

## Chemical Compositions of Essential Oil and Crude Oil of Some Fruits belonging to Umbelliferae Family cultivated in Konya Ecological Conditions

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### ABSTRACT

Apiaceae, also called Umbelliferae, the parsley family, in the order Apiales, comprising around 300 and 400 genera of plants distributed throughout a wide variety of habitats, principally in the north temperate regions of the world. Most members of Umbelliferae family are aromatic herbs. Species used as herbs and spices include fennel (*Foeniculum vulgare*), anise (*Pimpinella anisum*), dill (*Anethum graveolens*), coriander (*Coriandrum sativum*), and cumin (*Cuminum cyminum*). In this study, essential oil and crude oil components were determined in the seeds of dill, fennel, aniseed, cumin and coriander. The yield and components of essential oil and crude oil, main active compounds in the fruit of the plants of dill, fennel, anise, cumin and coriander grown in the ecological conditions of Konya were examined. According to the results, essential oil and crude oil yields were 3.5 % and 5.06 % in dill, 2.25 % and 22.07 % in anise, 2.70 % and 7.34 % in fennel, 1.90 % and 11.26 % in cumin, 0.95 % and 18.48 % in coriander. The main components of dill, fennel, anise, cumin and coriander seed essential oils were carvone (45.221 %), trans-anethole (86.898 %), (Z)-Anethole (92.478 %), cumin aldehyde (42.900 %) and linalool (87.238 %) respectively. In crude oils, the main component was determined as C18:1 (oleic acid).

### Research Article

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## Konya Ekolojik Şartlarında Kültüre Alınan Umbelliferae Familyasına ait Bazı Tohumların Uçucu Yağ ve Sabit Yağ Bileşenlerinin Kimyasal Kompozisyonları

### ÖZET

Umbelliferae (Apiaceae) yani maydanozgiller, özellikle dünyanın kuzey ılıman bölgelerinde yetişen ve 300 ile 400 civarında cinse sahip geniş bir familyadır. Familyadaki birçok bitki aromatik bitki sınıfına dahildir. Familyadaki özellikle baharat olarak kullanılan türler sırasıyla, rezene (*Foeniculum vulgare*), anason (*Pimpinella anisum*), dereotu (*Anethum graveolens*), kişniş (*Coriandrum sativum*), ve kimyon (*Cuminum cyminum*)dur. Bu çalışmada dereotu, rezene, anason, kimyon ve kişniş tohumlarında uçucu yağ ve sabit yağ bileşenleri belirlenmiştir. Konya ekolojik koşullarında yetiştirilen dereotu, rezene, anason, kimyon ve kişniş bitkilerinin meyvelerinde ana etken madde olan uçucu ve sabit yağ oranları ile uçucu ve sabit yağ bileşenlerine bakılmıştır. Elde edilen sonuçlara göre uçucu yağ ve sabit yağ oranları sırasıyla, dereotunda % 3.5 ve % 5.06, anasonda % 2.25 ve % 22.07, rezene de %2.70 ve % 7.35, kimyonda % 1.90 ve % 11.26, kişnişte ise % 0.95 ve % 18.48 olarak belirlenmiştir. Dereotu, rezene, anason, kimyon ve kişniş tohum uçucu yağlarının ana bileşenleri sırasıyla karvon (% 45.221), trans-anetol (% 86.898), (Z-) anetol (% 92.478), kumin aldehit (% 42.900) ve linalol(% 87.238)'dür. Sabit yağlarda da ana bileşen C18:1 (oleik asit) olarak belirlenmiştir.

### Araştırma Makalesi

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## INTRODUCTION

Turkey has a rich biodiversity in terms of medicinal and aromatic species due to its different climatic conditions and favourable geographical structure (Hajyzadeh et al., 2017). Medicinal plants in the world and in our country find an increasing range of use especially in the pharmaceutical and food industries, cosmetics, paints, decorative and feed industry. They are consumed as spice in the food industry at the most. Thyme (*Thymus vulgaris*), rose (*Rosa damascena*), poppy (*Papaver somniferum*), aniseed (*Pimpinella anisum*), fenugreek (*Trigonella foenum-graecum*), pepper mint (*Mentha piperita*), black cumin (*Nigella sativa*) and similar species have a place in cultured medicinal and aromatic plants. In recent years, the demand has increased rapidly both in the foreign and domestic markets as a result of the use of medicinal and aromatic herbal products.

