# Volatile oils, lipid constitutes and the antimicrobial activity of *Daucus syrticus* growing in Libya

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**Background/aim**

*Apiaceae* is a large plant family; it comprises about 60 annual and biannual species mostly distributed in Europe, Africa, West Asia, and Australia. The *Daucus* genus is one of the most common genera of this family in which *Daucus syrticus* (DS) is a common member, growing mainly in the Sirt region (Libya). It is locally known as wild carrot. This study aims to investigate volatile oils, lipid constitutes, and the antimicrobial activity of DS extracts.

**Materials and methods**

The herb of DS was collected from Wadi Telal, Sirt region (Libya), during January and April 2011. About 250 g of different parts from fresh plant material (aerial parts, roots, and seeds) of DS were subjected to hydrodistillation. Extraction of lipid constituents was carried out as follows: About 1500 g of dried powdered plant material of DS were extracted with petroleum ether in a soxhlet. The antimicrobial activity was determined using the disk diffusion method, and the inhibition zone (IZ) was measured for each extract under study against *Escherichia coli*, *Bacillus subtilis*, *Aspergillus niger*, and *Candida albicans*.

**Results**

Results of Gas chromatography/Mass spectrometry GC/MS analyses of the volatile oils of the aerial parts (January and April collections) proved that they contain a mixture of 47 and 33 compounds, respectively, whereas the roots (April and July) were found to contain a mixture of 32 and 20 compounds, respectively. In addition, the seeds (July) were found to contain 18 compounds, with β-asarone (26.23%) as the main compound. Investigation of the lipid fraction of the herb revealed the presence of a mixture of fatty alcohols; the major contents of the unsaponifiable fraction were identified as a series of *n*-alkanes $C_8$–$C_{28}$ (84.85%), four steroidal compounds, triterpene, and a mixture of fatty acid methyl esters consisting of eight different acids. The antimicrobial evaluation of DS extracts exhibited different IZ values against the tested microorganisms.

**Conclusion**

The main constituents of the different volatile oils of the aerial parts, the roots, and the seeds were identified. The fraction of total fatty acid had the highest activity against *E. coli* (IZ = 2.7, minimum inhibitory concentration = 250 mg/ml).

**Keywords:**
antimicrobial activity, Apiaceae, *Daucus syrticus*, lipid constituents, volatile oils

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## Introduction

The genus *Daucus*, family *Apiaceae* (*Umbelliferae*), comprises about 60 annual and biannual species, distributed mostly in Europe, Africa and West Asia, and a few in North America and Australia [1]. It is represented by three species in Libya [2]. The essential oils obtained from the leaves and fruits of *Daucus gingidium* ssp. *gingidium* have been studied by Flamini *et al.* [3]. They found that the main constituents of the essential oil from the leaves were sabinene, α-pinene, germacrene-D, and limonene. However, sabinene was the main compound identified in the essential oil from the fruits, followed by α-pinene and 4-terpineol. The main components in the essential oil of the flowers and fruits of *Daucus carota* [4,5] were α-pinene, sabinene, myrcene, limonene, and three monoterpene alcohols (geraniol, nerol, and carotol).

The main constituents of the essential oil from the leaves of *Daucus sahariensis* were myristicin, α-pinene, *cis*-chrysanthenyl acetate, and β-bisabolol, and those from the fruits were myristicin, α-pinene, limonene, and *cis*-chrysanthenyl acetate (7.4%) [6].

The fatty acid fractions of different organs (leaves, stems, and roots) of *Daucus crinitus* were characterized as lauric acid (17.9, 17.5, and 18.1%, respectively) and other long-chain fatty acids (until $C_{22}$) [7]. The plants of *Daucus* spp. genus were reported to have many medicinal properties such as antibacterial [8], stimulant [9], antiseptic, carminative, diuretic, hepatoprotective [10], antisteroidogenic [11], and anti-inflammatory [10,12].

This work aims to investigate the volatile oils, lipid constitutes, and antimicrobial activity of *Daucus syrticus* (DS) extracts.

## Materials and methods

### Plant material

The herb of DS was collected from Wadi Telal (Sirt region, Libya) during January and April 2011. The roots were collected during April and July 2011, whereas the seeds were collected during July 2011. The plant was identified by Dr El-Sayed Nafa, Botany Department, Faculty of Science, Sirte University (Sirt, Libya).

