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Changes in Essential Oil Content of Coriander (*Coriandrum sativum* L.) Aerial Parts during Four Phonological Stages in Iran

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Abstract: The quantitative variation of the essential oil from the aerial parts of cultivated *Coriandrum sativum* L. were examined during 2008 year in Iran. Plant materials were harvested at different phonological stages (i.e. vegetative, full flowering, green fruits, and brown fruits) of the life cycle of this species. Essential oils were obtained from the aerial parts of the plant by using an all glass Clevenger-type apparatus, for 3 h. The results of this experiment indicated that essential oil yields shown marked increase during maturation process. Essential oils at the green fruits stage of maturity (immature fruits) was more than other stages so that yields of oil (w/w %) at different stages were in the order of vegetative (0.14 %), full flowering (0.23 %), green fruits (0.37 %) and brown fruits (0.31 %).

Key words: *Coriandrum sativum* L., essential oil content, phonological stages.

Introduction: Coriander (*Coriandrum sativum* L.) is a culinary and medicinal plant from the *Umbelliferae* family. This plant is of economic importance since it has been used as flavoring agent in food products, perfumes and cosmetics. As a medicinal plant, *C. sativum* L. has been credited with a long list of medicinal uses. Powdered seeds or dry extract, tea, tincture, decoction or infusion have been recommended for dyspeptic complaints, loss of appetite, convulsion, insomnia and anxiety [9]. Moreover, the essential oils and various extracts from coriander have been shown to possess antibacterial, antioxidant, antidiabetic, anticancerous and antimutagenic activities [20], such as geranyl acetate, linalool, dihydro-carvone, anethole, camphor, α-pinene, phellandrene, linalyl acetate, limonene, para-cymene, Decanal the main components, content of the essential oils are considered as a quality criterion [12, 29].

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Many phytochemical studies so far investigated the chemical composition of the essential oil from *C. sativum* L. seeds from different origins [1, 4, 25], that's shown in fig. 1. Evaluations of the oil composition extracted from leaves have also been reported [10, 12, 29]. Chemical essential oil composition of Italian coriander fruits was greatly influenced by the age and origins as mentioned by Carruba and la Tore [6].

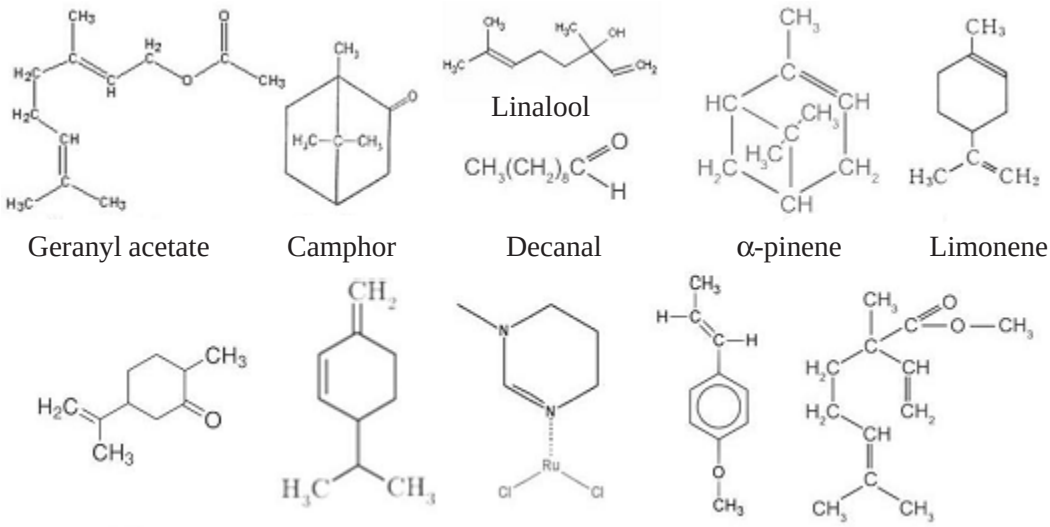

Fig. 1. Structures of the major compounds identified in the essential oil of coriander (*Coriandrum sativum* L.) in previous investigations

Additionally, variations of the essential oil composition in many different fruits have been observed, depending on genetic and environmental factors as well as ontogeny and analytical methods [10, 14]. The effect of maturity stage on the essential oil composition was also reported in many essential oil bearing plants [16, 22, 26, 27, 28]. A little research was conduced on phenological stages effects on oil content of coriander. Highest essential oil content of coriander at previous research was obtained 0.35 % at brown fruit [16].