The main factors determining the importance of medicinal and aromatic plants are the active ingredients. These active ingredients in the plants, especially essential and fixed oils, depend on such many factors as primarily the genetic structure of the plant, climate, environmental factors, cultural treatments, the region of growth of the plant, different parts of the plant (morphogenetic variability) (Singh and Randhawa, 1991), development periods of the plant (ontogenetic variability) (Özel, 2000) and temperature changes during the day (diurnal variability) (Kaçar and Özkan, 2005; Uyanık, 2013). It is important to know the amount and distribution of active ingredient in essential oil plants and the plants belonging to the Umbelliferae family, whose herbs and seed are evaluated separately in particular (Ayhan and Özel, 2017).

Both herbs and fruit of the plants of dill, fennel, aniseed, cumin and coriander belonging to the Umbelliferae family are used in salads, soups and sauces as spices and vegetables. In addition, all of these plants are commonly used in medicine, alternative medicine and the public especially in the digestive system, common cold and cough.

Konya is one of the provinces with the least annual precipitation in our country. Due to the very hot and dry summers, irrigation problems are often encountered. This increases secondary metabolite production against stress conditions in medicinal and aromatic plants. For this reason, it was aimed to carry out this study in fruits of dill, fennel, anise, cumin and coriander consumed among the people. In this study, essential oil and crude oil yields and chemical compositions of dill, fennel, anise, cumin and coriander plants grown in Konya ecological conditions were investigated.

## MATERIALS AND METHODS

### Plant Materials

The fruits used in the trial, were dill (*Anethum graveolens*), fennel (*Foeniculum vulgare*), anise (*Pimpinella anisum*), cumin (*Cuminum cyminum*), coriander (*Coriandrum sativum*). This study was conducted to essential oil yield, crude oil yield and components of the fruits cultivated, Selçuk University, Faculty of Agriculture, Medical Plants Research and Application Experimental Area in Konya ecological conditions. Field trial was carried out in 2018. All the fruits used were populations. Dill, fennel, anise, cumin and coriander fruits were directly planted in the experimental area by hands in the first week of March (05 March). The growing period of plants were reached 150 days. Trial was set up in three repetitions according to the randomized parcels experimental design. In order to determine the soil properties of the trial area on which the experiment was conducted, the physical and chemical analyzes of the soil sample taken from 0-20 cm depth were carried out in Selçuk University, Faculty of Agriculture, Department of Soil Laboratory. Soil analysis was given in Table 1.

Table 1. Some Physical and Chemical Properties of Research Trial Soil

Çizelge 1. Deneme Alanı Toprağına ait Bazı Fiziksel ve Kimyasal Özellikler

Properties (Özellikler)	Amount (Miktar)
Sand (%)	25.8
Silt (%)	38.0
Clay (%)	36.2
Texture class	Clayed-loam
pH (1:2.5, Soil:Water)	7.4
EC(Salt) (1:5, Soil:Water) (µS/cm)	114
CaCO <sub>3</sub> (Calcitic) (%)	53
Organic Substance (%)	4
Inorganic Nitrogen(NH <sub>4</sub> +NO <sub>3</sub> -N) (ppm)	30
Phosphorus (P) (ppm)	40
Potassium (K) (ppm)	441.5
Calcium (Ca) (ppm)	5023
Magnesium (Mg) (ppm)	208.3
Sodium (Na) (ppm)	48.3
Changeable Na Percentage (%)	0.84
Boron (B) (ppm)	0.3
Copper (Cu) (ppm)	0.38
Iron (Fe) (ppm)	0.30
Zinc (Zn) (ppm)	5.66
Manganese (Mn) (ppm)	2.70

According to the results, the soil of the experimental area was a loamy structure and high lime rate. The soil was alkaline reaction and salinity problem. The soil was found to be poor in iron, one of the important micronutrients, but rich in organic matter and potassium. Weather properties of the experimental

area were given in Table 2. provided from Konya Meteorology Regional Management. The fruits of dill,

fennel, anise, cumin, coriander harvested in August, 2018.

Table 2. Average maximum, minimum temperature (°C), humidity (%) and precipitation (mm) values for long years (1960-2018) and months of research for Konya province.