### Instruments

GC/MS analyses of different volatile oils and acetone-insoluble fractions were carried out using an Agilent 6890 gas chromatograph equipped with an Agilent mass spectrophotometer with a direct capillary interface and fused silica capillary column HP-5MS (30 m × 0.32 mm × 0.25 μm film thickness). Samples were injected under the following conditions: the GC temperature program was started at 60°C (3 min), and then elevated to 280°C at the rate of 8°C/min. The detector and injector temperature were set at 280 and 250°C, respectively. Helium was used as the carrier gas at about 1.0 ml/min in a pulsed splitless mode, the solvent delay was 3 min and the injector size was 1.0 ml. The mass spectral detector was operated in an electron impact mode with an ionizing energy of 70 eV scanning from 50 to 500 *m/z*. The ion source temperature was 230°C and the quadruple temperature was 50°. Wiley and NIST were used as the mass spectral database.

### Gas liquid chromatography (GLC) analysis of unsaponifiable matters and fatty acid methyl esters

GLC analyses were carried out under the following conditions: Instrument, Hewlett Packard, HP-6890 GC method; oven: initial temperature 70°C, initial time 2 min; rate: rate 8, final temperature 280°C, final time 20 min; inlet temperature 280°C, detector temperature 300°C; Flame Ionization Detector Column capillary column HP, 5% phenyl methyl siloxane (length 30 m, diameter 320 μm, and film thickness 0.25 μm); flow rates: $N_2$ 20 ml/min, $H_2$ 20 ml/min, air 200 ml/min.

### Preparation of different volatile oils

About 250 g of different parts from fresh plant material (herb, roots, and seeds) of DS were subjected to hydrodistillation in an all-glass Clevenger-type apparatus for about 3 h [13]. The oil obtained was removed after complete distillation and dried over anhydrous sodium sulfate to yield a pale yellow oil having a characteristic odor. (Herb: 0.01 and 0.02% v/w for January and April, respectively; roots: 0.019 and 0.090% v/w for April and July, respectively; and seeds: 0.023% v/w for July).

### Extraction of lipid constituents

About 1500 g of the dried powdered plant of DS were extracted with petroleum ether (40–60 b.r.) using a soxhlet apparatus. The combined petroleum ether extract was passed through Fuller's earth to remove the colored pigments, filtered, dried over anhydrous sodium sulfate, and evaporated *in vacuo* at 40°C till dry to yield a pale yellow residue (12 g). The petroleum ether residue was dissolved in boiling acetone (250 ml) and left overnight at room temperature. An amorphous precipitate was filtered, washed with cold acetone, and recrystallized from chloroform/methanol to yield white crystals (4 g) of acetone-insoluble fraction (hydrocarbon and fatty alcohol mixture). The filtrate (acetone-soluble fraction) was evaporated till dry (6.85 g).

### Saponification of the acetone-soluble fraction

The acetone soluble-fraction (6.5 g) was saponified by refluxing with 100 ml N/2 alcoholic KOH. The alcoholic solution was concentrated to about 25 ml and diluted with cold distilled water (100 ml). The unsaponifiable matters were extracted with ether (3 × 100 ml). The combined ether extract was washed with distilled water, dehydrated over anhydrous sodium sulfate, and evaporated *in vacuo* till dry to yield a yellowish brown semisolid residue of unsaponifiable matters (3.2 g).

### Extraction of total fatty acids

The hydroalcoholic soap solution after saponification was rendered acidic (pH = 2) with 5% sulfuric acid. The liberated fatty acids were extracted thoroughly several times with ether. The combined ether extract was washed with distilled water till free from acidity and dehydrated over anhydrous sodium sulfate. The solvent was evaporated *in vacuo* at about 40°C till dry (2.8 g).

### Preparation of fatty acid methyl esters

About 2.5 g of the total fatty acids were dissolved in 75 ml dry methanol containing 5% HCl and refluxed on a boiling water bath for 4 h; the solvent was concentrated up to 25 ml and diluted with 100 ml distilled water. The methyl esters of fatty acids were extracted with successive portions of chloroform (3 × 100 ml). The combined chloroform extract was washed with distilled water till free from acidity, dried over anhydrous sodium sulfate and filtered, and the solvent was evaporated *in vacuo* at 40°C (2.0 g).

