Research Article Araştırma Makalesi DOI: 10.17097/agricultureatauni.1445748

Comparison of Essential Oil Components and Yield Parameters of *Artemisia dracunculus* and *Artemisia dracunculoides*

Artemisia dracunculus ve *Artemisia dracunculoides*'in Uçucu Yağ Bileşenleri ve Verim Parametrelerinin Karşılaştırılması

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ABSTRACT

Medicinal and aromatic plants have attracted attention recently for their essential oil content. This study aims to compare, for the first time, essential oil of *Artemisia dracunculus* L. and *Artemisia dracunculoides* L., which are closely related species. Yield values of this *Artemisia* spp. were determined, and the highest drug-herb yield (119.01 kg/ha) was found for *Artemisia dracunculus* L. The essential oil components of these species grown under organic production conditions in Bayburt, Türkiye, were determined by the microwave hydrodistillation method for the first time and gas chromatography-mass spectrometry (GC-MS). The essential oil ratio for *A. dracunculus* was 1.40 %, whereas it was 1.21 % for *A. dracunculoides*; 42 components were found in *A. dracunculus* essential oil, while 38 were found in *A. dracunculoides* essential oil. Estragole was the most abundant essential oil component in *A. dracunculus* L. (69.34%) and *A. dracunculoides* L. (67.51%). The GC-MS results, showed that *A. dracunculus* L. is more suitable for use in perfumery and food industries than *A. dracunculoides*.

Keywords: Medicinal plants, estragole, linalool, tarragon

ÖZ

Tıbbi ve aromatik bitkiler son zamanlarda içerdikleri uçucu yağ nedeniyle ilgi çekmektedir. Bu çalışma, yakın akraba türler olan *Artemisia dracunculus* L. ve *Artemisia dracunculoides* L.'nin uçucu yağlarını ilk kez karşılaştırmayı amaçlamaktadır. *Artemisia* spp.'nin verim değerleri belirlenmiş ve en yüksek drog herba verimi (119,01 kg/ha) A. *dracunculus* L.'da bulunmuştur. Bayburt (Türkiye) ilinde organik üretim koşullarında yetiştirilen bu türlerin uçucu yağ bileşenleri mikrodalga hidrodistilasyon yöntemi ile ve gaz kromatografisi-kütle spektrometrisi (GC-MS) ilk kez belirlenmiştir. *A. dracunculus*'un uçucu yağ oranı %1,40, *A. dracunculoides*'in ise %1,21; *A. dracunculus* esansiyel yağında 42 bileşen bulunurken, *A. dracunculoides* esansiyel yağında 38 bileşen belirlenmiştir. Estragole bileşeninin *A. dracunculus* L.'de (%69,34) ve *A. dracunculoides* L.'de (%67,51) en fazla bulunan uçucu yağ bileşeni olduğu görülmüştür. Elde edilen sonuçlar, parfümeri ve gıda endüstrisinde kullanım için *A. dracunculus*'un *A. dracunculoides*'ten daha uygun olduğunu göstermektedir.

Anahtar Kelimeler: Tıbbi bitkiler, estragol, linalool, tarhun

Received / Geliş Tarihi 01.03.2024
Accepted / Kabul Tarihi 17.04.2024
Publication Date / Yayın Tarihi 29.05.2024

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Cite this article: Gıdık, B. (2024). Comparison of Essential Oil Components and Yield Parameters of *Artemisia dracunculus* and *Artemisia dracunculoides*. *Research in Agricultural Sciences,* 55(2), 58-66.

Introduction

It is known that medicinal aromatic plants have been involved in people's daily lives from the past to the present. In addition to traditional treatment methods, many medicinal aromatic plants are consumed as food. Generally, their delicious taste and pleasant smell increase the use of these plants. Many herbs that emit pleasant odors with the essential oils secreted from their leaves are used in different ways, such as tea and spices.

Asteraceae is a family with 1,535 genera and between 23,000 to 32,000 species, with a wide distribution worldwide (Zappi et al., 2015). Tarragon is a fragrant, medicinal, and aromatic plant. The two most commonly cultivated tarragon species are French (*Artemisia dracunculus* L.) and Russian tarragon (*Artemisia dracunculoides* L.) in Türkiye. When comparing *A. dracunculus* L. with *A. dracunculoides* L., it has been discovered that *A. dracunculus* has a thinner stem structure, while *A. dracunculoides* has a thicker stem structure with flower and seed production (Trendafilova et al., 2021). Especially, its anti-bacterial and antifungal properties support the industrial usage of tarragon (Azizkhani et al., 2021; Davis, 1982; Karimi et al., 2015). It is also known that, tarragon has muscle relaxant, anesthetic, and sedative properties (Sayyah et al., 2004). In addition, according to recent studies, some tarragon products are used to extend the shelf life and prevent mold formation by increasing the consistency of dairy products such as yogurt (Zedan et al., 2021). Some studies in the literature about this plant have various digestive, antioxidant, and pharmacological activities, including carminative, antiinflammatory, antipyretic, antiseptic, antispasmodic, antiparasitic, and anthelmintic antimicrobial, and fungicidal effects (Can et al., 2023; Mumivand et al., 2017; Obolskiy et al., 2011; Pelarti et al., 2021). The essential oil of tarragon, whose green leaves are used in salads and dried leaves in soups and pastries, gives flavor and aroma to the food industry (Ayoughi et al., 2011; Jazani et al., 2011). Also, this essential oil is used in perfumery with its pleasant smell. Golubkina et al., (2020), reported that tarragon plants contain 0.68% to 0.70% essential oil. On the other hand, Çil and Kara (2015) reported that tarragon essential oil ratio varied between 0.146% and 1.346%. In some studies, where the essential oil components of tarragon were determined, α-pinene 1.3%-5.1%, limonene 3.32%-12.40%, methyl eugenol 2.20-2.59% (Mumivand et al., 2021; Sayyah et al., 2004).

