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CORIANDER (*Coriandrum Sativum* L.) ESSENTIAL OIL CHANGES LEVELS DURING THE SPRING SEASON

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DOI: <https://doi.org/10.51193/IJAER.2023.9509>

Received: 09 Oct. 2023 / Accepted: 24 Oct. 2023 / Published: 30 Oct. 2023

ABSTRACT

Essential oils have been used for thousands of years for medicinal, health, and food purposes. Coriander (*Coriandrum sativum* L.), which belongs to the Mediterranean countries, is an herbaceous plant and a rich source of vitamins and minerals. There was a concentration on coriander's medical and nutritional aspects. Corianders were harvested for three consecutive months. Each time, they were transferred to the laboratory. Their essential oils were measured using a GC-MS (Hewlett Packard - US). Essential oils were identified by calculating specific indices and at programmed temperature conditions for (C6 - C26) oils of an HP-5 column under identical operating conditions. Essential oils evaluation was done in three replicates at each harvesting time, and the difference in the essential oil content showed the effect of harvesting stages on them. A total of 45 essential oils were measured in three harvesting stages. Linalool (3.46, 7.05, and -6.27% from the first to the third harvest, respectively) was identified as the main component in coriander oil. In the first harvest, the mass under study contained more than 20% Germacrene, which was reduced to below 2% in subsequent harvests. Also, Decanal, Cyclodecane, 2-docecen-1-ol, Tetradecanal, Neophetadiene, Oleic acid, and phytol had a significant percentage in all three harvests. Coriander samples had significantly higher amounts of essential oils as green leafy vegetables. On the other hand, scientists can achieve medical extract of coriander. It is concluded that coriander is a valuable sample to use in both the medical and food industries.

Keywords: Coriander (*Coriandrum sativum* L.), Essential oils, GC-MS, Chemical Analysis, Food Chemistry, Plant Science

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an annual aromatic herbaceous plant from the Umbelliferae family. It comes from the Mediterranean countries and is frequently applied as a flavoring agent in food products, perfumes, and cosmetics (Durata *et al.*, 2012). Coriander, this valuable plant product, has been widely used in many fields, including medicine. In historical sources, it is said that this plant has been used as a flavoring and for preserving food since long ago (Al-Khayri *et al.*, 2023). As a medicinal plant, possesses a lot of pharmacological activities, such as treating gastrointestinal problems, vomiting, jaundice, cough, diarrhea, rheumatism, and joint pains, as well as hypoglycemic action and influence on carbohydrate metabolism, hypolipidemic, anti-inflammatory, and antispasmodic activities (Asgarpanah & Kazemivash, 2012; Bhat *et al.*, 2014; Emamghoreishi *et al.*, 2005; Diederichsen, 1996; Laribi *et al.*, 2015; Parthasarathy, 2008). In addition, certain parts of this plant, such as the leaves, flowers, seeds, and fruits, contain many biologically active compounds and are a good source of valuable essential oil (Bhuiyan *et al.*, 2009). Essential oil is a hydrophobic liquid derivative of secondary metabolism in plants that contains volatile compounds that have long been widely used in medicine (Mandal *et al.*, 2015). Coriander essential oil is one of the well-known essential oils obtained from the oil of coriander leaves and seeds, and it has various biological activities. This essential oil is widely used in various cases, from food preservative to medicinal, and it has many medicinal properties, including allelopathic properties (Al-Khayri *et al.*, 2023). Coriander essential oils are frequently used for its therapeutic properties, including antibacterial, antifungal, antioxidant, anti-inflammatory, and antimicrobial (Begnami *et al.*, 2010). According to the International Organization of Standards (ISO) standard for the content of coriander, essential oils is as follows: α -pinene (3.0%-7.0%), myrcene (0.5%-1.5%), limonene (2.0%- 5.0%), γ -terpinene (2.0%-7.0%), linalool (65.0%-78.0%), camphor (4.0%-6.0%), α -terpineol (0.5%-1.5%), geraniol (0.5%-3.0%), and geranyl acetate (1.0%-3.5%) (ISO, 1997). Linalool is the principal constituent (up to 70%, some essential oil samples even more), (Msaada *et al.*, 2007). However, variation in oil content and compositions or even evolution of different chemical variants or chemotypes can occur due to differing soil conditions, altitude, climatic conditions, seasonal factors, and other environmental features (Heywood, 2002).