Çizelge 2. Denemenin yapıldığı Konya iline ait uzun yıllar için (1960-2018) ortalama, maksimum ve minimum sıcaklık (°C), ortalama nispi nem(%) ve toplam yağış değeri(mm)

Months (Aylar)	Average Temperature (Ortalama Sıcaklık) (°C)		Max. Temperature (Mak. Sıcaklık)(°C)	Min. Temperature (Min. Sıcaklık) (°C)	Average Relative Humidity (%) (Ortalama Nispi Nem)		Total Precipitation (mm) (Toplam Yağış)	
	Long Years (1960-2018) (Uzun Yıllar 1960-2018)	2018	2018	2018	Long Years (1960-2018) (Uzun Yıllar 1960-2018)	2018	Long Years (1960-2018) (Uzun Yıllar 1960-2018)	2018
January	-0.3	1.3	13.3	-10.2	76.7	82.3	36.6	55.8
February	1.2	5.8	18.0	-6.8	72.2	72.2	28.5	11.4
March	5.6	10.0	25.1	-2.7	64	58.4	27.6	28.1
April	10.9	14.0	26.8	0.4	58.3	47.0	33.5	7.2
May	15.7	17.3	28.1	5.9	55.9	58.4	44	52.0
June	20.1	21.2	33.7	10.5	48.4	50.3	24	97.9
July	23.4	25.1	34.5	13.7	42.1	39.9	6.6	8.2
August	22.8	24.6	34.4	13.8	42.9	35.9	5.5	0.2
September	18.4	20.1	33.6	9.0	48	42.3	12.8	5.9
October	12.4	13.9	25.5	-2.2	60.4	60.7	32	51.8
November	6	7.9	20.5	-4.2	70.4	67.8	32.6	20.6
December	1.6	2.9	13.3	14.4	77.3	82.0	43.3	81.8
Average	11.48	13.67	25.6	1.06	62.5	58.1	-	-
Total	-	-	-	-	-	-	327	420.9

### Essential Oil Distillation and Analysis

The fruits were milled with a grinder (Foss Kniftec 1095, Denmark) to analyse essential oil distillation. Then whole ground fruits (100 g) subjected to hydrodistillation for 3 h using Clevenger type apparatus to produce essential oil. Essential oil is calculated as volume (ml / 100 g). GC-MS instrument was used to determine the essential oil components. The essential oils were stored at -20°C until analyzed. GC-MS analysis was performed on a Agilent 6890N Network GC system combined with Agilent 5975 C VL MSD Network Mass Selective Detector. The GC conditions were; column, DB Wax tr; 60.0m x 0.25mm x 0.25µm; oven temperature programme: The column held initially at 60 °C for 10 min after injection, then increased to 220 °C with 4 °C min<sup>-1</sup> heating ramp for 10 min and increased to 240 °C with 10 °C min<sup>-1</sup> heating ramp without hold; inject or temperature 250 °C; carrier gas; He; inlet pressure, 9.60 psi; linear gas velocity, 7 cm sec<sup>-1</sup>; initial flow 0.3 ml min<sup>-1</sup>; split ratio,65.0:1; injected volume 1.0 µl. Computer matching against commercial libraries (Wiley GC-MS Library, Adams Library, MassFinder 3 Library) as well as MS literature data was used for the identification of essential oil components(European Pharmacopoeia 7.0).

### Isolation and Derivatization of The Fruit Crude Oils

The fruits of dill, fennel, anise, cumin and coriander were independently subjected to continuous extraction technique with diethyl ether for 8 h using

Soxhlet apparatus. The organic phases were evaporated in vacuo until dryness to give the crude oils. Prior to GC-MS analysis, trans-methyl derivatives of the crude oils were prepared. Fatty acid profiles were determined as fatty acid methyl esters (FAMES) and the FAMES were dissolved in n-hexane for injection and analyzed by GC-MS (European Pharmacopoeia 7.0).

### Fruit Crude Oil Analysis by GC-MS

GC-MS analysis was performed on a Agilent 6890N Network GC system combined with Agilent 5975 C VL MSD Network Mass Selective Detector. Determination of the components in the fruit fatty oils of dill, fennel, anise, cumin and coriander were performed by comparison of their mass spectra with Wiley, Famed-23 and Nist GC-MS Libraries and retention indices (RI), relative to n-alkanes as well as corresponding data from relevant literature. The percentages of the components were calculated from the GC peak areas using the normalization method.

## CONCLUSION and DISCUSSION

### Yields of Essential Oil and Crude Oil of the Fruits (%)

Essential oil yields (%) of dill, fennel, aniseed, cumin and coriander fruits were determined in the clevenger apparatus and crude oil yields (%) were determined in the soxhlet apparatus. Accordingly, the essential oil and crude oil yields of the fruits were given in Table 3.