### Antimicrobial activity

#### *Preparation of different extracts for antimicrobial activity studies*

About 100 g of the air-dried powdered plant were extracted firstly with petroleum ether using a Soxhlet for 24 h to obtain the petroleum ether extract, which

was tested, and other fractions such as fatty alcohols, fatty acids and unsaponifiable matters were also prepared and tested for their antimicrobial activity. Five concentrations [(a) 50 μg/ml, (b) 100 μg/ml, (c) 150 μg/ml, (d) 200 μg/ml, (f) 250 μg/ml] were prepared from each extract (fraction).

*Biological experiments*

The antimicrobial activity was evaluated using the microdilution method, in which the minimum inhibitory concentration was determined. Extracts were tested against a set of microorganisms including Gram-positive and Gram-negative bacteria, yeasts, and fungi according to the methods described by Cowan [14] and Kim *et al*. [15].

*Maintenance of the microorganism*

The microorganisms used in the current work were obtained from the Natural and Microbial Products Chemistry Department, National Research Center (Dokki, Cairo, Egypt). The bacterial species used were maintained on nutrient agar medium at 37°C; potato dextrose agar was used for fungi. After 12 h of activation, bacterial suspensions were prepared, and their turbidity was standardized by estimation of the optical density on a spectrophotometer (UV-VIS, 1610; Shimadzu, Tokyo, Japan). The final densities of bacteria were $1 \times 10^6$ and $1 \times 10^5$ cell/ml, respectively. In contrast, the fungal strain was used after 3 days of incubation, and was diluted using saline to yield a $1 \times 10^4$ spore/ml dilution.

## Results

Results of the GC/MS analysis of the volatile oil of the DS herb in January proved that it contains monoterpene hydrocarbons (31.91%), oxygenated monoterpenes (18.02%), sesquiterpene hydrocarbons (32.34%), oxygenated sesquiterpenes (4.98%), diterpene hydrocarbons (2.39%), oxygenated diterpenes (0.51%), sesterterpene hydrocarbons (1.31%), triterpene hydrocarbons (0.49%), carboxylic acid (3.64%), esters (1.61%), and heterocyclic compounds (2.08%). However, the volatile oil of the herb in April was found to contain a mixture of 33 compounds, accounting for 99.01% of the total essential oil; the percentages of different classes are monoterpene hydrocarbons (61.32%), oxygenated monoterpenes (13.06%), sesquiterpene hydrocarbons (17.61%), oxygenated sesquiterpenes (1.46%), diterpene hydrocarbons (0.77%), sesterterpene hydrocarbons (1.51%), triterpene hydrocarbons (1.17%), esters (1.54%), and heterocyclic compounds (0.56%).

The volatile oil of the roots in April (32 compounds) consists of oxygenated monoterpenes (14.81%), sesquiterpene hydrocarbons (5.52%), oxygenated sesquiterpenes (7.61%), diterpene hydrocarbons (8.57%), sesterterpene hydrocarbons (29.15%), triterpene hydrocarbons (8.03%), carboxylic acid (4.94%), esters (8.32%), and heterocyclic compounds (1.17%). The oil from the roots in July consisted of a mixture of 20 compounds belonging to many classes as follows: siloxane compounds (40.86%), monoterpenes hydrocarbons (3.34%), oxygenated monoterpenes (11.47%), sesquiterpene hydrocarbons (4.49%), oxygenated sesquiterpenes (0.15%), sesterterpene hydrocarbons (3.12%), diterpene hydrocarbons (4.78%), triterpene hydrocarbons (8.90%), oxygenated triterpenes (6.39%), carboxylic acid (5.80%), and heterocyclic compounds (9.67%).

The essential oil of the seeds was found to comprise 18 compounds, accounting for 99.81% of the total essential oil, among which monoterpene hydrocarbons (28.45%), oxygenated monoterpenes (28.18%), sesquiterpene hydrocarbons (8.16%), oxygenated sesquiterpenes (14.19%), and esters (20.86%) were found to be present. The results obtained are shown in Tables 1 and 2.

Results obtained from GC/MS of the acetone-insoluble fraction revealed the presence of a mixture of hydrocarbons and fatty alcohols, which were identified as tetracosanol, pentacosane, hexacosane, heptacosane, octacosane, nonacosane, and heptatriacontanol, as shown in Table 3.

The GLC analysis of the unsaponifiable fraction is shown in Table 4. Results of GLC of fatty acid methyl esters are summarized in Table 5. The antimicrobial activity of different extracts with different concentrations, as in a, b, c, d and f, were 50, 100, 150, 200, and 250 μg/ml, respectively, using the Disc diffusion method modified by Kirby–Bauer and the Streaking methods [16] against some selected microorganisms (bacteria and fungus). The data are shown in Tables 6 and 7.

