Phytochemical Study on the Essential Oils of Tarragon (Artemisia dracunculus L.) Growing in Tajikistan and Its Comparison With the Essential Oil of the Species in the Rest of the World

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Abstract
The aerial parts of the tarragon (Artemisia dracunculus) were collected around Kukteppa village, Ziddi, Varzob region of Tajikistan. The essential oil of tarragon was obtained by hydrodistillation and analyzed by gas chromatography-mass spectrometry. Forty-five compounds representing 99.8% of total oil were identified. Sabinene (29.1%), estragole (24.6%), limonene (7.8%), (Z)-artemidin (4.9%), myrcene (4.8%), and (E)-β-ocimene (4.0%) were components with a representation higher than 4% of the essential oils of aerial parts of tarragon. Hierarchical cluster analysis of A. dracunculus essential oils on the global phytogeographic origin based on 30 essential oil components and 105 samples (globally) of this species, indicated the existence of its 7 major chemotypes: ocimene, α-terpinene, capillene, methyl eugenol, mixed chemotype, (Z)-artemidin, and estragol chemotypes. The essential oils of A. dracunculus showed weak antioxidant and antibacterial activities. To our best knowledge, this is the first report concerning the chemical composition, chemotypic variation, antioxidant, and antimicrobial activities of the essential oils obtained from the aerial parts of A. dracunculus, growing wild in the Varzob region of Tajikistan.

Keywords
Artemisia dracunculus, essential oil, GC-MS, cluster analysis, chemotype, sabinene, estragole

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Artemisia dracunculus L. (common names: tarragon, estragon, tarkhun) is a small perennial shrub, 60-120 cm tall, and belongs to the Asteraceae. The plant is native to south-eastern Russia, Central Asia, Turkey, Mongolia, and western North America.1 In Tajikistan, tarragon forms dense thickets; it is distributed commonly in the vegetation belts of black and juniper forests, subalpine meadows, semi-savannas, mountain, and desertified steppes. Tarragon is an important species of the Artemisia genus.

Tarragon was a folk remedy a long time ago.2 Gelenus, Avicenna, Al-Beruni, Ibn al-Baitar, and others have noted about medicinal properties of tarragon in their works.3 Al-Beruni noted that “tarragon belongs to vegetables.” Avicenna had mentioned that “if tarragon chewed and kept in the mouth, it helps against foot-and-mouth disease; fresh tarragon grass useful for bleeding gums (gingiva) and bad breath.”3 Ibn al-Baitar pointed that tarragon makes breath “sweet,” removes the bitterness of drugs, and promotes good sleep.3

In Central Asian traditional medicine, tarragon is used to treat gastritis, dropsy, scurvy, and dyspepsia. The aerial parts of the tarragon are added as spices to dairy products and dishes; it
improves appetite, promotes digestion, and clears the respiratory tract from the mucus (sputum). Its flowers have been noted to have antihelminthic action. In Iranian folk medicine, aerial parts of tarragon were used to treat epilepsy, coagulopathy, and hyperlipidemia.

In modern medicine, the aqueous extract of tarragon is used for the treatment of patients with chronic gastritis with low acidity. The aerial parts of tarragon have antiscorbutic and antihelminthic properties. Essential oil of tarragon is widely applied in food flavoring formulations and perfumery.

This herb possesses a wide range of biological activities, including antioxidant, antimicrobial, antihelminthic, hepatoprotective, and anticonvulsant activities.

The chemical compositions of essential oil of tarragon have been intensively investigated. Estragol (methyl chavicol), methyl eugenol, (E)-anethole, capillene, (E)-β-ocimene, (Z)-β-ocimene, (E)-α-ocimene, limonene, α-pinene, α-terpinolene, elemicin, isoelemicin, 5-phenyl-1,3-pentadiyne, β-phellandrene, β-phellandrene, pulegone, hinokitiol, (Z)-aromadendrene, and methyleugenol have been reported as major compounds of the essential oil of \textit{A. dracunculus}. 4

In the present work, we investigated the chemical composition, chemotypic variation, antioxidant, and antimicrobial activities of the essential oils obtained from the aerial parts of \textit{A. dracunculus}, growing wild in Tajikistan.

**Results and Discussion**

In Tajikistan, tarragon grows wild on pebbles, fine earth-gravelly slopes, along streams, rivers, irrigation ditches at an altitude of 1700-4000 m above the sea; it is widespread at the vegetation belts of Turkestan, Zeravshan, Gissar-Darvaz, West-Tajikistan, and West and East-Pamir floristic zones.