Table 3. Essential oil (%) and crude oil (%) yields of some plant fruits belonging to Umbelliferae family

*Çizelge 3. Umbelliferae familyasına ait bazı bitkilerin meyvelerine ait uçucu yağ ve sabit yağ miktarları (%)*

TheFruits (Meyveler)	Essential Oil Yield (%) (Uçucu Yağ Miktarı)	Crude Oil Yield (%) (Sabit Yağ Miktarı)
<b>Dill</b>	3.15	5.06
<b>Fennel</b>	2.70	7.34
<b>Anise</b>	2.25	22.07
<b>Cumin</b>	1.90	11.26
<b>Coriander</b>	0.95	18.48

The essential oil yields of dill, fennel, aniseed, cumin and coriander fruits were determined as 3.15%, 2.70%, 2.25%, 1.90% and 0.95% respectively. Şanlı et al. (2012), essential oil yields in the fruits of dill, fennel, aniseed, cumin and coriander grown in the ecological conditions of Burdur were respectively determined as 3.02%, 2.74%, 2.68%, 1.82% and 0.32%. In another study reported that average essential oil rates were determined as 3.18% in dill fruit, 2.49% in fennel fruit, 3.33% in aniseed fruit, 1.77% in cumin fruit and 0.42% in coriander fruit in Isparta ecological conditions (Keskin and Baydar, 2016). According to the studies investigated with dill fruits, Charles et al. (1995) determined essential oil yield of the fruit as 1.75%- 4%, Tian et al. (2011) determined essential oil yield of dill fruit grown in China as 3.5% and Akgül (1986) determined as 2.2%- 3%. When the studies conducted with fennel fruit are examined, Uzun et al. (2011) determined essential oil yield of the fruit as 2.67%- 3.09%, Özkan and Gürbüz (2000) determined essential oil yield of the fennel fruit grown in the conditions of Ankara as 1.93%-2.28% and Şanlı et al. (2012) determined as 2.74%. When the studies conducted with aniseed fruit are examined, Keskin

and Baydar (2016) determined essential oil yield of the fruit as 3.10%- 3.60%, Haşimi et al. (2014) determined essential oil yield of aniseed fruit as 1.94%, Zheljzakov et al. (2013b) determined as 0.09%- 2.01% and Şanlı et al. (2012) determined as 2.68%. When the studies conducted with cumin fruit are examined, Haşimi et al. (2014) determined essential oil yield of cumin fruit as 1.94%, Keskin and Baydar (2016) determined as 1.47%-2.13% and Şanlı et al. (2012) determined as 1.82%. When the studies conducted with coriander fruit are examined, Niamah et al. (2016) determined essential oil yield of coriander fruit as 2%, Keskin and Baydar (2016) determined as 0.40%- 0.47% and Şanlı et al. (2012) determined as 0.32%.

Crude oil yields determined in the fruits were given in Table 3. The crude oil yields of dill, fennel, aniseed, cumin and coriander fruits were respectively determined as 5.06%, 7.3422.07%, 11.26% and 18.48%. The crude oil yields of coriander genotypes were determined as 18.64%-22.53% (Gökdoğan and Telci, 2018). In another research, it was reported that coriander's crude oil was 13%- 21%, cumin's crude oil was 10%- 15% and aniseed's crude oil was 30% (Gruenwald et al., 2004). The results were consistent with other results.

The results of the study revealed that the essential oil and crude oil ratios were in parallel with the other studies.

#### Essential Oil Compositions of the Fruits

The essential oil components of the dill fruit were given in Table 4. The essential oil components of dill, fennel, aniseed, cumin and coriander determined in the GC-MS. Wiley, Nist-Spectral and Volatile libraries were used to determine components in the GC-MS.

Table 4. Chemical composition of *Anethum graveolens* essential oil(%)

*Çizelge 4. Anethum graveolens meyvesinin uçucu yağ kimyasal kompozisyonu (%)*

No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amount (%) (Miktar)	No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amount (%) (Miktar)
1	1025	$\alpha$ -pinene	0.045	15	1647	trans-dihydrocarvone	9.373
2	1134	Sabinene	0.022	16	1673	Estragole	0.171
3	1186	$\alpha$ -phellandrene	0.342	17	1758	Carvone	45.221
4	1246	Limonene	35.905	18	1820	Anethole	3.716
5	1248	$\beta$ -phellandrene	0.053	19	1826	6-oxo-2,3,5,6-tetrahydro-1-H-pyrazine	0.030
6	1253	(1,3,8-para-menthatriene)	0.254	20	1832	Isophorone	0.042
7	1260	Ortho-cymene	0.103	21	2045	Para anisaldehyde	0.019
8	1409	Trans-epoxy-cymene	0.042	22	2210	Carvacrol	0.008
9	1441	Para-cymene	0.138	23	2224	Elemicin	0.011
10	1451	cis-limonene oxide	0.097	24	2272	Myristicin	0.927
11	1464	Trans-limonene oxide	0.067	25	2371	Dillapiole	1.681
12	1524	Dill ether	0.107	<b>TOTAL</b>			<b>100</b>
13	1587	Artemisiaketone	0.026				
14	1624	Cis-dihydrocarvone	1.598				