Several phyto chemical studies have been implemented on the essential oil composition of leaves and seeds of coriander from different parts of the world (Diederichsen, 1996). Although Iran is one of the coriander producers in the world, and it has been cultivated in other parts of Iran for a long time, to the best of our knowledge, there is no report in the literature about the variation in essential oils content and compositions of aerial parts of coriander (*Coriandrum sativum* L.) during the spring season in Iran. Therefore, this study aimed to investigate the changes in

essential oils and other compounds obtained from the aerial parts of coriander during the spring season (from early May to late July).

MATERIALS AND METHODS

Coriander Seed Collection and Cultivation: Coriander seeds (*Coriandrum sativum L.*) were collected from the Ministry of Agriculture (Department of legume, vegetable, and seed production), Tehran. The seeds of coriander were sown in pots (15 *30) during the first week of March. Prior to planting, the clay-sand soil of experimental pots with pH 6.7, was passed through a sieve with mesh width of 2 mm. To avoid any water stress and ensure optimum growth plants thus regularly irrigated (two times a week during the early stage of growth increasing to up to three times a week during the stages prior to harvest), however, no fertilizer was used. In order to extract the essential oil of the cultivated plants, the aerial parts were plucked three times during the early May to late July. Afterward, the collected samples were dried (24 hours) and grinded at ambient temperature and sent to a qualified *laboratory* for further experiments. (the 9 treatments in total were experiments, tree treatments for each month)

Extraction of Essential Oil: The essential oil from the dried-grounded coriander leaves was extracted through hydro-distillation in three replications using a Clevenger apparatus. 40 g dried-grounded coriander leaves were subjected to a stainless-steel distillatory hydro-distillation and the extraction of essential oils was obtained during 4 h. To find the most suitable temperature programming of the column and the best separation, the collected distillate was extracted three times with 50 mL of HPLC grade n-hexane (Merck, Germany). In order to remove any traces of water, the obtained essential oils were dried over a small amount of anhydrous Na₂SO₄ (Merck, Germany), and filtered through Whatman filter paper. Subsequently, the extracts were stored in sealed vials at 4°C until used for GC-MS analysis.

GC-MS analyses: GC-MS analysis was carried out on a Hewlett Packard 7890A GC coupled with Hewlett Packard 5975C mass spectrometer (MS) equipped with an HP-5 capillary column (30 m × 0.25 mm i.d., film thickness 0.25 μm). (Agilent Technologies, United States). The carrier gas was helium with a constant flow rate of 0.9 mL/min. The GC oven temperature was held at 50 °C for 2 min and then the temperature program raised from 50 °C to 260 °C at a rate of 5 °C/m⁻¹, and kept at 260 °C for 10 min. The mass spectra conditions recorded at 70 eV with a scan range of 40–500 m/z, transfer line temperature 230 °C; ion source 150 °C. All essential oils compounds were recognized by calculation of their retention indices under temperature-programmed conditions for (C6 – C26) n-alkanes (Kovats indices) and the oils on an HP-5 column under the same conditions.

Qualitative and quantitative analysis of the coriander essential oil: All essential oils constitutes were recognized by calculation of their retention indices under temperature-programmed

conditions for (C6 – C26) n-alkanes (Kovats index) and the oils on an HP-5 column under the same operating conditions. Identification of individual compounds was performed by comparing their mass spectra and retention indices with those of standards available in our laboratories and confirmed with those present in NIST 98 and Wiley 7 libraries or those published in the literature (Adams, 2001; Bhuiyan, Begum, & Sultana, 2009; Marques *et al.*, 2002). Relative percentages of essential oils compositions were calculated based on GC peak areas without using correction factors.