## Discussion

Investigation of the volatile oil of the DS herb collected during January revealed the presence of different classes of terpene and nonterpene compounds, among which γ-terpinene, α-terpineol, α-humulene, α-bisabolol, neophytadiene, phytol, heptacosane, nonacosane, *n*-hexadecanoic acid, 9,12,15-octadecatrienoic acid methyl ester and acetyl-5-methyl-furan were found to be the main compounds. These data were in agreement

**Table 1 Composition of the essential oils of the herb, roots and seeds of *Daucus syrticus***

| | | | % | | | | |
|---|---|---|---|---|---|---|---|
| | | | Herb | | Roots | | Seeds |
| Number | Compound | Molecular weight | January | April | April | July | July |
| 1 | α-Terpinene | 136 | 0.57 | 4.45 | — | — | — |
| 2 | (+)-4-Carene | 136 | 1.35 | — | — | — | 0.43 |
| 3 | P-cymene | 134 | 4.98 | — | — | 3.34 | — |
| 4 | γ-Terpinene | 136 | 21.89 | 22.58 | — | — | 14.58 |
| 5 | β-Ocimene | 136 | 1.14 | — | — | — | — |
| 6 | α-Terpinolene | 154 | 4.36 | — | — | 0.40 | 0.89 |
| 7 | α-Terpineol | 154 | 12.69 | — | — | — | — |
| 8 | Thiophene, tetrahydro-, 1,1-dioxide | 118 | 0.48 | 0.56 | 1.17 | 7.97 | — |
| 9 | Copaene | 204 | 1.1 | 0.68 | — | — | — |
| 10 | *trans*-Caryophyllene | 204 | 1.90 | 0.66 | 0.37 | — | — |
| 11 | γ-Elemene | 204 | 6.30 | 4.71 | 0.38 | 1.01 | — |
| 12 | α-Humulene | 204 | 14.68 | 1.50 | 2.84 | 1.24 | 5.20 |
| 13 | 2-Acetyl-5-methylfuran | 124 | 1.60 | — | — | — | — |
| 14 | Germacrene-D | 204 | 1.63 | 2.26 | — | — | — |
| 15 | β-Ionone | 192 | 0.52 | — | — | — | — |
| 16 | Germacrene-B | 204 | 0.06 | 0.67 | — | — | — |
| 17 | α-Farnesene | 204 | 2.69 | — | — | — | — |
| 18 | δ-Cadinene | 204 | 1.30 | 3.10 | — | — | — |
| 19 | Myristicin | 204 | 0.45 | 0.35 | 13.09 | 11.07 | — |
| 20 | *Cis*-α-bisabolene | 204 | 1.45 | 0.05 | — | — | 4.40 |
| 21 | (-)-Spathulenol | 220 | 0.30 | — | — | — | — |
| 22 | α-Gurjunene | 204 | 0.23 | — | — | — | 2.96 |
| 23 | 12-Oxabicyclo [9.1.0] dodeca-3,7-diene 1,5,5,8-tetramethyl | 138 | 0.77 | — | 1.72 | — | — |
| 24 | τ-Muurolol | 222 | 0.80 | — | — | — | 0.43 |
| 25 | α-Cadinol | 222 | 0.70 | — | — | — | — |
| 26 | α-Bisabolol | 222 | 1.71 | 0.77 | 0.45 | 0.15 | — |
| 27 | Juniper camphor | 222 | 0.7 | — | — | — | — |
| 28 | Tetradecanoic acid | 228 | 0.65 | — | — | — | — |
| 29 | Neophytadiene | 278 | 1.50 | — | — | — | — |
| 30 | 7,10,13-Hexadecatrienoic acid | 306 | 0.8 | — | — | — | — |
| 31 | Hexadecanoic acid methyl ester | 270 | 0.11 | — | 0.27 | — | — |
| 32 | 9,12,15-Octadecatrienoic acid methyl ester | 292 | 1.24 | — | — | — | — |
| 33 | *n*-Hexadecanoic acid | 257 | 2.19 | — | 4.94 | 5.80 | — |
| 34 | 1-Naphthalenamine 5,6,7,8-tetrahydro-*N*, *N*-dimethyl | 175 | 0.10 | — | — | — | — |
| 35 | Heneicosane | 296 | 0.80 | 0.15 | 1.01 | — | — |
| 36 | Benzene,1-(2-butenyl)-2,3-dimethyl | 160 | 0.78 | — | — | — | — |
| 37 | Phytol | 296 | 0.51 | — | — | — | — |
| 38 | 9,12-Octadecadienoic acid (2,2) | 280 | 0.26 | — | — | — | — |
| 39 | Docosane | 310 | 0.09 | 0.19 | 2.42 | — | — |
| 40 | Benzene,4-(2-butenyl)-1,2-dimethyl | 160 | 0.20 | — | — | — | — |
| 41 | Tricosane | 324 | 0.10 | 0.43 | 2.68 | — | — |
| 42 | Tetracosane | 338 | 0.13 | — | 3.92 | — | — |
| 43 | Pentacosane | 352 | 0.23 | 0.32 | 4.44 | — | — |
| 44 | Hexacosane | 366 | 0.29 | 0.30 | 6.43 | — | — |
| 45 | Heptacosane | 380 | 0.36 | 0.38 | 6.41 | — | — |
| 46 | Octacosane | 394 | 0.20 | 0.51 | 7.94 | 3.12 | — |
| 47 | Nonacosane | 408 | 0.49 | 1.17 | 8.03 | — | — |
| 48 | Pentadecane | 212 | — | — | 0.29 | — | — |
| 49 | Phenol,2,6-bis(1,1-di-methylethyl)-4-methyl | 220 | — | — | — | — | — |
| 50 | Hexadecane | 226 | — | — | 0.69 | — | — |
| 51 | Heptadecane | 240 | — | — | 0.85 | — | — |
| 52 | Octadecane | 254 | — | — | 0.83 | — | — |
| 53 | Butyl tetradecyl phthalate | 223 | — | — | 0.74 | — | — |
| 54 | Nonadecane | 268 | — | — | 0.42 | — | — |