When the essential oil components of the dill fruit were examined, primary components were carvone (45.221 %), limonene (35.909 %), trans-dihydrocarvone (9.373%), anethole (3.716 %), dillapiole (1.681 %) and dilleter (0.107 %). The number of totally determined components was 25 and the total amount was 100 %. Aside from these components, para-anisaldehyde (0.019 %), cis-dihydrocarvone (1.598 %),  $\alpha$ -phellandrene (0.342 %) were determined. Main components (carvone, limonene, trans-dihydrocarvone, anethole, dillapiole and dilleter) constitute 96.007% of the amount of all the components. Carvone was found to be the main component of the fruit essential oil when the studies conducted with dill were examined. Şanlı et al. (2012) found the essential component of the fruit essential oil as D-Carvone (71.80%) and  $\alpha$ -fenchene (11.85%) and limonene (9.75%) were other components. In other studies, the rate of carvone was determined as 18.18-81.15% (Charles et al., 1995), 81.35-89.98%

(Hah and Ea, 2016), 75.2% (Radulescu et al., 2010), 85.9% (Stanojevic et al., 2016), 37.87-67.76% (Keskin and Baydar, 2016). Orhan et al. (2013) found that the main component of the dill herb's essential oil is  $\alpha$ -phellandrene (47.748% in organic dill and 27.940% in culture dill). In our study, the main component was determined as carvone. It was in parallel with other studies. However, the reason for the fact that its quantity was slightly lower than others could be explained as climate, environmental conditions and applied agricultural techniques. It was thought to be effective that it the ecological conditions of Konya was more arid.

The essential oil components of the fennel fruit were given in Table 5. When the essential oil components of the fennel fruit were examined, main components were Trans-anethole (86.898 %), Limonene (5.210 %), p-ally-anisole (3.992%), L-fenchone (1.427 %), p-Anisealdehyde (0.457 %) and  $\beta$ -ocimene (0.713 %).

Table 5. Chemical composition of *Foeniculum vulgare* fruit essential oil (%)

Çizelge 5. *Foeniculum vulgare* meyvesinin uçucu yağ kimyasal kompozisyonu (%)

No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amoun(%) (Miktar)	No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amount (%) (Miktar)
1	1025	$\alpha$ -pinene	0.250	12	1653	p-ally-anisole	3.992
2	1117	$\beta$ -pinene	0.030	13	1706	Germacrene D	0.050
3	1132	Sabinene	0.188	14	1881	Trans-anethole	86.898
4	1180	$\beta$ -myrcene	0.281	15	2047	p-Anisaldehyde	0.457
5	1230	Limonene	5.210	16	2168	Anisylacetone	0.017
6	1263	$\beta$ -ocimene	0.713	17	2184	Methylisoeugenol	0.012
7	1277	$\gamma$ -terpinene	0.088	18	2211	Carvacrol	0.006
8	1302	p-cymene	0.031	19	2222	1-M-Anisyl-1-propanone	0.015
9	1317	$\alpha$ -terpinolene	0.028	20	2269	1-Allyl-3-Methoxy-4,5-MethylEnedioxybenzene	0.008
10	1429	L-fenchone	1.427	21	2365	Dillapiole	0.017
11	1535	Camphor	0.040	<b>TOTAL</b>			<b>99.758</b>

The number of the totally determined components was 21 and the total amount was 99.758 %. In addition to these components, the components of  $\alpha$ -pinene (0.250%), sabinene (0.188%),  $\beta$ -myrcene (0.281%) were determined. Main components (Trans-anethole, limonene, p-ally-anisole, L-fenchone, p-Anisealdehyde and  $\beta$ -ocimene) constituted 96.697% of the amount of all the components. It was also seen in the studies that the major component of the essential oil of fennel fruit was trans anethole. The amounts of trans anethole detected in these studies were 85.22% (Şanlı et al., 2012), 47%- 80.2% (Bowes and Zheljaskov, 2005), 32.6%-59.4% (Zheljaskov et al., 2013), 60.15%- 84.20% (Rebey et al., 2016), 53.51% (Negahban et al., 2015), 34.8%- 82% (Raal et al., 2012) and 79.67%-89.13% (Keskin and Baydar, 2016). In addition, the other major component identified in the other studies was fenchone (Shahat et al., 2011). The amounts of fenchone in the literature were 6.22%