The aerial parts of the tarragon were collected around Kukteppa village, Ziddi, Varzob region of Tajikistan. The essential oil of tarragon was obtained by hydrodistillation and analyzed by gas chromatography-mass spectrometry (GC-MS). Forty-five components representing 99.8% of total oil were identified. The essential oil of aerial parts of tarragon was dominated by the monoterpene hydrocarbons and oxygenated aromatic compounds. Sabinene (29.1%), estragole (24.6%), limonene (7.8%), (Z)-aromadendrene (4.9%), myrcene (4.8%), and (E)-β-ocimene (4.0%) were the components (with a representation higher than 4%) of the essential oils of aerial parts of tarragon.

The chemical composition of the essential oil of tarragon growing wild in Tajikistan is presented in Table 1. Sabinene was noted to have antihelminthic action. 3,4 In Iranian folk medicine, aerial parts of tarragon were used to treat epilepsy, coagulopathy, and hyperlipidemia.

![Image](image.png)

**Table 1.** Essential Oil Composition of Tarragon From Tajikistan.

| RI | Compound | % |
|----|----------|---|
| 823 | 1,3-Octadiene | 0.2 |
| 935 | α-Thujene | 0.4 |
| 941 | α-Pinene | 3.6 |
| 950 | α-Fenchene | 0.3 |
| 952 | Camphene | 0.3 |
| 978 | Sabinene | 29.1 |
| 979 | β-Pinene | 1.5 |
| 987 | Dehydro-1,8-cineole | 0.1 |
| 993 | Myrcene | 4.8 |
| 1003 | α-Phellandrene | 0.1 |
| 1018 | α-Terpinene | 0.6 |
| 1019 | β-Cymene | 0.3 |
| 1027 | β-Phellandrene | 3.2 |
| 1033 | Limonene | 7.8 |
| 1039 | (Z)-β-Ocimene | 2.1 |
| 1050 | (E)-β-Ocimene | 4.0 |
| 1061 | γ-Terpinene | 1.0 |
| 1066 | cis-Sabinene hydrate | 0.2 |
| 1089 | Terpinolene | 0.3 |
| 1100 | Linalool | 0.6 |
| 1132 | Camphor | 0.1 |
| 1138 | allo-Ocimene | 0.8 |
| 1180 | Terpinen-4-ol | 1.1 |
| 1184 | Methyl salicylate | 0.1 |
| 1197 | Methyl chavicol (=Estragole) | 24.6 |
| 1289 | Bornyl acetate | 1.4 |
| 1343 | δ-Elemene | 0.1 |
| 1353 | Citronellyl acetate | 0.3 |
| 1361 | Neryl acetate | 0.1 |
| 1382 | Geranyl acetate | 0.1 |
| 1386 | α-Copaene | tr |
| 1390 | Methyl eugenol | 0.8 |
| 1420 | β-Caryophyllene | 0.3 |
| 1450 | α-Humulene | tr |
| 1459 | (E)-β-Farnesene | 0.7 |
| 1470 | (E)-β-Ionone | tr |
| 1479 | α-Curcumene | 0.7 |
| 1493 | Bicyclogermacrene | 0.1 |
| 1496 | (E,E)-α-Farnesene | 0.1 |
| 1505 | 1-Pentadecene | 0.1 |
| 1522 | δ-Cadinene | 0.1 |
| 1525 | β-Sesquiophellandrene | 0.7 |
| 1578 | Spathulenol | 0.6 |
| 1806 | 3-(1Z-butenyl)-isocoumarin (= (Z)-Artemidin) | 4.9 |
| 1840 | 3-(1E-butenyl)-isocoumarin (= (E)-Artemidin) | 1.5 |