**Table 1 (Continued)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 55 | Eicosane | 284 | — | — | 0.62 | — | — |
| 56 | Ethyl linoleate | 308 | — | — | 0.53 | — | — |
| 57 | 1-Octadecene | 252 | — | — | 1.27 | — | — |
| 58 | 1-Nonadecene | 266 | — | — | 0.42 | — | — |
| 59 | Limonene | 136 | — | 28.82 | — | — | 6.05 |
| 60 | Isoterpinene | 254 | — | 5.47 | — | — | — |
| 61 | Linalool | 136 | — | — | — | — | 0.67 |
| 62 | α-Fenchyl acetate | 196 | — | 1.40 | — | — | 14.87 |
| 63 | Geranyl acetate | 196 | — | — | — | — | 5.92 |
| 64 | *Cis*-methyl isoeugenol | 204 | — | — | — | — | 7.39 |
| 65 | 1,6-Germacradien 5-ol | 222 | — | — | — | — | 0.23 |
| 66 | Carotol | 222 | — | — | — | — | 8.99 |
| 67 | β-Asarone | 108 | — | — | — | — | 26.23 |
| 68 | (-)-(Z)-Lanceol | 220 | — | — | — | — | 0.14 |
| 69 | Benzoic acid cyclohexyl ester | 204 | — | — | — | — | 0.07 |
| 70 | 4-Terpineol | 154 | — | 12.41 | — | — | 0.39 |
| 71 | 7-Oxadicyclo [4.1,0] hepta-2-one, 1-methyl-4-(1-methylethenyl) | 166 | — | 0.30 | — | — | — |
| 72 | (-)-myrtenyl acetate | 194 | — | 0.14 | — | — | — |
| 73 | α-Cubebene | 204 | — | 0.69 | — | — | — |
| 74 | β-Cubenene | 204 | — | 2.50 | — | — | — |
| 75 | Zingiberene | 204 | — | 0.23 | — | — | — |
| 76 | Dioctyl phthalate | 391 | — | 5.47 | — | — | — |
| 77 | γ-Cadinene | 222 | — | 1.01 | — | — | — |
| 78 | β-Eudesmol | 222 | — | 0.33 | — | — | — |
| 79 | Cyclotetrasiloxaneoctamethyl | 281 | — | — | — | 3.57 | — |
| 80 | Pentadecane,2,6,10, 14-tetramethyl | 267 | — | — | — | 2.24 | — |
| 81 | Arsenous acid, tris (trimethylsilyl) ester | 289 | — | — | — | 22.14 | — |
| 82 | Cyclopentasiloxane, decamethyl | 355 | — | — | — | 10.23 | — |
| 83 | Cyclohexasiloxane, dodecamethyl, cycloheptasiloxane, tetradecamethyl | 429 | — | — | — | 2.17 | — |
| 84 | Propanephosphonic acid | 450 | — | — | — | 1.03 | — |
| 85 | Bis(trimethylsilyl) ester triacontane | 235 | — | — | — | 1.18 | — |
| 86 | Propanephosphonic acid, bis(trimethylsilyl) ester | 422 | — | — | — | 8.90 | — |
| 87 | Friedelin | 426 | — | — | — | 6.39 | — |
| 88 | 2-Ethylacridine | 207 | — | — | — | 1.70 | — |