(Şanlı et al., 2012), 0%- 8.2%(Bowes and Zheljaskov, 2005), 9.8-22.7% (Zheljaskov et al., 2013), 4.26%- 11.12% (Rebey et al.,2016), 8.32% (Negahban et al., 2015), 1.6% - 22.8% (Raal et al., 2012). In some studies the major component of fennel essential oil was trans-anethole, while in others it had been identified as fenchone. This was because trans-anethole and fenchone were two main components in the fennel essential oil. The reason for the difference in these components was kemataxonomic and chemotypic as well as regional, ie ecological differences. The amount of trans anethole obtained in our study was compatible with the result in other studies.

The essential oil components of the aniseed fruit were given in Table 6. The number of the totally determined components was 16 and the total amount was 99.866 %. The main essential oil components of anise fruit were (Z)-anethole (92.478%), Estragole

Table 6. Chemical composition of *Pimpinella anisum* fruit essential oil  
 Çizelge 6. *Pimpinella anisum* meyvesinin uçucu yağ kimyasal kompozisyonu (%)

No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amount (%) (Miktar)	No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amount (%) (Miktar)
1	1201	Limonene	0.347	10	2019	Para-anisaldehyde	0.820
2	1299	Fenchone	0.110	11	2119	1-(4-methoxy phenyl)-2-propanone	0.031
3	1683	Estragole	3.360	12	2216	Carvacrol	0.030
4	1700	α-himachalene	0.070	13	2228	1-(4-methoxy phenyl)-1-propanone	0.028
5	1749	γ-himachalene	1.214	14	2381	Dil apiole	0.014
6	1760	α-zingiberene	0.170	15	2646	3,4-Dimethoxystyrene	0.626
7	1767	(E-) Anethole	0.396	16	2897	3-hydroxycarbofuran	0.093
8	1811	Curcumene	0.079	<b>TOTAL</b>			<b>99.866</b>
9	1865	(Z-) Anethole	92.478				

(3.360%), himachalene (1.214%), L-fenchone (1.427%), para-Anisealdehyde (0.820%) and (E-) Anethole (0.396%). In addition to these components, limonene (0.347 %), fenchone (0.110 %), α-zingiberene (0.170 %) were determined. Main components (Z-)anethole, estragole, γ-himachalene, L-fenchone, para-Anisealdehyde and (E-) Anethole constituted 99.695% of the amount of all the components. Şanlı et al. (2012) found that the main component of the essential oil of aniseed was trans anethole (85.27%). The main component was determined as trans anethole (avg. 95.69%) in 2016 (Keskin and Baydar, 2016). In other studies, the amounts of trans anethole were investigated to be 52.94% (Haşimi et al., 2014), 93.9% (Shojaii and Fard, 2012), 93.6%-96.2% (Zheljazkov et al., 2013b), 92.4% (Saibi et al., 2013) and 90.35% (Omidbaigi et

al., 2003). The amount of trans anethole detected in our study was 92.478%. In our study, trans anethole was determined as the main component and the results were consistent with other studies.

The essential oil components of the cumin fruit were given in Table 7. The main components of cumin fruit essential oil were identified as Cuminaldehyde (42.900%), orth-terpinen-7-al (22.649%), α-terpinen-7-al (9.661%), ortho-cymene (8.283%), γ-terpinene (5.305% and β-pinene (3.430%). In total, 37 compounds were identified 99.903 % of the total essential oil constituents. Limonene (0.268 %), trans-1-decalone (1.334 %), 4-methyl-1-cyclohexane (0.438 %) were found as other constituents in the oil. Main components (Cuminaldehyde, γ-terpinen-7-al, α-terpinen-7-al, ortho-cymene, γ-terpinene and β-pinene) constitute 92.228% of the amount of all the

Table 7. Chemical composition of *Cuminum cyminum* fruit essential oil (%)  
 Çizelge 7. *Cuminum cyminum* meyvesinin uçucu yağ kimyasal kompozisyonu (%)