Statistical Analysis: All experiments and measurements were carried out in triplicate; the data were statistically analyzed using the SPSS version 24 on replicated test data and a p -value ≤ 0.05 was significantly considered.

RESULTS AND DISCUSSION

The essential oil of *C. sativum*, obtained by hydro-distillation, was analyzed by gas chromatography-mass spectrometry (GC-MS). The results of GC-MS analysis of the coriander essential oils in several harvesting stages are shown in fig 1. The differences in the content of the coriander essential oils indicated the impact of the harvesting stages on them (Argyropoulou, Daferera, Tarantilis, Fasseas, & Polissiou, 2007; Juteau, Masotti, Bessière, & Viano, 2002; Mandal & Mandal, 2015). The data in Table 1 clearly demonstrate that the major components of the essential oil extracted from the aerial parts of the plant in several harvesting stages (during the early May to late July) were different. A total of 45 of essential oils were determined in the three harvesting stages, although 24 compounds were identified in the first harvesting. Predominant compounds on the first harvesting stage were Germacrene (29.89%) and Neophetadiene (19.84%) respectively. In addition, the following compounds were also detected in higher amounts: Olyel amide (8.45%), Caffeine (6.94%), Alloaromadendren (3.68%), Alpha phellandrene (3.51%), Linalool (3.46%), and Phytol (3.07%), Hexadecanoic acid, Tridecanal (2.87%), Methyl ester (2.86%), Tetradecanal (2.76%), Tetradecan (2.42%), 9-octadecenamamide (2.42%), Hexadecane (2.24%), Thymol (2.05%), γ -elemene (1.63%), 2-pentaecanone (1.43%), Beta phellandrene (1.39%), Octadecane (1.27%), Diethyl phthalate (1.24%), Caryophyllene (1.19%), Eicosan (1.03%), Elemene (0.76%) and Para cymene (0.76%) accounting 98.16% of total constituents. GC-MS analysis of regrowing shoots of coriander which were harvested on the second time led to the identification of 19 compounds which were notably varied from the first harvesting (Table 1). As shown in table 1, among the recognized compounds, Phytol (16.17%) and Tetradecanal (15.04%) were found in the highest concentrations. In addition, Caryophyllene (7.31%), Linalool (7.05%), Nanodecane (4.38%), Neophetadiene (4.18%), Chlorpyrifos (4%), Caffeine (2.44%), Oleic acid (2.34%), 9-octadecenamamide (2.32%), Elemene (2.04%), 1-dodecanal (1.72%), Diethyl phthalate (1.41%), Phenol, 2,4-bis (1,1-dimethylethyl) (1.33%), 2-pentaecanone (1.24%), 9-octadecen-1-ol (1.14%), Germacrene (1.05%) and Hexadecanal

(1.01%) were identified in higher amounts. The determined compounds represented 94.21% of all the compounds in the coriander essential oil. The essential oil constituents obtained from regrowing shoots of coriander which were harvested on the third harvesting, are summarized in Table 1. Seventeen compounds were identified on the third harvesting stage which comprising 76.01% of its total oil composition. Among the identified compounds, 2-docecen-1-ol (11.82%) and Tetradecanal (11.01%) were the major components in the essential oil, while, the concentration of linalool was 6.27%.