There is some research about essential oil components of *Artemisia* spp. but there isn't any study essential oil of *Artemisia dracunculoides* L. This study aims to determine the essential oil ratios and essential oil components of *A. dracunculus* L. and *A. dracunculoides* L. Especially in this study, the essential oil ratio of *A. dracunculus* and *A. dracunculoides* were determined for the first time by using the microwave hydrodistillation method. While this study can be a reference to new studies about essential oil of *A. dracunculus* and *A. dracunculoides*, the possible potential of these plants are elucidated in usage in the food and perfume industry.

Methods

Plant Material

This study used seedlings of *A. dracunculus* L. and *A. dracunculoides* L. as plant materials. Plant materials were obtained from local populations in the fields from Bayburt Province of Turkey.

The species identification of the plant specimens was carried out by Assoc. Prof. Dr. Abdurrahman Sefalı of Bayburt University, Department of Basic Education. Flora of Turkey and the East Aegean Islands (Davis, 1965-1985; Davis et al., 1988; Güner et al., 2000) were used as the main source for the identification of these samples. Plants were chosen randomly from the farmer fields and, they were grown in experimental plots. The experimantal area is located at the coordinates of 40º 12' North parallel and 40º 15' East meridian. Plants were grown in the research and application area of Bayburt University Faculty of Applied Sciences, in 60x60 cm row spacing and in-row spacing, in three replications according to the Random Blocks Trial Design. The general view of the grown plants is shown in Figure 1.

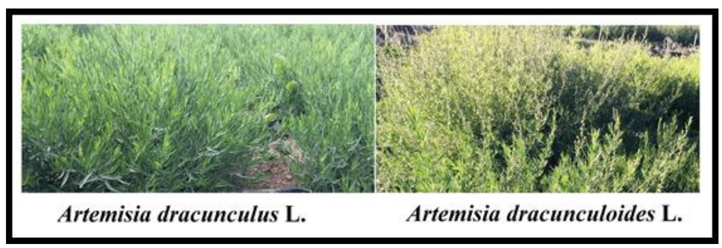

Figure 1.
Artemisia dracunculus L. and Artemisia dracunculoides L. grown in the experimental area.

Climatic and soil characteristics of the trial field

The plant material was grown in the central district of Bayburt, Turkey. The General Directorate of Meteorology provided climate data for the cultivation area for several years until 2020 (GDM 2021). Climate data is shown in Table 1.

Soil samples from 0-30 cm depth from the experimental field where the plant material was grown were analyzed in the laboratories of the Republic of Türkiye Ministry of Agriculture and Forestry, Black Sea Agricultural Research Institute. The pH value was 7.90, the lime rate was 17.31%, the organic matter rate was 0.99%, the potassium quantity was 43.80 kg/ha, the phosphorus amount was 1.33 kg/ha, and the total salt rate was 0.01% when the soil samples from the tribal territory were studied. Analysis results show that, according to the soil criteria analyzed by Gedikoglu (1990) and Ulgen and Yurtsever (1995), it is slightly alkaline, deficient in organic matter, low in phosphorus, moderately calcareous, and moderate in potassium. The locations where the plants are grown on the map of Turkey is shown in Figure 2. Tarragons that reached sufficient maturity were harvested and dried for 20 days in a dry, calm, and sun-free environment. The dried samples were stored at +4˚C for analysis.

Determination of yield values

It was determined the plant height in cm by measuring five plants randomly selected from each plot among the plants that reached harvest maturity, from just above the soil to the tip of the plant. After the plants were harvested by cutting five cm above the soil surface, they were weighed using a precision scale. After each plot's weighing process, the data obtained were converted to hectares, and the green herb yield in kg/ha was calculated. Tarragon plants were harvested from 50 m^2 and separated their leaves were from their stems. Determined the green leaf yield and green stems yield of the plant in kg/ha was by weighing the leaves and stems on precision scales.

Tarragon plant samples, harvested from 50 m^2, and the leaves were separated from their stems, were dried in a shaded and cool place. The leaf and stem parts of the dried plant were weighed separately on sensitive scales to determine the drug leaf yield and drug stem yield in kg/ha. After the plants were harvested, each plot was dried, they were weighed using the precision scale, the data obtained were converted to hectares, and the drug herb yield in kg/ha was calculated.

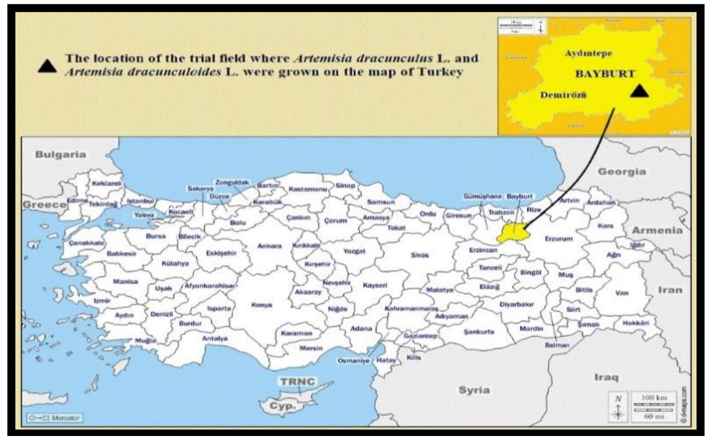

Figure 2.
The locations where Artemisia dracunculus L. and Artemisia dracunculoides L. plants are grown on the map of Türkiye.