**Table 2 The main classes of chemical constituents of different volatile oils of *Daucus syrticus***

| | | % | | | | |
|---|---|---|---|---|---|---|
| | | Herb | Roots | | Seeds | |
| Number | Compound | January | April | April | July | July |
| 1 | Monoterpenoids hydrocarbon | 31.91 | 61.32 | — | 3.34 | 28.45 |
| 2 | Oxygenated monoterpenoids | 18.02 | 13.06 | 14.81 | 11.47 | 28.18 |
| 3 | Sesquiterpenoids hydrocarbons | 32.34 | 17.61 | 5.52 | 4.49 | 8.16 |
| 4 | Oxygenated Sesquiterpenoids | 4.98 | 1.46 | 7.61 | 0.15 | 14.19 |
| 5 | Ester compounds | 1.61 | 1.54 | 8.32 | — | 20.86 |
| 6 | Diterpenoids hydrocarbon | 2.39 | 0.77 | 8.57 | 4.78 | — |
| 7 | Oxygenated diterpenoids | 0.51 | — | — | — | — |
| 8 | Carboxylic acid | 3.64 | — | 4.94 | 5.80 | — |
| 9 | Sesterterpenoids hydrocarbons | 1.31 | 1.51 | 29.15 | 3.12 | — |
| 10 | Triterpenoids hydrocarbons | 0.49 | 1.17 | 8.03 | 8.90 | — |
| 11 | Oxygenated triterpenoids | — | — | — | 6.39 | — |
| 12 | Hetero cyclic compounds | 2.08 | 0.56 | 1.17 | 9.67 | — |
| 13 | Siloxane compounds | — | — | — | 40.86 | — |
| | Total identified | 98.65 | 99.01 | 98.71 | 98.97 | 99.24 |

with those reported by Mansour *et al.* [17], who investigated the volatile oil of *Daucus glaber* in April 2004 and identified γ-terpinene as one of the main compounds. However, the volatile oil of the DS herb

**Table 3 GC/MS data of the acetone-insol. fraction of *Daucus syrticus***

| Peak number | Relative% | Molecular weight | Compound | Chemical formula |
|---|---|---|---|---|
| 1 | 21.28 | 364 | Tetracosanol | $C_{24}H_{49}OH$ |
| 2 | 3.17 | 352 | Pentacosane | $C_{25}H_{52}$ |
| 3 | 2.50 | 279 | Unkwon | – |
| 4 | 1.04 | 366 | Hexacosane | $C_{26}H_{54}$ |
| 5 | 15.75 | 380 | Heptacosane | $C_{27}H_{56}$ |
| 6 | 1.27 | 394 | Octacosane | $C_{28}H_{58}$ |
| 7 | 52.23 | 408 | Nonacosane | $C_{29}H_{60}$ |
| 8 | 2.77 | 536 | Heptatriacontanol | $C_{37}H_{75}OH$ |

**Table 4 GLC analysis of the unsaponifiable fraction of *Daucus syrticus***

| Compound | Relative% | Compound | Relative% |
|---|---|---|---|
| *n*-$C_8$ | 0.56 | $C_{21}$ | 3.2 |
| $C_9$ | 0.44 | $C_{22}$ | 8.12 |
| $C_{10}$ | 0.34 | $C_{23}$ | 18.52 |
| $C_{11}$ | 0.59 | $C_{25}$ | 15.98 |
| $C_{12}$ | 1.06 | $C_{26}$ | 1.50 |
| $C_{13}$ | 2.12 | $C_{27}$ | 2.48 |
| $C_{14}$ | 1.94 | $C_{28}$ | 0.86 |
| $C_{15}$ | 0.55 | Cholesterol | 0.43 |
| $C_{16}$ | 3.44 | Campesterol | 0.40 |
| $C_{17}$ | 3.00 | Stigmasterol | 0.60 |
| $C_{18}$ | 3.35 | β-Sitosterol | 0.85 |
| $C_{19}$ | 7.7 | α-Amyrine | 0.96 |
| $C_{20}$ | 9.10 | — | — |