No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amount (%) (Miktar)	No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amount (%) (Miktar)
1	1066	β-pinene	3.430	20	1557	β-bisabolene	0.073
2	1078	Sabinene	0.149	21	1577	2-(2-hydroxy cyclohexyl)-furan	0.320
3	1097	Myrcene	0.279	22	1644	(Z-) Anethole	0.351
4	1109	α-phellandrene	0.143	23	1656	Cuminaldehyde (Cuminal)	42.900
5	1128	Limonene	0.268	24	1667	γ-Terpinen-7-al	22.649
6	1153	β-phellandrene	0.125	25	1713	α-Terpinen-7-al	9.661
7	1168	γ-terpinene	5.305	26	1716	2,4(10)-thujadien	0.064
8	1204	Orthocymene	8.283	27	1719	4'-methoxy-4-flavanol	0.054
9	1283	Cis-sabinenehydrate	0.035	28	1741	4-isopropylphenylacetic acid	0.154
10	1297	α-terpinolene	0.103	29	1784	1,4-p-Menthadien-7-ol	0.167
11	1433	Cis-para-Menth-2-en-1-ol	0.144	30	1831	Cuminalcohol (cymen-7-ol)	0.609
12	1451	4-t-pentylcyclohexene	0.132	31	1848	Caratol	0.869
13	1473	Terpinen-4-ol	0.249	32	1872	Veridiflorol	0.184
14	1497	Trans-1-decalone	1.334	33	1908	Caryophyllene oxide	0.215
15	1512	4-methyl-1-cyclohexane	0.438	34	1932	2-Acetylcyclopentanone	0.229
16	1514	β-farnesene	0.073	35	1979	4-hydrazinobenzonitrile	0.053
17	1534	α-terpineol (p-menth-1-en-8-ol)	0.089	36	2008	1-Bromo-5-hexanone	0.086
18	1546	β-acoradiene	0.187	37	2103	4-hydroxy-cryptone	0.437
19	1553	Trans-piperitol	0.062	<b>TOTAL</b>			<b>99.903</b>

components. The essential oil of the cumin fruit was determined as 2.5% - 4%, its main component was determined as cuminaldehyde and it was reported that limonene, eugenol,  $\alpha$ -pinene and  $\beta$ -pinene were determined (Gohari and Saeidna, 2011). When essential oil components are examined in the study in the conditions of Burdur, 2-carene-10-al (% 50.02) was determined as the main component and cuminal was determined as 22.25% (Şanlı et al., 2012). In another study conducted in India in 2018, the main component was determined as cuminaldehyde at the rate of 74.62% and  $\beta$ -pinene, p-cymene,  $\alpha$ -terpinen-7-al were also determined (Gotmare and Tambe, 2018). Rana (2014) described cuminaldehyde (49.4%) as the main component in the essential oil of the cumin fruit and determined p-cymene (17.4%),  $\beta$ -pinene (6.3%),  $\alpha$ -terpinen-7-al (6.8%),  $\gamma$ -terpinene (6.1%). According to another study conducted in Isparta,  $\alpha$ -thujenal (average 35.69%) was determined as the main component (Keskin and Baydar, 2016). Kan et al. (2007) examined the effect of harvest time on essential oil and found cuminaldehyde (19.9%- 20.4%) the main component. Studies suggested that the results we have obtained was consistent with the literatures.

Components of coriander fruit essential oil are given in Table 8. Linalool (87.238 %), Geraniol (4.076 %), geranyl acetate (3.542 %), camphor (2.160 %), (2E) Dodecenal (1.347 %) were identified as main constituents in the essential oil. In total, 28 compounds were identified 99.994 % of the total essential oil constituents. Limonene (0.027 %), (2E) Decanal (0.120 %),  $\alpha$ -terpineol (0.240 %) and cis-linalool oxide (0.092 %) were determined as other essential oil components of coriander. Main components (Linalool, geraniol, geranyl acetate, camphor, (2E) Dodecenal) were constituted 98.363% of the amount of all the components. The main component of the essential oil of the coriander fruit is linalool as stated in the studies. According to other studies, the amounts of linalool were 37.7% (Bhuiyan et al., 2009), 95.56% (Şanlı et al., 2012), 59.14% (Niamah and Alali, 2016), 69.60% (Anwar et al., 2011), 58.0-80.3% (Orav et al., 2010), 81.85%- 88.94% (Keskin and Baydar, 2016).

### Crude Oil Components of the Fruits

Fatty acid methyl esters of the fruit of dill, fennel, aniseed, cumin and coriander were determined in the GC-MS. Wiley, Nist-Spectral and Famed 23 libraries were used to determine the components in the GC-MS. Fatty acid components of dill, fennel, aniseed, cumin and coriander were given in Table 9.