Table 1.
Climate data, for long years up to 2020 of the land where A. dracunculus L. and A. dracunculoides L. plants were grown (GDM 2021).

Years	January	February	March	April	May	June	July	August	September	October	November	December
Monthly Total Precipitation (mm)												
1959-2020	27.0	28.0	40.7	62.5	73.2	51.6	21.3	15.5	21.8	43.1	33.0	29.4
2020	19.4	52.3	65.7	87.0	113.8	51.9	61.0	14.4	8.5	16.4	24.6	22.2
Monthly Average Temperature (˚C)												
1959-2020	-6.3	-5.0	0.4	6.9	11.6	15.2	18.8	18.7	14.8	9.3	2.7	-3.2
2020	-4.5	-3.1	4.9	7.0	12.1	17.2	20.5	18.7	18.5	13.1	3.2	-1.4
Monthly Average Relative Humidity (%)												
1959-2020	71.7	65.5	58.2	42.5	64.8	52.1	49.7	45.4	50.9	54.9	67.1	77.0
2020	68.2	67.1	60.4	57.1	55.0	49.4	48.9	44.5	39.4	27.6	62.4	71.8
Monthly Average Wind Speed (m÷sn)												
1959-2020	1.3	1.2	1.4	1.3	1.3	1.4	1.4	1.4	1.2	0.9	0.8	1.0
2020	1.0	1.3	1.3	1.3	1.6	1.6	1.5	1.5	1.3	1.1	1.1	0.9

Extraction and analysis of essential oil

Microwave hydrodistillation

Microwave hydrodistillation was carried out on a Milestone brand Ethos X model microwave extractor. Wetted with 200 milliliters of water, 150 grams of dried tarragon samples were placed in the extraction tank. The power of the microwave digestion was set to 1000 Watt, and the program was set as follows: The temperature rose to 100˚C in 10 minutes and continued for 30 minutes. Moisture in the sample was removed with anhydrous sodium sulfate, and then the dehydrated sample was placed in a sealed glass vial and stored at +4˚C until analysis. The advantage of the microwave hydrodistillation method is that the entire plant sample is heated at the same time, unlike conventional methods of heat conduction by contact, which breaks down the oxidized weak hydrogen bonds at the poles of the molecules. This method was preferred because more reliable results were obtained.

Methylation of Samples

It puts a weighted 100 mg oil sample in a 20 mL screw capped tube or reaction vial. Oil sample, dissolved in 10 mL of hexane. Added 100 µL of 2N potassium hydroxide in methanol. The tube was closed and vortexed for 30 s. Centrifuged and transferred the clear supernatant into a 2 mL autosampler vial (David et al., 2005; IUPAC, 1992; Regulation, 1991).

Determination of essential oil components by GC-MS

A mass selection detector equipped Agilent series GC (model 7890A) and MS (model 5975C) were used for the GC-MS analysis of the plant sample. An HP-5MS capillary column (30 m x 0.25 mm i.d., 0.25 m) was used for the separation during the analysis. Injector and detector temperatures were 210°C. The column temperature was first set to 40°C for 3 min, then increased to 90°C at 3 min/degrees and held for 4 min, then to 115°C at 3 min/degrees and held for 10 min, then to 140°C at 2 min/degrees and held for 8 min, and lastly to 210°C at 3 min/degrees and held for 5 min. The carrier gas used was helium. The scan period was 0.3 seconds, the ionization energy was 70 eV, and the AMU mass range was 45–500. Using Agilent GC-MS solution software, the GC-MS system was managed, the GC and mass spectrometry parameters were established, and data was received and processed. According to the NIST Chemistry WebBook (https://webbook.nist.gov/chemistry), identification by GC-MS was based on comparing mass spectra with WILEY-NIST data libraries.

Statistical Analysis

Statistical analysis of this study was performed by using the SPSS (IBM SPSS Corp., Armonk, NY, USA) 25.0 software program. In this study, a One-Way ANOVA analysis of variance was made to determine the differences between Tarragon species in yield values.

Results

Plant height, green herb yield, green leaf yield, green stems yield, drug leaf yield, drug stems yield, and drug herb yield measure the yield for *Artemisia* spp. as in other green leafy plants. Tarragon is a plant that uses the leaf part, drug, or green. According to the results of yield measurement, although *A. draduncculoides* L. has higher values for plant height, green herb yield, green stem yield, *A. dracunculus* L. has higher values for green leaf yield, drug leaf yield, drug stems yield, and drug herb yield (Table 2.).

Table 2.
Average yield values of Artemisia dracunculus L. and Artemisia dracunculoides L.

	Species	
	A. dracunculus L.	*A. dracunculoides* L.
Plant height (cm)	42.10	66.27
Green herb yield (kg/ha)	477.82	531.98
Green leaf yield (kg/ha)	358.11	311.14
Green stem yield (kg/ha)	121.11	238.89
Drug leaf yield (kg/ha)	82.28	64.94
Drug stem yield (kg/ha)	36.72	33.56
Drug herb yield (kg/ha)	119.01	98.50

Tarragon is a medicinal plant cultivated for its leaf, so the values of green herb yield, green leaf yield, and drug leaf yield have importance. When the differences between these values are examined, it is seen that *A. dracunculus* is more advantageous than *A. dracunculoides*. Although *A. dracunculoides* seem to be more efficient than *A. dracunculus* in terms of green herb yield, its superior properties in terms of drug herb, drug leaf, and green leaf yield make *A. dracunculus* more preferred.

