et al. (2011) studied the essential oil of *R. officinalis* in Algeria by GC-MS and concluded that more than 90% of its volume was occupied by 1,8-cineole (52.4%) and camphor (12.6%) which were significant. In another study, Rašković et al. (2014) studied the chemical composition of the isolated rosemary essential oil by gas chromatography-mass spectrometry in Tunisia and concluded that 29 chemical compounds were available while the main constituents were 1,8-cineole (43.77%), camphor (12.53%), and alpha-pinene (11.51%). The results for alpha-pinene were somewhat similar to my research; but, in general diversity of compounds in their study was very low compared to mine, which was responsible for differences. Jafari-Sales and Pashazadeh (2020) studied the chemical composition of rosemary essential oil collected from Tabriz in northwest of Iran and concluded that 19 compounds were identified where 1,8-cineole and alpha-pinene had the highest volume in the essential oil. One of the main reasons for these differences is the geographical differences between the two regions in Iran (Tabriz and Kermanshah). Also, the variety of compounds in my study was remarkable, indicating the suitability of Kermanshah province in the west of Iran for the growth of this medicinal plant.

## 4. Conclusions

The medicinal plants are god-given natural resources in each region; therefore, essential issues in plant science are their identification, taxonomy, and study of chemical features. According to this research, rosemary has valuable secondary compounds that could seriously be focused on them in medical, pharmacology, and toxicology. The author of the article hopes that next researchers study the chemical content of the other medicinal plants belonging to different species and families for their practical application in the future.

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## Conflict of interest

The author confirms that there is no known conflict of interest.

## CRediT authorship contribution statement

**Mohammad Asadi:** M. Asadi performed all parts of the article alone.

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## Supplementary File

None.

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