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**Article** *in* Zeitschrift fur Naturforschung C · May 2018

DOI: 10.1515/znc-2017-0219

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Letter

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# Chemical composition and antifungal activity of essential oils from four Asteraceae plants grown in Egypt

https://doi.org/10.1515/znc-2017-0219
Received December 10, 2017; revised March 20, 2018; accepted April 16, 2018

**Abstract:** The objective of the present paper was the assessment of the chemical composition of the essential oils from four Asteraceae species with a considerable food, medicinal, and agricultural value, collected in Egypt, together with their in vitro inhibitory activity against molds and yeasts. The essential oil of *Launaea cornuta* flowers was also evaluated for the first time, but because of its very low yield (<0.01%), no antifungal test was performed.

**Keywords:** *Artemisia dracunculus*; *Artemisia judaica*; *Launaea cornuta*; *Tagetes lucida*.

## 1 Introduction

Asteraceae, the largest family of flowering plants, consists of about 1700 genus and 27,000 species distributed through the world (http://www.theplantlist.org/browse/A/Compositae/). *Launaea cornuta* (Hochst. ex Oliv. & Hiern) C. Jeffrei (syn. *Sonchus cornutus* Hochst. ex Oliv. & Hiern) is a perennial herb whose leaves are traditionally used as a vegetable and to treat measles. Its root decoct is made to relieve cough [1, 2]. *Tagetes lucida* Cav. is an herb native of central and Southern America used in folk medicine as digestive and tranquilizing agent and for treatment of diarrhea, colds, dysmenorrhea, and muscle pains. It is also cultivated as ornamental plant [3, 4]. *Artemisia* species are distributed in North America even though some species grow in the Southern Hemisphere [5, 6]. In traditional medicine, these species are used to prepare homemade remedies with anti-inflammatory, antifungal, and anti-thermic properties and to treat gastrointestinal disorders [7–9]. These three aromatic species, besides their medicinal applications, are widely used as spice in many dishes of traditional cuisines. Furthermore, they are a rich source of plant-derived pesticides used in agriculture [10–12].

According to the literature data, essential oils (EOs) obtained from *Artemisia* species such as *Artemisia dracunculus* L. inhibited the growth of some fungi such as *Candida albicans* [13], *Sclerotinia sclerotiorum* [14], *Colletotrichum* sp. [15], and some bacterial strains [16, 17]. *Artemisia judaica* L. EO showed antifungal activity against *Aspergillus* spp. [18] and *Fusarium oxysporum* [19] together with antibacterial [20] and insecticidal [11] activities. Also, the EO of *T. lucida* exhibited antimicrobial [21, 22] and insect repellent activities [11].

## 2 Results and discussion

The EOs obtained from *A. judaica*, *A. dracunculus*, and *T. lucida* gave yields of 1.3%, 1.0%, and 0.6%, respectively, while the hydrodistillation of *L. cornuta* produced very low amount of EO, not detectable. Gas chromatography-mass spectrometry (GC-MS) analyses of all EOs are shown in Table 1. Oxygenated monoterpenes constituted the predominant class of constituents in *A. judaica* (55.7%) and *L. cornuta* (79.2%) EOs, with piperitone (28.3%) and carvacrol (60.6%) as the main components, respectively. A similar composition was observed for *A. judaica* EO

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**Table 1:** Chemical composition (%) of the EOs from the examined plant samples.