It was seen that the yield values of Tarragon species in the study were different from each other by examining the average values. One-Way ANOVA Analysis of Variance was performed to determine whether these differences were significant ($p < .05$) (Table 3.). Interspecies yield values were at a significant ($p < .05$) difference. There wasn't a significant ($p < .05$) difference for only drug stem yield. Especially the most significant difference ($p < 0.001$) was mainly seen in the drug leaves yield value of *Artemisia* spp.

Table 3.
One-Way ANOVA Analysis of Variance of A. dracunculus L. and A. dracunculoides L.

		Sum of Squares	df	Mean Square	F	Sig.
Plant height (cm)	Between Groups	876.042	1	876.042	26.239	**0.007***
	Within Groups	133.547	4	33.387		
	Total	1009.588	5			
Green Herb Yield (kg/da)	Between Groups	7822.870	1	7822.870	8.905	**0.041***
	Within Groups	3514.052	4	878.513		
	Total	11336.922	5			
Green Leaf Yield (kg/da)	Between Groups	3309.741	1	3309.741	19.007	**0.012***
	Within Groups	696.518	4	174.129		
	Total	4006.259	5			
Green Stems Yield (kg/da)	Between Groups	20808.193	1	20808.193	25.747	**0.007***
	Within Groups	3232.728	4	808.182		
	Total	24040.920	5			
Drug Leaves Yield (kg/da)	Between Groups	451.360	1	451.360	71.026	**0.001***
	Within Groups	25.419	4	6.355		
	Total	476.780	5			
Drug Stems Yield (kg/da)	Between Groups	15.010	1	15.010	3.597	0.131
	Within Groups	16.691	4	4.173		
	Total	31.701	5			
Drug Herb Yield (kg/da)	Between Groups	630.990	1	630.990	30.974	**0.005***
	Within Groups	81.486	4	20.372		
	Total	712.476	5			

*Significance level $p < .05$ n.d.: not detected, N: Number

Artemisia spp. is known as a fragrant perennial medicinal and aromatic plant. *A. dracunculus* and *A. dracunculoides*, which are among the essential oil plants, are grown in many different regions and are also consumed as food. It is known that essential oils have been used to treat diseases from ancient times to the present day because of having important components (Azizkhani et al., 2021; Galoviˇcová et al., 2021; Wi´nska et al., 2019). It is important to determine the essential oil ratio and components of plants used in the food industry. In this study, the essential oil ratio and the components of the tarragon species were determined, most commonly used in the food industry, to draw attention to this reason. The essential oil ratio for *A. dracunculus* was 1.40 %, whereas it was 1.21 % for *A. dracunculoides*; 42 components were found in *A. dracunculus* essential oil, while 38 were found in *A. dracunculoides* essential oil. According to the GC analysis, estragole was the most abundant component in the *Artemisia* spp. that was used in this study. Linalool (4.68%) and cis-ocimene (3.92%) for *A. dracunculus*, cis-ocimene (4.52%), and β-ocimene (4.00%) for *A. dracunculoides* are the highest components after estragole. The estragole component was 69.34% in *A. dracunculus* and 67.51% in *A. dracunculoides* (Table 4).

After estragole, the most abundant essential oil components are cis-ocimene, β-cis-ocimene, and β-ocimene, in the group of regular hydrocarbons. In this study, cis-ocimene values were between 3.92%-4.52%, β-cis-ocimene was 3.45%, and β-ocimene was 4.00%. In addition, β-ocimene could not be detected in *A. dracunculus*, and β-cis-ocimene was not found in *A. dracunculoides.*

In addition to being a monoterpene used in the food industry due to its pungent odor and aroma, D-Limonene has a chemo-preventive effect on breast, skin, and liver cancers, according to studies con-ducted with rodents (Kim et al., 2013; Saini et al., 2022). This study determined D-Limonene at 2.76%-2.67% for *A. dracunculus* and *A. dracunculoides*, respectively. It is known that volatile linalool is used in the production of food flavors and in the perfumery and pharmaceutical industries to remove undesirable odors (Amazonas et al., 2022). This study found the linalool component in *A. dracunculus* and *A. dracunculoides* at 4.68%-1.82%, respectively. The linalool component was found in *A. dracunculus* and *A. dracunculoides* at rates of 4.68%-1.82%, respectively, the linalool content of *A. dracunculus*, showed that, more suitable for use in perfumery and food industries than *A. dracunculoides.*

Table 4.