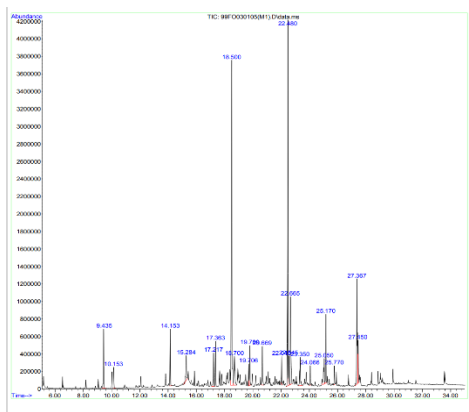
Differences in the content of the essential oils under diverse conditions like phenological stages, different storage conditions, hydro-distillation conditions, different plant growth stages and different landraces have been reported for the coriander (Huzar *et al.*, 2018; Ramezani *et al.*, 2009; Wahba *et al.*, 2020; Nejad Ebrahimi *et al.*, 2010). Therefore, variety of geographical and ecological factors can lead to qualitative and quantitative differences in the essential oil produced. In this regard, our results indicated that various seasonal conditions have much effect on content of coriander essential oils. Germacrene and neophetadiene as the highest coriander essential oils were obtained at the first harvesting stage. Meanwhile, the amount of mentioned essential oils significantly reduced to less than 1.7% in the later harvesting stages (second and third harvest). In comparison to the second and third harvest date, the percentage of linalool, oleic acid, phytol, tetradecanal, 2-docecen-1-ol, decanal as well as nanodecane were notably increased; however, their relative abundances were different in different harvesting stages. Among the above-mentioned compounds, linalool, oleic acid, and phytol should be highlighted, as they are biologically active substances widely applied in the pharmaceutical industry (table 1); their contents were different in the oil of the areal parts from the first, second and third harvest. The results found in our study corroborate those obtained by Renata Nurzyńska-Wierdak (2013) (Nurzynska-Wierdak, 2013). The changes in the amount of these compounds may be related to the fact of coriander, after the first harvest which is done in the flowering stage, tending to form fruits and seeds. Therefore, the plant collected from the regrowth shoots is not typical for the vegetative stage, which is verified by the increased concentration of linalool - a compound mostly representative of the oil distilled from the fruit and depends on the harvesting stage (Beatovic *et al.*, 2015; M. Bhuiyan *et al.*, 2009; Telci *et al.*, 2006). It seems that the seasonal conditions in which the plant is planted and harvested may significantly affect the quantity and quality of the coriander compounds. However, some of the index compounds like linalool was reported below than the standard and differ from many conducted studies (Huzar *et al.*, 2018; Nejad Ebrahimi *et al.*, 2010; Ramezani *et al.*, 2009; Wahba *et al.*, 2020). Therefore, more research is needed to conduct in the consecutive months of summer, autumn and winter comparing and check more closely to confirm or reject the present finding.

CONCLUSION

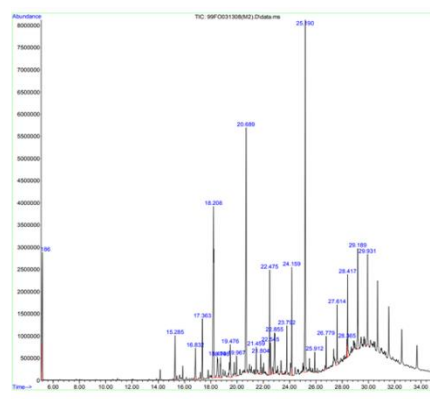
Essential oils have been a safe treatment method for thousands of years. These essential oils have different medicinal properties that can be attributed to the bioactive compounds in essential oils. The importance of using cilantro essential oils as a valuable medicinal-food substance is discussed in this study. Also, the changes in the composition of essential oils of the coriander plant were investigated for three consecutive months from the spring season.

In conclusion, the study at three different harvesting stages effects on essential oil compositions of *Coriandrum sativum* which was extracted from aerial parts. Based on the GC-MS analysis, the major compounds of essential oils during the first harvest were germacrene, neophetadiene while their concentrations were notably decreased in the second and third harvests. However, concentrations of phytol, tetradecanal, linalool, 2-docecen-1-ol, Tetradecanal Decanal as well as oleic acid were predominated in the second and third harvest. Among the mentioned compounds, linalool, phytol, and oleic acid, are components with a significant biological value which their contents were different in the oil of the herb from different harvesting stages.