Monoterpene hydrocarbons 60.2
Oxgenated monoterprenoids 4.0
Sesquiterpene hydrocarbons 2.7
Oxgenated sesquiterpenoids 0.6
Phenylpropanoids 25.4
Others 6.9
Total identified 99.8
A hierarchical cluster analysis of *A. dracunculus* essential oils on the global phytogeographic origin, based on 30 essential oil components and 105 samples (globally) of this species, indicated the existence of its 7 major chemotypes: (1) a (-)-β-ocimene/(Z)-β-ocimene chemotype, (2) an α-terpinene chemotype, (3) a capillene chemotype, (4) a methyl eugenol chemotype, (5) a mixed chemotype, (6) a (Z)-arctemidin (3-(1-Z-butenyl)-isocoumarin) chemotype, and (7) an estragole (methyl chavicol) chemotype (see Supplemental Material). The present study investigated that essential oil of *A. dracunculus* from Tajikistan belongs to cluster (5), the mixed chemotypic variation (Figure 1). Cluster (5) can be further subdivided into 5 subclusters (Figure 2): (5a) with no dominating component, (5b) a sabinene group, (5c) an elemicin group, (5d) an estragole/capillene group, and (5e) an anethole group, with the present essential oil fitting into a group (5b). Eisenman and co-authors had previously reported 6 clusters: (1) estragole (methyl chavicol), (2) methyl eugenol, (3) α-terpinene, (4) capillene, (5) 5-phenyl-1,3-pentadiyne, and (6) (E)-β-ocimene/(Z)-β-ocimene, based on essential oils diversity in North American wild tarragon. In 2010, Chauhan and co-authors reported on a capillene chemotype of *A. dracunculus* from North-West Himalaya, India. In 2012, Mir and co-workers described a new chemotype of *A. dracunculus* from Kashmir with acenaphthene as the major component, but this conclusion is unlikely; the compound identified as acenaphthene is most likely capillene, and the compound identified as capillene is most likely 5-phenyl-1,3-pentadiyne.

According to International Standard ISO 10115 (second edition 2013) the chromatographic profile of the essential oil of tarragon (French type) shall be the limits: α-pinene (0.5%-2%), limonene (2%-7%), (Z)-β-ocimene (5%-13%), (E)-β-ocimene (6%-12%), estragole (68%-84%), and methyl eugenol (up to 1%). In 2019, Bakova and co-authors reported that 2 varieties of tarragon from Tajikistan belong to cluster (5e) 5-phenyl-1,3-pentadiyne, based on essential oils diversity in North American wild tarragon. The dried plant material (pooled from multiple individuals; 300 g) of *A. dracunculus* L. was subjected to hydrodistillation, using a Clevenger-type apparatus for 3 hours. Yield of the essential oil was 0.5%.

**GC-MS Analysis**

GC-MS analysis was performed on the essential oil of *A. dracunculus* (3 analyses of the essential oil) using an Agilent 6890 GC with Agilent 5973 MSD and HP-5ms capillary column as described previously by us. Identification of the essential oil components was based on retention indices (RI) and mass spectral fragmentation patterns with those reported in the literature, and our own in-house database.

**Antioxidant Activity**

The antioxidant activity of the essential oils of *A. dracunculus* was evaluated by DPPH and ABTS assays. DPPH and ABTS assays were performed as described earlier by us.

**Antimicrobial Activity**

The antimicrobial activity of the essential oil of *A. dracunculus* was determined against *S. aureus* (ATCC 23235), *P. aeruginosa* (ATCC 27853), and *E. coli* (ATCC 25922). Bacterial strains were tested on agar. Sterilized paper disks were loaded with 10 µL of tarragon essential oil or positive control and applied on the surface of agar plates. Inhibition zones (mm) of bacterial strains were defined after the incubation period for 24 hours at 37 °C.

**Hierarchical Cluster Analysis**

Cluster analysis methodology was described previously by us. The agglomerative hierarchical cluster analysis was performed by using the XLSTAT software, version 2018.1.1.62926 (Addinsoft, Paris, France). Euclidean distance was used to measure dissimilarity, and Ward’s method was used for cluster definition.
Figure 1. Hierarchical cluster analysis of *Artemisia dracunculus* essential oils.
Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