Essential oil components of A. dracunculus and A. dracunculoides

		A. dracunculus		*A. dracunculoides*				*A. dracunculus*		*A. dracunculoides*	
N	Essential Oil Components	R.T	%	R.T	%	N	Essential Oil Components	R.T	%	R.T	%
1	α-Pinene	7.59	0.88	7.59	0.87	27	Trans-Carveol	17.75	0.04	n.d.	n.d.
2	Camphene	8.04	0.20	8.04	0.12	28	Borne ol, Formate	18.03	0.09	n.d.	n.d.
3	Sabinene	8.86	0.10	8.86	0.09	29	Hexyl 2-Methylbutanoate	18.22	0.10	n.d.	n.d.
4	β-Pinene	8.95	0.16	8.95	0.13	30	Propanal, 2-Methyl-3-Phenyl	18.35	0.08	n.d.	n.d.
5	β-Myrcene	9.45	0.14	9.46	0.14	31	D-Carvone	18.47	0.05	n.d.	n.d.
6	α-Terpinolene	10.31	0.04	12.86	0.11	32	Bornyl Acetate	19.84	0.12	n.d.	n.d.
7	Cymene	10.61	0.17	n.d	n.d	33	Carvacrol	20.30	0.08	n.d.	n.d.
8	P-Cymene	n.d.	n.d.	10.61	0.08	34	Eugenol	22.16	0.48	22.18	0.67
9	D-Limonene	10.82	2.76	10.81	2.67	35	Cinnamic acid, Methyl Ester	22.96	0.13	22.98	0.46
10	1,8-Cineole	10.88	1.68	10.87	0.76	36	Methyleugenol	23.73	1.70	23.72	1.34
11	Cis-Ocimene	11.19	3.92	11.21	4.52	37	Trans-Caryophyllene	24.16	0.08	24.16	0.16
12	β-cis-Ocimene	11.55	3.45	n.d.	n.d.	38	Trans-β-Farnesene	25.27	0.09	n.d.	n.d.
13	β- Ocimene	n.d.	n.d.	11.58	4.00	39	Germacrene-d	26.06	0.11	26.06	0.07
14	Gamma-Terpinene	11.83	0.06	11.84	0.04	40	β-İonone	26.19	0.08	n.d.	n.d.
15	Linalool	13.45	4.68	13.36	1.82	41	Trans-Beta-İonone	n.d.	n.d.	26.19	0.07
16	Alloocimene	14.32	0.11	14.31	0.14	42	Bicyclo[3.1.1]hept-2-ene hyl-6-(4-Methyl-3-Pentenyl)	n.d.	n.d.	26.44	0.07
17	Acetic acid, 1,7,7-trimethyl-bicyclo[2.2.1]hept-2-yl ester	n.d.	n.d.	19.84	0.32	43	Methyl Eicosan-5(Z),8(Z),11(Z),14 Z)-Tetraen-19-Onoate	n.d.	n.d.	28.64	0.15
18	Borneol	15.71	2.65	15.62	0.72	44	α-Farnesene	26.44	0.06	n.d.	n.d.
19	Terpinene-4-ol	16.08	1.02	16.04	0.27	45	Bicyclogermacrene	26.53	0.09	26.53	0.11
20	Estragole	17.54	69.34	17.55	67.51	46	Spathulenol	28.94	0.48	28.94	0.54
21	Benzaldehyde,4-Methoxy	n.d.	n.d.	18.76	0.09	47	α-Bisabolol	32.08	0.15	n.d.	n.d.
22	Camphor	14.88	1.34	14.85	0.44	48	Herniarin	32.78	0.26	32.79	0.56
23	3,4,6-Trinitro-2-methylanisole	n.d.	n.d.	23.65	0.21	49	2-Pentadecanone, 6,10,14-Trimethyl	34.01	0.02	34.01	0.03
24	1-Acetoxyindole	n.d.	n.d.	22.13	0.37	50	N-İsobutyl Deca-2,4-Dienamide	34.63	0.04	34.63	0.09
25	Hexadecanoic Acid	n.d.	n.d.	34.77	0.04	51	Phytol	35.51	0.05	n.d.	n.d.
26	Tetracosane	39.05	0.03	39.05	0.16	52	Achillea amide	35.67	0.02	35.67	0.06

*Significance level $p < .05$ n.d.: not detected, N: Number

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In addition to being a monoterpene used in the food industry due to its pungent odor and aroma, D-Limonene has a chemo-preventive effect on breast, skin, and liver cancers, according to studies con-ducted with rodents (Kim et al*.,* 2013; Saini et al*.,* 2022). This study determined D-Limonene at 2.76%-2.67% for *A. dracunculus* and *A. dracunculoides*, respectively. It is known that volatile linalool is used in the production of food flavors and in the perfumery and pharmaceutical industries to remove undesirable odors (Amazonas et al*.,* 2022). This study found the linalool component in *A. dracunculus* and *A. dracunculoides* at 4.68%-1.82%, respectively. The linalool component was found in *A. dracunculus* and *A. dracunculoides* at rates of 4.68%-1.82%, respectively, the linalool content of *A. dracunculus*, showed that, more suitable for use in perfumery and food industries than *A. dracunculoides.*

Discussion

Green herb yield, green leaf yield, drug herb yield, and drug leaf yield were found 477.82-531.98 kg/ha, 311.14-358.11 kg/ha, 98.50-119.01 kg/ha, 64.94-82.28 kg/ha, respectively (Table 2). In their study, Cil and Kara (2015), determined the effect of different plant densities on the yield of *Artemisia dracunculus* L., and they showed higher results than the values we obtained. Basiri and Nadjafi (2019), were found lower values for tarragon. It is thought that these differences can be caused by the ecological characteristics of the cultivation area.

The essential oil ratios obtained in this study were 1.40% and 1.21% for *A. dracunculus* and *A. dracunculoides*, respectively. Çil and Kara (2015) stated that the essential oil ratio for *A. dracunculus* varied between 0.146% and 1.346% in their previous study and showed results close to the values we obtained. Golubkina et al., (2020) reported that tarragon contains 0.68% to 0.70% essential oil, which is lower than the value we obtained. It is thought that the differences observed between the studies may be due to the age of the seedlings and the climatic conditions in which the plant samples were grown.