Although the substantial data of its chemical composition and essential oil content, there are no previous phytochemical reports that have been recorded for *C. sativum* L. from Iran. In the present work, we investigated for the first time the essential oil content isolated from the Iranian coriander at different stages of plant growth.

Materials and methods

Site information: The experiment was carried out in 2008 at the Experimental Farm of Agricultural Faculty, Shiraz University in Shiraz, located in the Badjgah, Fars province, Iran (Table 1). The soil of experimental plots was a clay silt loam with pH of 7.6. The daily climatic data during this study were obtained from the agro-meteorological station of irrigation department located in a state farm about 1 km far from the experimental site. The mean values for maximum and minimum temperature (°C) for the months of April, May, June and July 2008 were 24.61 and 4.72, 29.68 and 8.7, 35.11 and 12, 35.65 and 15.2,

respectively. The average relative humidity and total rainfall of the months of April, May, June and July 2008 were 39.93 % and 3.5 mm; 19.2 % and 0 mm; 28.76 % and 0 mm and 29.74 % and 0 mm, respectively.

Table 1. Geographical situation and weather condition of the field under coriander

Characteristics	Results
Latitude	29° 36´ N
Altitude	52° 32´ E
Sea level	1810 m
Min. Temperature*. In recent 10-year period	-9°C
Max. Temperature In recent 10-year period	38°C
Rain fall in recent 10-year period	400 mm Semi arid moderate
Climate class*	

Plant material: Seeds of the Iranian natural population of coriander were provided by the horticultural department of Shiraz University and then were sown in April 2008 by hand in rows of 55 cm apart and spaced 35 cm distances between every plant in the row. Furrow Irrigation was applied two times a week during the early stage of growth increasing to up to three times a week during the stages prior to harvest so that was not any water stress. Fertilizer was not applied before sowing and during growth of plant up to harvest so that coriander plants were grown as organic culture. Coriander shoots were collected from cultivated plants at different stages of development during June and July 2008. For collection at the initial stage of maturity (vegetative stage), only shoots with leaves were harvested. For the second stage, the parts of plants above ground in full flowering were harvested. Aerial parts at full green fruits (immature) were harvested as third stage of growth. For the final stage, aerial parts of plants at brown fruits stage (mature) were picked up (Fig. 2).

Fig. 2. The growth phonological stages of coriander were used in this experiment, A: vegetative, B: full flowering, C: green fruit (immature) and D: brown fruit (mature)

The aerial parts were harvested on numerous representative plants, early in the evening, and the material was taken immediately to the laboratory to be shade-dried at room temperature (25°C), with ventilation. Under this condition in experiment, 3-5 days typically was required to complete the drying process.

Isolation of the essential oil: One hundred grams of dried aerial parts (stems, leaves flower and fruits), wooden parts were separated and hydro-distilled for 3 h, using an all glass Clevenger-type apparatus [2]. The oil volume was measured directly in the extraction burette. Yield percentage was measured as volume (ml) of essential oil per 100 g of plant dry matter. The distilled essential oils were dried over anhydrous sodium sulphate, filtered, weighed and stored in sealed vials at 4°C.

Statistical analysis: The experiments were arranged as a completely randomized design (CRD) with three replications of each treatment. The significance of differences ($P < 0.01$) between treatments was determined by LSD tests. The means were compared by using the one-way analysis of variance (ANOVA) followed by LSD tests. All the statistical analysis was performed using SPSS/PC software version 13.

Results and discussion: Differences in the content of the essential oils under the influence of the phonological stages have been reported for several plants [3, 6, 13, 16, 17, 22, 26, 27, 28] such as coriander, Lemon verbena, Styrax, wormwood, thyme. Also our results indicated that various phonological stages have much influence on content of coriander essential oils.