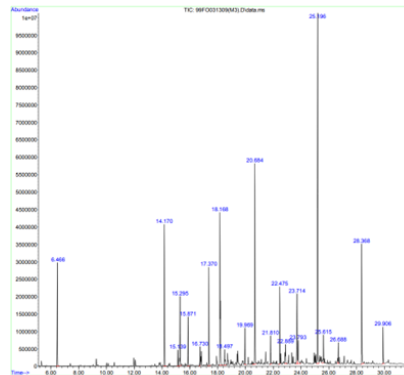
Focusing on the essential oil compounds of coriander in other seasons and comparing these compounds in other seasons is recommended. On the other hand, analyzing the changes in levels of the essential oils of other plants is highly advised. Examining the factors influencing the change in levels of essential oils in coriander and other plants are suggested.



a



b



c

Figure 1: The GC-MS total chromatograms of coriander essential oils in. (a. chromatogram of the coriander in the first harvest, b. chromatogram of the coriander in the second harvest, c. chromatogram of the coriander in the third harvest.

Table 1: Essential Oil constituents of coriander (*Coriandrum sativum L.*) (a. Coriander in the first harvest b. Coriander in the second harvest c. Coriander in the third harvest)

Row	Name	KI	Area%		
			a	b	c
1	Alpha phellandrene	1008	3.51	--	--
2	Para cymene	1026	0.76	--	--
3	Beta phellandrene	1040	1.39	--	--
4	Linalool	1098	3.46	7.05	6.27
5	Decanal	1199	--	--	7.48
6	Thymol	1272	2.05	1.05	0.77
7	Cyclodecane	1274	--	--	3.83
8	Tridecanal	1311	--	--	2.26
9	Elemene	1337	0.76	2.04	
10	1-dodecanal	1376		1.72	
11	Tetradecan	1401	2.42		
12	Tridecanal	1414	2.87		4.79
13	Caryophyllene	1418	1.19	7.31	0.94
14	γ -elemene	1437	1.63	--	
15	2-docecen-1-ol	1479	--	--	11.82
16	Germacrene	1506	20.89	1.05	1.14
17	Alloaromadendren	1521	3.68	--	--
18	Phenol, 2,4-bis(1,1-dimethylethyl)	1524	--	1.33	--
19	Diethyl phthalate	1595	1.24	1.41	--
20	Hexadecane	1601	2.24	--	--
21	Hexadecanal	1626	--	1.01	1.72

22	Tetradecanal	1711	2.76	15.04	11.01
23	9-octadecen-1-ol	1788	--	1.14	--
24	Octadecane	1805	1.27	--	--
25	Neophetadiene	1848	19.84	4.18	1.61
26	2-pentaecanone	1854	1.43	1.24	--
27	Caffeine	1866	6.94	2.44	3.49
28	Hexadecanoic acid, Methyl ester	1934	2.86	--	--
29	Hexadecanoic acid	1968	--	--	1.99
30	Oleic acid	1978	--	2.34	5.52
31	Eicosan	2006	1.03	--	--
32	Chlorpyrifos	2016	--	4	--
33	8- octadecenoic acid, Methyl ester	2111	--	--	--
34	Phytol	2127	3.07	16.17	1.76
35	ni	2208	--	0.66	--
36	1-octadecane	2297	--	--	2.01
37	ni	2306	--	1.3	--
38	Olyel amide	2360	8.45	--	--
39	9-octadecenamide	2367	2.42	2.32	--
40	ni	2382	--	2.56	--
41	ni	2469	--	--	1.06
42	ni	2476	--	3.28	--
43	Nanodecane	2544	--	4.38	--
44	ni	2597	--	--	6.54
45	ni	2599	--	3.54	--

*ni= not identified

Authors' contributions

Mirmohammadmakki F. contributed and design of research, final revised the manuscript, performed experiments and prepared tools and facilities for field study; Hosseini E. drafted and final revised the manuscript, final revised the manuscript and references.

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