Estragole was the major component of *Artemisia dracunculus* and *Artemisia dracunculoides*, used in this study (Table 4). Although some studies have reported that the estragole component has carcinogenic effects (De Vincenzi et al*.,* 2000; Gori et al*.,* 2012; Zeller et al*.,* 2009). Smith et al. (2013), reported that some herbal products containing this component are used in the field of food as a flavor enhancer and that the important point in this regard is the consumption amount, as consumption in low amounts is not harmful. Bahmani et al. (2018), determined that essential oil components obtained from tarragon leaves contain estragole between 76.67% and 83.06%. In addition; there are also current studies that support this study by reporting 67.70% of estragole in *A. dracunculus* (Ulu & Aksu Kılıçle, 2020). In addition, linalool and cis-ocimene for *A. dracunculus*, cis-ocimene, and β-ocimene for *A. dracunculoides* are the highest components after estragole. Some previous studies reported that the essential oil components of β-cis-ocimene and β-ocimene in *A. dracunculus* were between 3.40% and 11.00%, and higher values were determined than the results obtained in this study (Haghi et al*.,* 2010; Ulu & Aksu Kılıçle, 2020). It is thought that the differences between the results obtained may be due to the cultivation of the plant material used in different locations and under different production conditions.

The obtained by using GC analysis in this study, D-Limonene values (2.76%-2.67) show that tarragon can be useful in the production of drugs with its anticancer effect as well as its use in the food field. In some previous studies, D-Limonene component values were between 1.63% and 3-9%, supporting the results obtained in this study (Haghi et al*.,* 2010; Ulu & Aksu Kılıçle, 2020). Sayyah et al. (2004), determined that 12.4% limonene was found in *A. dracunculus* and showed different results from this study. The differences between these values are thought to be due to the eco-geographical features of the plant's growing area. It is known that the linalool molecule has many biological activities such as antitumoral, antioxidant, antimicrobial, and anti-inflammatory properties and is found in the essential oils of many medicinal and economic plants (Mitic-Culafic et al*.,* 2009; Tepe et al*.,* 2004). The linalool component content of *Artemisia* spp., used in this study, was between 1.8% and 4.68%. In previous studies, it was seen that the linalool content of tarragon ranged between 0.19% and 5.09%, and the results obtained were supported by this study (Ayoughi et al*.,* 2011; Karimi et al*.,* 2015; Sahakyan et al*.,* 2021). In addition, when compared in terms of linalool content, *A. dracunculus* was determined to contain a higher rate of linalool than *A. dracunculoides*. As a result, *A. dracunculus* is considered to be preferred to *A. dracunculoides* in the perfumery, food, and pharmaceutical industries.

Conclusions

Green and drug yield values of *Artemisia* spp. showed that *Artemisia dracunculus* L. has more advantages for drug-leaf yield and drug herb yield. Tarragon is a valuable plant for its green and dry leaves as well as its essential oil. The results obtained in this study showed that *A. dracunculus* contained a higher percentage of essential oil than *A. dracunculoides*. It was determined that *A. dracunculus* and *A. dracunculoides* plant materials, used in this study have valuable essential oil components. For the first time, essential oil components of *A. dracunculus* and *A. dracunculoides* were compared. Although there are negative opinions about estragole, studies also show this possibility can be eliminated by determining the amount of use. It has been seen that the tarragon plant has positive potential for use in the perfumery and pharmaceutical industries, as well as in the food industries. With its aromatic effect and linalool content, *A. dracunculus* can use in food and medication manufacturer, particularly perfume. Considering the increasing use of medicinal aromatic plants and the variety of products needed, it is seen that more research is needed in this field. A more comprehensive study can be done on this subject, including different *Artemisia* spp. Considering its economic importance and other uses, it suggests the idea that *A. dracunculus* and *A. dracunculoides* should be cultivated in larger areas.

Peer-review: Externally peer-reviewed.
Conflict of Interest: The author has no conflicts of interest to declare.
Acknowledgments: I want to thank to Prof. Dr. Agnieszka Najda for supporting about writing - review and editing, validation. I want to thank to Assoc. Prof. Dr. Abdurrahman Sefalı for identification of the plant species.
Funding: This research received no external funding.

Hakem Değerlendirmesi: Dış bağımsız.
Çıkar Çatışması: Yazar, çıkar çatışması olmadığını beyan etmiştir.
Teşekkür: Prof. Dr. Agnieszka Najda'ya yazım-inceleme ve düzenleme ile doğrulama konularında verdiği destek için teşekkür ederim. Doç. Dr. Abdurrahman Sefalı'ya bitki türlerinin tanımlanması için teşekkür ederim.
Finansal Destek: Bu araştırma herhangi bir dış finansman almamıştır.

References

Amazonas, D. R., Oliveira, C., Barata, L. E. S., Tepe, E. J., Kato, M. J., Mourão, R. H. V., & Yamguchi, L. F. (2021). Chemical and Genotypic Variations in *Aniba rosiodora* from the Brazilian Amazon Forest. *Molecules, 26*, 69.

Ayoughi, F., Marzegar, M., Sahari, M. A., & Naghdibadi, H. (2011). Chemical compositions of essential oils of *Artemisia dracunculus* L. and endemic *Matricaria chamomilla* L. and an evaluation of their antioxidative effects. *Journal of Agricultural Science and Technology, 13,* 79–88.