The hydro-distillation of *C. sativum* L. aerial parts gave essential oils at vegetative, full flowering, green fruit (immature) and brown fruit (mature) with a yield of 0.14 %, 0.23 %, 0.37 % and 0.31 % (w/w), based on dry weight, respectively. In this case, especially at all maturity stages, obtained yields were high when compared to other previously investigated [16].

In our study the maximum content of coriander essential oil from aerial parts was obtained in green fruit stage (3.75 ml/kg dry matter) so that was significant difference at 1 % level between all phonological stages (Fig. 3 and Table 2). The highest of essential oil of coriander in previous research was obtained at brown fruit stage. Yield of *C. sativum* oils varies notably, ranging from 0.01 % to 0.35 % in previous studies [15, 16]. Thus, the high yields we obtained in this work greatly differed from those found in the preceding works.

Table 2. Analysis of variance (ANOVA) of coriander essential oil content in different phenological stages

Source of Variation	DF	MS	P value
Phonological stages	3	.058	.000
Error	20	.000	
Total	23		

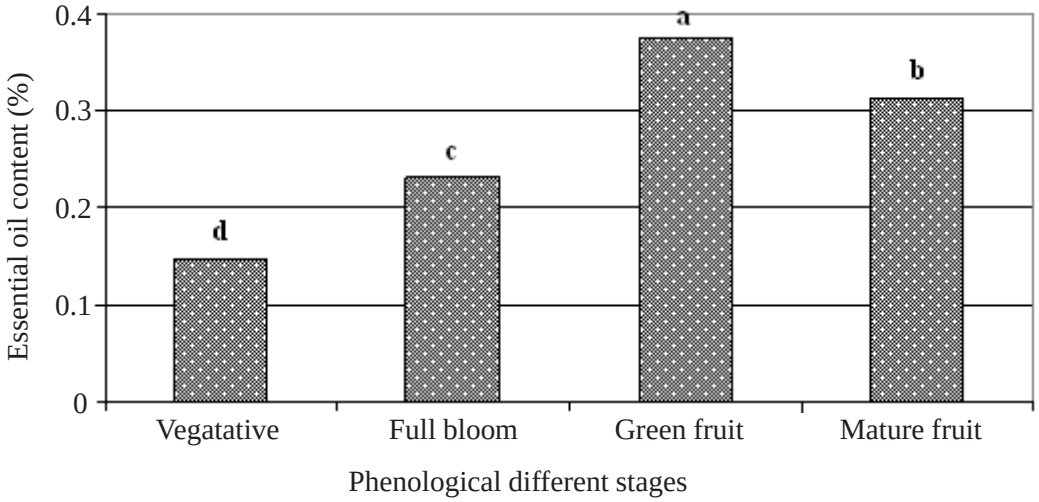

Fig. 3. Different phonological stages effects on essential oil content of coriander in south west of Iran in 2008 year. Means followed by the different letter are significantly difference, as indicated by LSD Test (P = 0.01)

It is known that genetic constitution and environmental conditions influence the yield and composition of volatile oil produced by medicinal plants. Volatile compounds in various plant species are different that this is resulted in variation yield of essential oils to environmental factors such as temperature and light, so that synthesis of these compound in various hours of diurnal will be vary [18, 19, 20].

The literature citations emphasize that a variety of geographical and ecological factors can lead to qualitative and quantitative differences in the essential oil produced. At the same time, a number of other factors can influence its content and composition, such as the developmental stage of the plant, its physiology, the age of leaves and the growing conditions [5, 8, 11, 24, 30]. It must be pointed out that the essential oil production is highly influenced by the physiology of the plant and therefore depends on its developmental stage [23].

The observed increase of the essential oils content may be linked in quantity, with the maturity stages. On the other hand, the deep changes in the coriander shoots essential oils content during stages of maturity can be used as a marker of the maturation process.

In conclusion, the study at four different growth stages effects on essential oil content of *Coriandrum sativum* aerial parts of Iran origin showed significant differences in the percentages of the essential oil content. We suggested that for obtain the high content of essential oil from coriander (*C. sativum* L.) in Iran and same region from the viewpoint of environmental condition, harvest in green fruit (immature) is best, so that maximum yield and income will obtain.

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