**Table 5 GLC data of fatty acid methyl esters of *Daucus syrticus***

| Peak number | Fatty acid | Relative% |
|---|---|---|
| 1 | Lauric ($C_{12:0}$) | 0.48 |
| 2 | Myristic ($C_{14:0}$) | 1.97 |
| 3 | Palmitic ($C_{16:0}$) | 16.68 |
| 4 | Stearic ($C_{18:0}$) | 14.64 |
| 5 | Oleic ($C_{18:1}$) | 1.35 |
| 6 | Linoleic ($C_{18:2}$) | 29.30 |
| 7 | Linolenic ($C_{18:3}$) | 34.35 |
| 8 | Behenic ($C_{22:0}$) | 1.23 |

**Table 6 Antimicrobial activity of different extracts of *Daucus syrticus***

| Extract | *Escherichia coli* | *Bacillus subtilis* | *Aspergillus niger* | *Candida albicans* |
|---|---|---|---|---|
| Volatile oil of the herb | 1.4 | 1.3 | 1.0 | 1.2 |
| Volatile oil of seeds | 1.1 | 1.0 | 0.8 | 0.9 |
| Petroleum ether | 0.4 | 0.6 | 0.5 | — |
| Acetone soluble | 0.6 | 0.7 | 0.4 | 0.4 |
| Acetone insoluble | 0.5 | 0.9 | — | + |
| Fatty acids | 1.2 | — | — | — |

The scale of measurement was as follows (disk diameter not included): 14–11 mm zone of inhibition is strong; 10–8 mm zone of inhibition is moderate/mild; 7–4 mm zone of inhibition is weak; and <4 mm, no inhibition.

collected during April was found to contain a mixture of 33 compounds, accounting for 99.01% of the total essential oil, with limonene, 4-terpineol, γ-elemene, α-bisabolol, tricosane, octacosane, nonacosane, fenchyl acetate and thiophene, tetrahydro-, 1,1-dioxide being the main compounds. These data were found to be in agreement with those reported by Bendiabdellah *et. al*. [18] and Meliani *et. al*. [19] who investigated the volatile oil of *Daucus muricatus* in May 2012 and *Daucus carrota* in June 2013, and identified limonene as one of the main compounds. The volatile oil of the roots in April was composed of 32 compounds, among which myristicin, α-humulene, phenol, 2, 6-bis(1, 1-dimethyleth)-4-methyl, tricosane, octacosane, nonacosane, hexadecanoic acid, dioctyl phthalate and thiophene, tetrahydro-, 1,1-dioxide were the main compounds. The results obtained were in accordance with those reported by Smaili *et al*. [6], who investigated the volatile oil of *D. sahariensis* in 2011 and identified myristicin as one of the main compounds. In contrast, the oil from the roots collected during July consisted of a mixture of 20 compounds belonging to many classes, among which decamethylcyclopentasiloxane, *p*-cymen, myristicin, α-humulene, α-bisabolol, octacosane, tricosane, triacontane, friedelin, hexadecanoic acid, and thiophenetetrahydeo-1,1-dioxide were the major compounds. The presence of siloxane compounds has been reported before in other plants of the Apiaceae family such as dill and in essential oils of other *Daucus* spp. [20]; also isolated octamethylcyclotetrasiloxane from the volatile oil of *Actinidia deliciosa*.

From the essential oil of the seeds, 18 compounds were identified, accounting for 99.81% of the total essential oil, among which γ-terpinene, β-asarone, α-humulene, carotol, and α-fenchyl acetate are the main compounds. These data agree with those reported by Kameoka *et al*. (1989) [21] and Halim *et al*. [5], who investigated the volatile oil of *D. carota* and identified β-asarone and carotol as the main compounds. It was found that the acetone-insoluble fraction contains two fatty alcohols and five hydrocarbons, among which nonacosane was the main constituent (52.23%).