Azizkhani, M., Jafari Kiasari, F., Tooryan, F., Shahavie, M. H., & Partovi, R. (2021). Preparation and evaluation of food-grade nanoemulsion of tarragon (*Artemisia dracunculus* L.) essential oil: antioxidant and antibacterial properties. *Journal of Food Science and Technology, 58,* 1341–1348.

Bahmani, L., Aboonajmi, M., Arabhosseini, A., & Mirsaeedghazi, H. (2018). Effects of ultrasound pre-treatment on quantity and quality of essential oil of tarragon (*Artemisia dracunculus* L.) leaves. *Journal of Applied Research on Medicinal and Aromatic Plants, 8,* 47–52.

Basiri, M. H., & Nadjafi, F. (2019). Effect of plant density on growth, yield and essential oil characteristics of Iranian Tarragon (*Artemisia dracunculus* L.) landraces. *Scientia Horticulturae, 257*, 108655.

Can, Z., Ayazoglu Demir, E., Akar, Z., Kara, Y., & Gıdık, B. (2023). Determination of cytotoxic, anti-acetylcholinesterase and antioxidant activity of some medicinal *Artemisia* spp. *Turkish Journal of Analytical Chemistry*, *5*(1), 1–10.

Cil, M., & Kara, K. (2015). Effects of different plant densities on some agronomic characteristics and essential oil ratios of tarragon (*Artemisia dracunculus* L.). *Journal of Agricultural Sciences, 21*, 373–381.

David, F., Sandra, P., & Vickers, A. K. (2005). Column selection for the analysis of fatty acids methyl esters, *Agilent Technologies*, Inc.: Santa Clara, CA, USA.

Davis, P.H. (1965-1985) (Ed.). Flora of Turkey and the East Aegean Islands. Vol.1-9, Edinburgh: Edinburgh Univ. Press.

Davis, P. H. (1982). Flora of Turkey and The East Aegean Islands, pp. 311, *Edinburgh University Press,* Edinburgh.

Davis, P.H., Mill R.R. & Tan, K. (1988). (Eds.) Flora of Turkey and the East Aegean Islands. Vol.10, Edinburgh: Edinburgh Univ. Press.

De Vincenzi, M., Silano, M., Maialetti, F., & Scazzocchio, B. (2000). Constituents of aromatic plants: II. Estragole. *Fitoterapia, 71,* 725–729.

Galoviˇcová, L., Borotová, P., Valková, V., Vukovic, N. L., Vukic, M., Štefániková, J., Dúranová, H., ˇKowalczewski, P. Ł., Cmiková, N., & ˇKaˇcániová, M. (2021). *Thymus vulgaris* essential oil and its biological activity. *Plants,* 10, 1959.

Gedikoglu, I. (1990). Laboratory Analysis Methods Used in Determination of Soil Fertility, pp. 55, KHGM, *Sanliurfa Res Inst Manager Arrow General Release Publishing*, Sanliurfa Türkiye.

General Directorate of Meteorology (GDM). (2021). https://mgm.gov.tr/veridegerlenen/il-ve-ilceler-istatistik.aspx?k=H.

Gori, L., Gallo, E., Mascherini, V., Mugelli, A., Vannacci, A., & Firenzuoli, F. (2012). Can estragole in fennel seed decoctions really be considered a danger for human health? A fennel safety update. *Evidence Based Complementary and Alternative Medicine,* 2021, 10.

Golubkina, N., Logvinenko, L., Novitsky, M., Zamana, S., Sokolov, S., Molchanova, A., Shevchuk, O., Sekara, A., Tallarita, A., & Caruso, G. (2020). Yield, essential oil and quality performances of *Artemisia dracunculus*, *Hyssopus officinalis* and *Lavandula angus*tifolia as affected by arbuscular mycorrhizal fungi under organic management. *Plants, 9,* 375.

Güner, A., Özhatay N., Ekim T. & Başer, K.H.C. (2000). (Eds.) Flora of Turkey and the East Aegean Islands. Vol.10 (supplement 2): Edinburgh: Edinburgh University Press. pp. 29–41.

Haghi, G., Ghasian, F., & Safaei-Ghomi, J. (2010). Determination of the essential oil from root and aerial parts of *Artemisia dracunculus* L. cultivated in central Iran. *Journal of Essential Oil Research, 22,* 294–296.

IUPAC, Standard method 2.301. (1992). Standards methods for the analysis of oils, fats and derivatives, *1st supplement. to the 7th ed, International Union of Pure and Applied Chemistry*, Blackwell, Oxford, England.

Jazani, N. H., Zartoshti, M., Babazadeh, H., & Ali-daiee, N. (2011). Antibacterial Effects of *Artemisia dracunculus* essential oil on multidrug resistant isolates of *Acinetobacter baumannii*. *Bacteriology Journal, 1,* 31–36.

Karimi, A., Hadian, J., Farzaneh, M., & Khadivi-Khubb, A. (2015). Phenotypic diversity and volatile composition of Iranian

Artemisia dracunculus L. *Industrial Crops and Products, 65,* 315–323.

Kim, Y. W., Kim, M. J., Chung, B. Y., Bang, D. Y., Lim, S. K., Choi, S. M., Lim, D. S., Cho, M. C., Yoon, K., Kim, H. S., Kim, B. K., Kim, Y. S., Kwack, S. J., & Lee, B. M. (2013). Safety evaluation and risk assessment of d-limonene. *Journal of Toxicology and Environmental Health Part B, 16,* 17–38.