| Entry | Component[a] | Class | LRI[b] | Content (%) | | | |
|---|---|---|---|---|---|---|---|
| | | | | *Ad*[c] | *Aj* | *Tl* | *Lc* |
| 1 | (*E*)-2-Hexenal | NT | 860 | | | | 0.3 |
| 2 | Sabinene | MH | 978 | 1.6 | 0.4 | tr | |
| 3 | β-Pinene | MH | 981 | 0.4 | 0.4 | | |
| 4 | 3-Octanone | NT | 987 | | | | 0.2 |
| 5 | β-Myrcene | MH | 991 | | 0.3 | | |
| 6 | Myrcene | MH | 993 | 0.4 | | 1.0 | |
| 7 | Mesitylene | NT | 996 | | 0.2 | | |
| 8 | *o*-Cymene | MH | 1026 | | 0.7 | 0.1 | |
| 9 | *p*-Cymene | MH | 1028 | 0.7 | | | |
| 10 | Limonene | MH | 1032 | | 5.2 | 1.6 | |
| 11 | Santolina alcohol | OM | 1037 | | 0.7 | | |
| 12 | (*E*)-β-Ocymene | MH | 1053 | 0.2 | | 0.3 | |
| 13 | γ-Terpinene | MH | 1062 | 0.2 | 0.3 | 0.2 | |
| 14 | Artemisia ketone | MH | 1065 | | 0.3 | tr | |
| 15 | *cis*-Sabinene idrato | OM | 1072 | 0.3 | | | |
| 16 | Linalool | OM | 1102 | 0.8 | | 1.4 | tr |
| 17 | *cis*-α-Thujone | OM | 1108 | | 0.6 | | |
| 18 | *trans*-β-Thujone | OM | 1120 | tr | 0.2 | | |
| 19 | Isophorone | AC | 1125 | | 2.1 | | |
| 20 | *cis*-*p*-Menth-2-en-1-ol | OM | 1126 | 0.3 | | | tr |
| 21 | Camphor | OM | 1148 | 0.4 | 15.0 | | |
| 22 | Menthone | OM | 1154 | | | | 0.4 |
| 23 | Borneol | OM | 1169 | | 3.2 | | |
| 24 | Isomenthol | OM | 1179 | | | | 3.0 |
| 25 | 4-Terpineol | OM | 1180 | | 0.2 | tr | |
| 26 | Cryptone | NT | 1187 | | 0.2 | | |
| 27 | *p*-Cymen-8-ol | OM | 1187 | | 0.3 | | |
| 28 | α-Terpineol | OM | 1189 | 0.1 | 0.4 | | 0.7 |
| 29 | Methyl chavicol | PP | 1198 | 1.1 | 0.9 | 82.9 | |
| 30 | Safranal | AC | 1200 | | | | 0.2 |
| 31 | *trans*-Carveol | OM | 1221 | tr | | | 0.2 |
| 32 | Ethyl phenylacetate | NT | 1230 | | 0.3 | | |
| 33 | Pulegone | OM | 1237 | | | | 0.2 |
| 34 | Carvone | OM | 1248 | | | | 0.2 |
| 35 | Piperitone | OM | 1254 | 0.2 | 28.3 | | |
| 36 | Linalool acetate | OM | 1260 | 0.5 | | | |
| 37 | Isobornyl acetate | OM | 1287 | | 4.1 | | |
| 38 | (*E*)-Anethole | PP | 1290 | 0.1 | | | |
| 39 | Menthyl acetate | OM | 1294 | | | | 0.2 |
| 40 | Thymol | OM | 1293 | | | | 13.7 |
| 41 | Carvacrol | OM | 1301 | | 1.1 | | 60.6 |
| 42 | Piperitenone | OM | 1350 | | 0.4 | | |
| 43 | α-Terpinyl acetate | OM | 1352 | 0.2 | | | |
| 44 | Citronellyl acetate | OM | 1357 | 0.9 | | | |
| 45 | (*Z*)-Ethylcinnamate | NT | 1360 | | 4.6 | | |
| 46 | 1-Undecanol | NT | 1362 | | | | 0.2 |
| 47 | Neryl acetate | OM | 1368 | | 0.4 | | |
| 48 | (*E*)-Methylcinnamate | NT | 1384 | | 0.9 | | |
| 49 | Geranyl acetate | OM | 1386 | 0.8 | | | |
| 50 | (*E*)-β-Damascenone | AC | 1386 | | | | 0.2 |
| 51 | β-Elemene | SH | 1391 | 0.1 | | 0.1 | |
| 52 | Methyleugenol | PP | 1407 | 72.6 | 0.1 | | |
| 53 | Decenyl acetate | NT | – | | | | 0.2 |
| 54 | (*E*)-β-Caryophyllene | SH | 1418 | | tr | 0.7 | tr |
| 55 | *trans*-α-Bergamotene | SH | 1437 | | | 0.2 | |