References

1. Hassanzadeh MK, Najaran ZT, Nasery M, Tarragon ESA. (Artemisia dracunculus L.) oils. In: Preedy VR, ed. Essential Oils in Food Preservation, Flavor and Safety. Elsevier Academic Press; 2016:813-817.
2. Obolskiy D, Pischel I, Feistel B, Glotov N, Heinrich M. Artemisia dracunculus L. (tarragon): a critical review of its traditional use, chemical composition, pharmacology, and safety. J Agric Food Chem. 2011;59(21):11367-11384. doi:10.1021/jf202277w
3. Hojimatov M. Wild Medicinal Plants of Tajikistan. Tadj. Sovet. Enclopedii; 1989:337-238.
4. Zaurov DE, Belolipov IV, Kurnukov AG, Sodombeev IS, Akimov AA, Eisenman SW. The medicinal plants of Uzbekistan and Kyrgyzstan. In: Eisenman SW, Zaurov DE, Struve L, eds. Medicinal Plants of Central Asia: Uzbekistan and Kyrgyzstan. Springer; 2013:15-273.
5. Abtahi Froushani SM, Zarei L, Esmaeili Gouvarchin Ghaleh H, Mansori Motlagh B. Estragole and methyl-eugenol-free extract of Artemisia dracunculus possesses immunomodulatory effects. Avicenna J Phytomed. 2016;6(3):526-534.
6. Ruzkich IB, MA K, Serich AE, Pokrovskiy LM, AV T. Sostav efirnogo masla polini tarkhun (Artemisia dracunculus L.) sbirkoy flori. Khimiya Rastitelogo Sirya. 2000;3:65-76.
17. Mousavi M, Maroufpoor N, Valizadegan O. Fumigant toxicity of Artemisia dracunculus against CCl4-induced hepatotoxicity in rats. *Avicenna J Phytomed.* 2018;8(1):51-62.

18. Mehrparvar M, Goltapeh EM, Safaie N, Ashkani S, Hedesh RM. Anti-fungal activity of essential oils against mycelial growth of Lecanicillium fungicola. *Advances in Agriculture.* 2019;4(1):1-6.

19. Meepagala KM, Sturtz G, Wedge DE. Antifungal constituents of the essential oil fraction of Artemisia dracunculus L. *J Agric Food Chem.* 2002;50(24):6989-6992. doi:10.1021/jf020466w

20. Bahmani L, Aboonajmi M, Arabhosseini A, Mirsaeedghazi H. Ann modeling of extraction kinetics of essential oil from tarragon using ultrasound pre-treatment. *Engineering in Agriculture, Environment and Food.* 2018;11(1):25-29. doi:10.1016/j.jaef.2017.10.003

21. Tak I, Mohiuddin D, Ganai B, Chishti M, Ahmad F, Dar JS. Phytochemical studies on the extract and essential oils of Artemisia dracunculus (Tarragon). *Afri J Plant Sci.* 2014;8:72-75.

22. Zorca M, Gainar I, Bala D. Isolation and fractional separation of tarragon essential oil by supercritical fluid. *An Univ Bucuresti Chimie.* 2009;1:21-25.

23. Chauhan RS, Kitchlu S, Ram G, Kaul MK, Tava A. Chemical composition of capillene chemotype of Artemisia dracunculus L. from North-West Himalaya, India. *Ind Crops Prod.* 2010;31(3):546-549. doi:10.1016/j.indcrop.2010.02.005

24. Venskonitis R, Dapkevicius A, Gramshaw JW, Baranauskiene M. Composition of volatile constituents in tarragon (Artemisia dracunculus L.) at different vegetative periods. In: Taylor AJ, Mottram DS, eds. *Flavour Science.* Woodhead Publishing; 1996:46-51.

25. Kordali S, Kotan R, Mavi A, Cakir A, Al a A, Yildirim A. Determination of the chemical composition and antioxidant activity of the essential oil of Artemisia dracunculus and of the antifungal and antibacterial activities of Turkish Artemisia absinthium, A. dracunculus, A. santonicum, and Artemisia spicigera essential oils. *J. Agric Food Chem.* 2005;53(24):9452-9458. doi:10.1021/jf0516538

26. Suleimenov EM, Tkachev AV, Adekenov SM. Essential oil from Kazakhstan Artemisia species. *Chem Nat Compd.* 2010;46(1):135-139. doi:10.1007/s10600-010-9548-y

27. Goryaev MI, Bazalitskaya VF, Polyakov PP. *Chemical Composition of Artemisia.* Alma-Ata: Izd. Akad. Nauk Kaz SSR; 1962:127-128.

28. Verma MK, Anand R, Chisti AM, et al. Essential oil composition of Artemisia dracunculus L. (Tarragon) growing in Kashmir-India. *J Essen Oil-Bear Plants.* 2010;13(3):331-335. doi:10.1080/0972060X.2010.10643830

29. Eisenman SW, Juliani HR, Sruwe I, Simon JE. Essential oil diversity in North American wild tarragon (Artemisia dracunculus L.) with comparisons to French and Kyrgyz tarragon. *Ind Crops Prod.* 2013;49:220-232. doi:10.1016/j.indcrop.2013.04.037

30. Heidari S, Azizi M, Soltani F, Hadian J. Foliar application of Artemisia dracunculus L. var. qinghaiensis L. (Tarragon) for resistance to CCl4- induced hepatotoxicity in rats. *Jundishapur J Nat Pharm Prod.* 2017;12(1):323-325.