The main fatty acid component of dill, fennel, aniseed, cumin and coriander was oleic acid (6Z-octadecanoic acid- petroselinic acid- C18:1). The highest amount of

oleic acid was determined in the dill fruit (%88.296), while the lowest amount of oleic acid was determined in the cumin fruit (66.593%). The amount of oleic acid in fennel, coriander and aniseed was 84.356%, 79.651% and 70.818% respectively. The other major fatty acid component was identified as linoleic acid (C18:2). The highest amount of linoleic acid was 26.464% in the cumin fruit and the lowest was 6.625% in the dill fruit. As seen, the amounts of oleic acid and linoleic acid were inversely proportional. Other determined unsaturated fatty acids are palmitoleic acid (C16:1), linolenic acid (C18:3) and gadoleic (9-eicosenic acid- C20:1) acid. Palmitic acid (C16:0) and arachidic acid (C20:0) were determined as saturated fatty acids. The highest amount of palmitic acid was determined in coriander (5.057%) and the lowest amount was determined in cumin (4.338%). Arachidic acid was found only in coriander (0.954%) and cumin (2.017%).

Table 8. Chemical composition of *Coriandrum sativum* fruit essential oil  
 Çizelge 8. *Coriandrum sativum* meyvesinin uçucu yağ kimyasal kompozisyonu (%)

No (Sıra No)	RI (Retensiyon İndisi)	Compound (Bileşen)	Amount (%) (Miktar)
1	1197	Limonene	0.027
2	1240	$\gamma$ -terpinene	0.180
3	1263	Ortho-cymene	0.035
4	1439	Cis-linalool oxide	0.092
5	1460	Cis-sabinenehydrate	0.050
6	1467	Trans-linalool oxide	0.074
7	1498	Decanal	0.094
8	1521	Camphor	2.160
9	1543	Linalool	87.238
10	1594	Terpinen-4-ol	0.047
11	1606	Caryophyllene	0.043
12	1649	(2E-) Decanal	0.120
13	1689	$\beta$ -citral	0.029
14	1695	Myrtenylacetate	0.042
15	1701	$\alpha$ -terpineol	0.240
16	1726	Nerylpropanoate	0.037
17	1738	Geraniol	0.062
18	1747	Bicyclogermacrene	0.058
19	1757	Geranylacetate	3.542
20	1768	Decylalcohol	0.043
21	1773	$\beta$ -citronellol	0.053
22	1805	1,3,6-octatriene	0.070
23	1817	(2E-) dodecen-1-ol	0.060
24	1849	Geraniol	4.076
25	1860	(2E) Dodecenal	1.347
26	2003	E-2-tetradecen-1-ol	0.072
27	2009	Nerolidol	0.034
28	2049	(2E-) tridecen-1-al	0.069
		<b>TOTAL</b>	<b>99.994</b>

Table 9. Fatty Acid Components of Dill, Fennel, Anise, Cumin, Coriander, Fruit Crude Oil (%)  
*Cizelge 9. Dereotu, Rezene, Anason, Kimyon ve Kişniş meyvelerine ait Yağ Asidi Bileşenleri (%)*

Fatty Acids (Yağ Asitleri)	R.T. (Retensiyon Zamanı)	R.I. (Retensiyon İndisi)	<i>Anethum graveolens</i>	<i>Foeniculum vulgare</i>	<i>Pimpinella anisum</i>	<i>Cuminum cyminum</i>	<i>Coriandrum sativum</i>
C16:0 (Palmitic Acid)	25.473	1285	4.392	5.048	4.980	4.338	5.057
C16:1(Palmitoleic Acid)	26.401	1296	0.435	0.283	0.503	0.371	0.472
C18:1 (Oleic Acid)	33.07	1591	88.296	84.356	70.818	66.593	79.651
C18:2 (Linoleic Acid)	34.788	1649	6.625	10.014	23.343	26.464	12.587
C18:3 (Linolenic Acid)	37.426	1742	0.252	0.299	0.356	0.216	0.262
C20:0(Eicosenoic Acid)	40.257	1846	-	-	-	2.017	0.954
C20:1 (Arashidic Acid)	41.372	1887	-	-	-	-	1.017

The crude oils of some species belonging to the Umbelliferae family such as parsley, fennel, dill, aniseed, cumin, coriander, are very rich (55-90%) in petroselinic acid (C18:1, cis 6), which is not found in the oil of other plants, and can be used both as food and industrial oil. In a study conducted in the conditions of Isparta, the main fatty acid component of aniseed, dill, fennel, cumin and coriander was determined as petroselinic acid (55.44%-87.28%) (Keskin and Baydar, 2016). In our study, the main fatty acid component was also determined as petroselinic acid.

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