**Table 1** (continued)

| Entry | Component[a] | Class | LRI[b] | Content (%) | | | |
|---|---|---|---|---|---|---|---|
| | | | | *Ad*[c] | *Aj* | *Tl* | *Lc* |
| 56 | (*E*)-Geranyl acetone | AC | 1455 | | tr | | 0.6 |
| 57 | (*E*)-β-Farnesene | SH | 1460 | 0.1 | | tr | |
| 58 | (*E*)-Ethyl cinnamate | NT | 1462 | | 12.6 | | |
| 59 | Germacrene D | SH | 1481 | 0.1 | | 0.3 | |
| 60 | Ar-curcumene | SH | 1484 | 0.3 | | | |
| 61 | (*E*)-β-Ionone | AC | 1485 | | | | 0.5 |
| 62 | Bicyclogermacrene | SH | 1495 | 0.2 | tr | | |
| 63 | (*E*)-Methyl isoeugenol | PP | 1495 | 2.4 | | | |
| 64 | *n*-Pentadecane | NT | 1500 | | | | 0.3 |
| 65 | β-Bisabolene | SH | 1509 | | | 0.1 | |
| 66 | Tridecanal | NT | 1509 | | | | 0.2 |
| 67 | δ-Cadinene | SH | 1523 | 0.3 | | | |
| 68 | β-Thujaplicinol | NT | 1532 | | | | 0.7 |
| 69 | (*E*)-Nerolidol | OS | 1566 | 1.2 | | | |
| 70 | Caryophyllene alcohol | OS | 1571 | | | | 0.2 |
| 71 | γ-Asarone | PP | 1574 | 4.2 | | | |
| 72 | Germacrene D-4-ol | OS | 1576 | 0.1 | | tr | |
| 73 | Spathulenol | OS | 1577 | 1.5 | 3.3 | | 1.6 |
| 74 | Caryophyllene oxide | OS | 1582 | | | tr | 4.2 |
| 75 | Globulol | OS | 1584 | 0.3 | | | 2.6 |
| 76 | *n*-Hexadecane | NT | 1599 | | | | 0.4 |
| 77 | Cedrol | OS | 1599 | | | | 0.3 |
| 78 | 5-epi-7-α-Eudesmol | OS | 1606 | | | | 0.6 |
| 79 | Valeranone | OS | 1672 | | | 0.3 | |
| 80 | Humulene oxide II | OS | 1607 | | | | 0.3 |
| 81 | 1,10-di-epi-Cubenol | OS | 1614 | | | | 1.1 |
| 82 | γ-Eudesmol | OS | 1634 | | | | 0.8 |
| 83 | epi-α-Cadinol | OS | 1642 | | | | 1.6 |
| 4 | α-Cadinol | OS | 1655 | | | | 0.3 |
| 85 | *n*-Tetradecanol | NT | 1675 | | | | 0.3 |
| 86 | Hexyl salicylate | NT | 1676 | | | | 0.2 |
| 87 | *n*-Heptadecane | NT | 1700 | | | | 0.3 |
| | Total identified | | | 92.6 | 88.5 | 89.2 | 97.6 |
| | Non-terpenes (NT) | | | | 18.8 | | 3.3 |
| | Monoterpene hydrocarbons (MH) | | | 3.5 | 7.6 | 3.2 | |
| | Oxygenated monoterpenes (OM) | | | 4.5 | 55.7 | 1.4 | 79.2 |
| | Sesquiterpene hydrocarbons (SH) | | | 1.1 | | 1.4 | |
| | Oxygenated sesquiterpenes (OS) | | | 3.1 | 3.3 | 0.3 | 13.6 |
| | Phenylpropanoids (PP) | | | 80.4 | 1.0 | 82.9 | |
| | Apocarotenoids (AC) | | | | 2.1 | | 1.5 |

[a]Chemical compounds that showed relative percentages smaller than 0.01% were excluded from the table. [b]LRI, linear retention index. Compounds with relative percentages lower or equal to 0.1% are considered traces (tr). The components are listed in order of their elution on the DB-5 column. [c]Plant material: *Ad*, *Artemisia dracunculus*; *Aj*, *Artemisia judaica*; *Tl*, *Tagetes lucida*; *Lc*, *Launaea cornuta*.

from Jordan [18], while the same plant from Algeria gave the highest content of piperitone [23]. No reports about *L. cornuta* EO composition are present in the literature. Phenylpropanoids were the most important class in the EOs from *A. dracunculus* and *T. lucida*. The oil of *A. dracunculus* contained mainly methyleugenol (72.6%), a compound with antifungal properties well documented in the literature [15]. On the other hand, methyl chavicol (82.9%) was the main compound for *T. lucida* EO. This result is in agreement with that reported by Ciccio [24] for the same species cultivated in Costa Rica but different from that reported by Bicchi et al. [25] with plants collected in Guatemala, where a lower content of this main compound was found.

Results of the antifungal activity are reported in Table 2. The growth of *Microsporum canis* is highly

**Table 2:** Antifungal activity of the EOs tested.

| Fungi | Essential oils (%, v/v) | | |
|---|---|---|---|
| | *Tagetes lucida* | *Artemisia dracunculus* | *Artemisia judaica* |
| *Microsporum canis* | 1.25 | 2.5 | 2.5 |
| *Trichophyton mentagrophytes* | 2.5 | 2.5 | 2.5 |
| *Microsporum gypseum* | 2.5 | 2.5 | 2.5 |
| *Alternaria* sp. | 2.5 | 1.25 | 1.25 |
| *Cladosporium cladosporioides* | 2.5 | >5 | 2.5 |
| *Cladosporium herbarium* | >5 | >5 | >5 |
| *Penicillium brevicompactum* | 2.5 | >5 | >5 |
| *Candida albicans* | >5 | 2.5 | >5 |
| *Pochonia* sp. | 2.5 | >5 | >5 |
| *Penicillium chrysogenum* | 2.5 | 2.5 | 2.5 |