Data obtained from the GLC analysis of the unsaponifiable fraction showed that it contains a series of hydrocarbons (80.24%), sterols, (2.28% cholesterol, campasterol, stigmasterol, and β-sitosterol) and triterpenes (0.96% α-amyrine), which is in accordance with that reported by Hong *et. al*. [22], who proved the presence of stigmasterol in the *D. carota* lipid fraction. The GLC of fatty acid methyl esters revealed the presence of saturated fatty acids (35%) and unsaturated fatty acids (65%), among which plasmatic and linolenic acid are the main compounds, respectively. These data were in accordance with those reported by *Dib et al.* [7]

**Table 7 Determination of minimum inhibitory concentration of different extracts of *Daucus syrticus***

| | | Microbes | | | |
|---|---|---|---|---|---|
| | | Bacteria | | Fungi | yeast |
| Extract | Concentration | *Escherichia coli* | *Bacillus subtilis* | *Aspergillus niger* | *Candida albicans* |
| Volatile oil of the herb | 50 mg/ml | 0.9 | 1.00 | 0.5 | 0.7 |
| | 100 mg/ml | 1.1 | 1.1 | 0.7 | 0.9 |
| | 150 mg/ml | 1.4 | 1.7 | 0.8 | 1.1 |
| | 200 mg/ml | 1.4 | 1.8 | 0.8 | 1.2 |
| | 250 mg/ml | 1.4 | 1.8 | 0.8 | 1.2 |
| Volatile oil of seeds | 50 mg/ml | 0.8 | 0.5 | 0.5 | 0.6 |
| | 100 mg/ml | 1.1 | 0.8 | 0.7 | 0.8 |
| | 150 mg/ml | 1.2 | 1.0 | 0.8 | 0.9 |
| | 200 mg/ml | 1.2 | 1.0 | 1.0 | 1.0 |
| | 250 mg/ml | 1.2 | 1.0 | 1.0 | 1.1 |
| Acetone soluble | 50 mg/ml | 1.0 | 1.00 | 0.5 | 0.7 |
| | 100 mg/ml | 1.5 | 1.3 | 1.1 | 0.9 |
| | 150 mg/ml | 2.4 | 1.7 | 1.8 | 1.1 |
| | 200 mg/ml | 2.3 | 2.3 | 2.00 | 1.2 |
| | 250 mg/ml | 2.6 | 2.4 | 2.1 | 1.2 |
| Petroleum ether | 50 mg/ml | 0.6 | 0.5 | 0.7 | – |
| | 100 mg/ml | 0.9 | 1.1 | 0.9 | – |
| | 150 mg/ml | 1.4 | 1.2 | 1.0 | 0.7 |
| | 200 mg/ml | 1.9 | 1.2 | 1 | 0.9 |
| | 250 mg/ml | 1.9 | 1.2 | 1.1 | 0.9 |
| Fatty acids | 50 mg/ml | 1 | 1 | 0.7 | 0.7 |
| | 100 mg/ml | 1.4 | 1.3 | 1.1 | 1.0 |
| | 150 mg/ml | 2.7 | 1.9 | 1.5 | 1.5 |
| | 200 mg/ml | 2.7 | 2.4 | 1.7 | 1.7 |
| | 250 mg/ml | 2.7 | 2.4 | 1.7 | 1.7 |

Antibacterial control is Cephalexin at a concentration of 150 mg/ml: 2.9 cm. Antifungal control is Nystatin at a concentration of 150 mg/ml: 3.1 cm.

who they studied the composition of fatty acids in *D. crinitus* and found that the major fatty acids are lauric acid and behenic acid.

The study of the antimicrobial activity of different oils and extracts of DS revealed the presence of different degrees of activity as shown in Tables 5 and 6: the volatine oil of the herb exhibited the highest activity against *B. subtilis* and the fatty acids against *Escherichia coli*; the petroleum ether extract had a moderate activity against — Gram negative and Gram positive bacteria and yeasts, but had no effect on *Aspergillus niger*. The acetone-insoluble extract had a remarkable effect against Gram negative and Gram positive bacteria, yeasts and fungi used. The fatty acid fraction had high activity against Gram negative and Gram positive bacteria, with a moderate effect on yeasts and fungi.

## Conclusion

The volatile oils of different parts (herb, roots, and seeds) of DS growing in Libya were isolated and their constituents were identified using GC/MS technique for the first time; in addition, the antimicrobial activity of different extracts of the plant was investigated.

## Acknowledgements

### Conflicts of interest

None

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