31. Jaalizadeh-Amin G, Maham M, Dalir-Naghadeh B, Kheiri F. In vitro effects of Artemisia dracunculus essential oil on ruminal and abomasal smooth muscle in sheep. *Comp Clin Path.* 2012;21(5):673-680. doi:10.1007/s00580-010-1155-6

32. Rajabian A, Hassanzadeh KM, Emami SA, Tayarani NZ, Rahimzadeh OR, Asili J. Phytochemical evaluation and antioxidant activity of essential oil, and aqueous and organic extracts of Artemisia dracunculus. *Jundishapur J Nat Pharm Prod.* 2017;12(1):323-325.

33. Mir F, Rather MA, Dar BA, et al. Comparative GC-FID and GC-MS analysis of the chemical profile of the leaf, stem and root essential oils of Artemisia dracunculus. L growing in Kashmir (India). *J Pharm Res.* 2012;5:1353-1356.

34. Fraternelle D, Flamini G, Ricci D. Essential oil composition and antioxidant activity of Artemisia dracunculus (tarragon). *Nat Prod Commun.* 2015;10(8):1469-1472. doi:10.1177/1934578X1500839
35. Karimi A, Hadian J, Farzaneh M, Khadivi-Khub A. Phenotypic diversity and volatile composition of Iranian Artemisia dracunculus. *Ind Crops Prod.* 2015;65:315-323. doi:10.1016/j.indcrop.2014.12.003

36. Osanloo M, Amani A, Sereshki H, Abai MR, Esmaeili F, Sedaghat MM. Preparation and optimization nanoemulsion of Tarragon (Artemisia dracunculus) essential oil as effective herbal larvicide against Anopheles stephensi. *Ind Crops Prod.* 2017;109:214-219. doi: 10.1016/j.indcrop.2017.08.037

37. Bedini S, Flamini G, Cosci F, et al. *Artemisia* spp. essential oils against the disease-carrying blowfly Calliphora vomitoria. *Parasit Vectors.* 2017;10(1):80-84. doi:10.1186/s13071-017-2006-y

38. Pappas RS, Sturtz G. Unusual alkynes found in the essential oil of *Artemisia dracunculus* L. var. dracunculus from the Pacific Northwest. *J Essen Oil Res.* 2001;13(3):187-188. doi:10.1080/10412905.2001.9699657

39. Ayoughi F, Barzegar M, Sahari MA, Naghdibadi H. Chemical compositions of essential oils of *Artemisia dracunculus* L. and endemic *Matricaria chamomilla* and an evaluation of their antioxidative effects. *J Agric Sci Technol.* 2011;13(1):102-108.

40. ISO. *Essential Oil of Tarragon (Artemisia dracunculus L).* ISO 10115:2013(E). International Organization for Standardization; 2013.

41. Bakova NN, Shevchuk OM, Logvinenko LA, Timasheva LA. To the question of standadization of the estragon raw. *Vegetable Crops of Russia.* 2019;2:58-62.

42. Khalifaev PD, Sharopov FS, Safomuddin A, et al. Chemical composition of the essential oil from the roots of Ferula kuhistanica growing wild in Tajikistan. *Nat Prod Commun.* 2018;13(2):219-222. doi:10.1177/1934578X1801300226

43. Sharopov FS, Numonov SR, Safomuddin A, et al. Chemical composition of essential oil from Cercis griffithii growing in Tajikistan. *Chem Nat Compd.* 2018;54(3):1002-1003. doi:10.1007/s10600-018-2535-4

44. Adams R. *Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry.* 4th Allured Publishing Corp; 2007:456.

45. Sharopov FS, Wink M, Setzer WN. Radical scavenging and antioxidant activities of essential oil components—an experimental and computational investigation. *Nat Prod Commun.* 2015;10(1):153-156. doi:10.1177/1934578X1501000135

46. Sharopov FS, Salimov A, Numonov S, et al. Chemical composition, antioxidant, and antimicrobial activities of the essential oils from Artemisia annua L. growing wild in Tajikistan. *Nat Prod Commun.* 2020;15(5):1-7.