inhibited using *T. lucida* EO at a concentration of 1.25%, while the other EOs (*A. dracunculus* and *A. judaica*) showed a moderate inhibitory effect only at the highest dose (2.5%). The growth of *Trichophyton mentagrophytes*, *Microsporum gypseum*, and *Penicillium chrysogenum* was inhibited only at intermediate concentration (2.5%) using all the EOs tested. The same pattern was observed for *Pochonia* sp. and *Penicillium brevicompactum* using *T. lucida* EO. *Candida albicans* showed moderate sensitivity to *A. dracunculus* EO and resistance to the others. Both *Artemisia* species showed good antifungal activity against *Alternaria* sp. (1.25%). *Cladosporium cladosporioides* was only moderately inhibited by *A. judaica* and *T. lucida* EOs (2.5%), while *Cladosporium* seemed not to be influenced by all the other EOs.

*Tagetes* spp. and *Artemisia* spp. are known to possess antiseptic activity; in particular, *Tagetes minuta* was effective against *C. albicans* [26] and other several molds [27], while *Artemisia annua* showed a good antimycotic action against some *Candida* spp. and mostly versus *C. albicans* [28]. Our results are in agreement with Céspedes et al. [29] who evidenced the antimicrobial and antifungal activities of both extracts and pure components of *T. lucida* against *T. mentagrophytes*. To the best of our knowledge, their inhibitory activity was never assayed before against *M. canis*.

The results of the activity of *A. judaica* EO against *C. albicans* disagree with that reported by Abu-Darwish et al. [18], while *A. dracunculus* was partially active according to the studies of Obistioiu et al. [30] and Behbahani et al. [13].

These in vitro assays indicated that the EOs of *T. lucida*, *A. dracunculus*, and *A. judaica* are promising active mixtures against *M. canis* and *Alternaria* sp., confirming their use as antiseptic preparation in folk medicine.

# 3 Materials and methods

## 3.1 Plant materials and EO extraction

The plants *A. judaica*, *A. dracunculus*, *T. lucida*, and *L. cornuta* were cultivated in the farm station of the SEKEM Company (El Sharkia Governorate of Egypt) and harvested in the period of May 2014 and June 2015. The dried aerial parts of each plant material were hydrodistilled separately in a Clevenger-type apparatus for 3 h. The EOs obtained were stored at −4 °C till the analysis. After hydrodistillation, due to its very low yield (<0.01%), only *L. cornuta* EO was collected using a small amount of *n*-hexane (high-performance liquid chromatography grade) before analysis.

## 3.2 GC-MS and GC-flame ionization detector analysis

The GC analyses were accomplished with an HP-5890 series II instrument (Hewlett-Packard, Palo Alto, CA, USA) equipped with dual flame ionization detector and two silica capillary columns (30 m × 0.25 mm; film thickness: 0.25 μm), an HP-Wax, and a DB-5 (Agilent, Santa Clara, CA, USA). The oven temperature was programmed to be isothermal at 60 °C for 10 min and then rising from 60 °C to 220 °C at 5 °C/min (injector and detector temperatures of 250 °C; carrier gas $N_2$ at 2 mL/min; splitless injection). GC-MS analysis was carried out with a Varian CP-3800 gas chromatograph equipped with a DB-5 capillary column (30 m × 0.25 mm; coating thickness: 0.25 μm) and a Varian Saturn 2000 ion trap mass detector (Varian is now Agilent Technologies, Santa Clara, CA, USA). Analytical conditions: injector and transfer line temperatures, 220 °C and 240 °C, respectively; carrier gas He (1 mL/min); splitless mode. The oven temperature was programmed rising from 60 °C to 240 °C at 3 °C/min. The identification of the components was performed by comparison of their retention time with those of pure authentic samples and by means of their linear retention indices relative to the series of *n*-hydrocarbons and on computer matching against commercial [31, 32] and homemade library mass spectra built up from pure substances, components of known oils, and MS literature data.

## 3.3 Antifungal assay

The antifungal effectiveness of the selected EOs was determined on molds affecting human and animal health,

such as *M. canis*, *M. gypseum*, *T. mentagrophytes*, and phytopathogenic and food-spoiling molds such as *Alternaria* sp., *C. herbarium*, *C. cladosporioides*, *P. chrysogenum*, *P. brevicompactum*, and *Pochonia* sp. and the yeast *C. albicans*. Minimum inhibitory concentrations were determined by a microdilution test carried out as reported elsewhere [33], starting from a dilution of 5% (v/v). Inoculums were accomplished following the methods described by the Clinical and Laboratory Standards Institute M38A2 [34] for molds and the Clinical and Laboratory Standards Institute M27A3 [35] for yeasts. Each EO concentration was tested in triplicate.

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