Mitic-Culafic, D., Zegura, B., Nikolic, B., Vukovic-Gacic, B., Knezevic-Vukcevic, J., & Filipic, M. (2009). Protective effect of linalool, myrcene and eucalyptol against t-butylhydroperoxide induced genotoxicity in bacteria and cultured human cells. *Food and Chemical Toxicology, 47*, 260–266.

Mumivand, H., Ebrahimi, A., Morshedloo, M. R., & Shayganfar, A. (2021). Water deficit stress changes in drug yield, antioxidant enzymes activity and essential oil quality and quantity of Tarragon (*Artemisia dracunculus* L.). *Industrial Crops and Products, 164,* 113381.

Mumivand, H., Babalar, M., Tabrizi, L., Craker, L. E., Shokrpour, M., & Hadian, J. (2017). Antioxidant properties and principal phenolic phytochemicals of Iranian tarragon (*Artemisia dracunculus* L.) accessions. *Horticulture, Environment and Biotechnology, 58*, 414–422.

Obolskiy, D., Pischel, I., Feistel, B., Glotov, N., & Heinrich, M. (2011). *Artemisia dracunculus* L. (tarragon): a critical review of its traditional use, chemical composition, pharmacology, and safety. *Journal of Agricultural and Food Chemistry, 59*, 11367–11384.

Pelarti, S. M., Zarehshuran, L. K., Babaeekhou, L., & Ghane, M. (2021). Antibacterial, anti-biofilm and anti-quorum sensing activities of *Artemisia dracunculus* essential oil (EO): a study against *Salmonella enterica* serovar *Typhimurium* and *Staphylococcus aureus*. *Archives of Microbiology, 203*, 1529–1537.

Regulation, H. (1991). Commission Regulation (EEC) No. 2568/91 of 11 July 1991 on the characteristics of olive oil and olive-residue oil and on the relevant methods of analysis. *Official Journal, 248*, 1–83.

Sahakyan, N., Andreoletti, P., Cherkaoui-Malki, M., Petrosyan, M., & Trchounian, A. (2021). *Artemisia dracunculus* L. essential oil phytochemical components trigger the activity of cellular antioxidant enzymes. *Journal of the Science of Food and Biochemistry, 45*, e13691.

Sayyah, M., Nadjafnia, L., & Kamalinejad, M. (2004). Anticonvulsant activity and chemical composition of *Artemisia dracunculus* L. essential oil. *Journal of Ethnopharmacology, 94*, 283–287.

Saini, R. K., Ranjit, A., Sharma, K., Prasad, P., Shang, X., Gowda, K. G. M., & Keum, Y. S. (2022). Bioactive compounds of *Citrus* Fruits: A review of composition and health benefits of carotenoids, flavonoids, limonoids, and terpenes. *Antioxidants, 11*, 239.

Smith, R. L., Adams, T. B., Doull, J., Feron, V. J., Goodman, J. I., Marnett, L. J., Portoghese, P. S., Waddell, W. J., Wagner, B. M., Rogers, A. E., Caldwell, J., & Sipes, I. G. (2002). Safety assessment of allylalkoxybenzene derivatives used as flavouring substances-methyl eugenol and estragole. *Food and Chemical Toxicology, 40*, 851–870.

Tepe, B., Donmez, E., Unlu, M., Candan, F., Daferera, D., Vardar, U. G., Polissiou, M., & Sokmen, A. (2004). Antimicrobial and antioxidative activities of the essential oils and methanol extracts of *Salvia cryptantha* (Montbret et Aucher ex Benth.) and *Salvia multicaulis* (Vahl). *Food Chemistry, 84,* 519– 525.

Trendafilova, A., Moujir, L. M., Sousa, P. M. C., & Seca, A. M. L. (2021). Research advances on health effects of edible *Artemisia* species and some sesquiterpene lactones constituents. *Foods, 10*, 65.

Ulgen, N., & Yurtsever, N. (1995). Turkey Fertilizer and Fertilization Guide, 4th Edition; pp.66-209. T.R. Prime Ministry General Directorate of Rural Services*, Soil and Fertilizer Research Institute Publications: General Publication, Technical Publications*, Ankara, Türkiye.

Ulu, H., & Aksu Kılıcle, P. (2020). Determination of the possible protective effect of tarragon (*Artemisia dracunculus* L.) leaf extract in the mouse bone marrow cells against cyclophosphamid by micronucleus test. *Caucasian Journal of Science, 7*, 92–108.

Wi´nska, K., Maczka, W., Łyczko, J., Grabarczyk, M., Czubaszek, A., & Szumny, A. (2019). Essential oils as antimicrobial agents-myth or real alternative? *Molecules, 24*, 21–30.

Zappi, D. C., Ranzato Filardi, F. L., Leitman, P., Souza, V. C., Walter, B. M. T., Pirani, J. R., Morim, M. P., Queiroz, L. P., Cavalcanti, T. B., & Mansano, V. F. (2015). Growing knowledge: An overview of seed plant diversity in Brazil. *Rodriguesia, 66*, 1085–1113.

Zedan, H., Masou, S., & Mohammadi, H. A. (2021). The effect of tarragon (*Artemisia dracunculus*) essential oil and high molecular weight Chitosan on sensory properties and shelf life of yogurt. *Food Science and Technology, 147*, 1–8.

Zeller, A., Horst, K., & Rychlik, M. (2009). Study of the metabolism of estragole in humans consuming fennel tea. *Chemical Research in Toxicology, 22*, 1929–1937.