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Seed contents of *Coriandrum sativum* in Jordan Valley

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Abstract: The aim of this research was to determine seed contents of Coriander (*Coriandrum sativum*). Research was conducted in the Jordan Valley at 150 m below sea level and in northern Jordan at 200 m above. Analyses of fertilized seeds showed that they contain 14.9% protein while non fertilized seeds had a significantly lower content (4.7%). The seeds contain 7.4% oil, which can vary according to strain. The fatty acid composition varied significantly among the seeds from the selected locations. Petroselinic acid was significantly the most concentrated fatty acid (80.10%). This acid (C18:1) can be split to produce C6 (adipic acid) and C12:0 (lauric acid) molecules. Adipic acid is used for the manufacture of a wide range of polymers including high grade engineering plastics; at present it is derived from mineral oil by a process that damages the ozone layer and contributes to the releases of gasses such as N2, which affect global warming. Petroselinic acid is abundant in *C. sativum* and could be an alternative, more environmentally friendly raw material for use in industry.

1. Introduction

Coriander (*Coriandrum sativum*) is a culinary and medicinal plant of the Umbelliferae, and is an annual herb originally from the Mediterranean area; several authors have indicated *Coriandrum sativum* as a wild plant. Linnaeus (1780) reported that *C. sativum* also occurs as a weed in cereals. Alefeld (1866) mentioned that *C. sativum* was a common weed spread from southeastern Europe to southern Russia. Stoletova (1930) reported on wild *C. sativum* from Armenia. All parts of the plant have a strong odor, from which the plant takes its name. Cultivation of *C. sativum* is widespread, but it is planted on a small scale only; it is cultivated as a summer or winter crop. In Jordan, it is found in gardens rather than in large fields, while in Germany there are many landraces of *Coriandrum sativum* (Diederichsen, 1996).

Description of the plant

The plant can reach heights of 20 to 80 cm. The stem is more or less erect, branched sometimes with several side branches at the basal node. Each branch finishes with an inflorescence. The color of the more or less ribbed stem is green and sometimes turns to red or violet during the flowering period. The leaves alternate, and the first ones are often gathered in a rosette. The leaves are of two types: lower ones with leaflets and upper ones divided into narrow linear segments (Diederichsen, 1996). The *Coriandrum sativum* flower has five irregular-shaped petals, five stamens, five sepals, and two styles. Flowering starts with the primary umbel. The first umbels to bloom have hermaphrodite flowers, with possibly a few staminate ones (Diederichsen, 1996). The inner flowers of umbellets are staminate. The central flowers are circular, with small inflexed petals. The color of the petals is pale pink or sometimes white. The umbels of higher order usually contain more staminate flowers than the first ones, and their flowering period is shorter (Diederichsen, 1996).

In a single flower, the five filaments of the staminate are located between the five petals. After the flower opens, the white filaments are visible between the petals. Under optimum conditions, many different insect species are pollinators or visitors of *C. sativum* umbels (Diederichsen, 1996), and the species that pollinate the plants depend on the area of cultivation. Flowering and pollination biology of *C. sativum* is typical of that for umbelliferous plants, according to Bell (1971). Depending on the weather conditions, two to three days after opening of the first flower, the pollen sacs open and spread the pollen. McGregor (1976) showed that selfing of *C. sativum* is impossible but Glukhov (1955) showed that it is partially self-fertile. He suggested that geitongamy is common and cross is possible. Bees are beneficial to *C. sativum*: Glukhov (1955) reported that when they were excluded only 49.4% of the seeds set, but when they were present 68.3% of the seeds set. Bogoyavlenseii and Akimenko (1966) associated seed yields with greater insect visitation.

Use of Coriandrum sativum

This plant is of economic importance since it has been used as a flavoring agent in food products, perfumes and

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cosmetics. Moreover, the essential oils of the fruits and various extracts from *C. sativum* have been shown to possess antibacterial (Burt, 2004; Cantore *et al.,* 2004; Kubo *et al.*, 2004), anticancerous and antimtagenic (Chithra and Leelamma, 2000) properties and the plant has been used in medicine for thousands of years. In Jordan, the primary product is the fresh green herb of *C. sativum* used for its specific flavor, which is completely different from that of the ripe fruits. In other countries the fruits are used as a spice and vegetable.

Oleum (1993) stated that Russia produces high quality *C. sativum* oil, with a linalool content of 55%.

Bauer (1942) found that *Coriandrum sativum* attains its greatest yield of volatile oil (0.9%). The fatty oil of *Coriandrum sativum* is of interest because of the high level of petroselinic acid.

2. Materials and Methods

Research sites

The research was conducted in Jordan at two different locations. The first is located 150 m below sea level. This area is humid with warm temperatures in winter, and dry and hot in summer. The other location is 200 m above sea level. It is characterized by rainy, cold winters and dry, mild summers (Fig. 1). Both locations have produced relatively high biodiversity in wild plants and bees. The Jordan valley, latitude 22° 40’ 0’’ and longitude of 35° 30’ 0’’, is located in Jordan, a part of the Middle East (Fig. 2) and extends down the entire flank of Jordan 50 km from Amman; it is the country’s most distinctive natural feature. The northern segment of the Jordan valley, known in Arabic as the Ghor, is the nation’s most fertile region. It contains the Jordan River and extends from the northern border down to the Dead Sea. Several degrees warmer than the rest of the country, its year-round agricultural climate, fertile soils, high winter rainfall and extensive summer irrigation have made the Ghor the food bowl of Jordan. According to MD (2002), the mean maximum and minimum temperatures are 29.9°C and 16.98°C, respectively, with rainfall of around 77-392 mm over 44.84 rainy days yearly. Over the last 30 years, mean relative humidity has been 72.45% in winter and 48% in summer. The Jordan valley is subjected to ground frost nearly 2.5 days yearly.


Fig. 1 - Jordan Valley overview of vegetation covers.

Coriandrum sativum *plantation*

Coriandrum sativum seeds, obtained from local markets (landraces), were planted at locations A and B on 5 November 2007. The rows were 20 m long with 1 m between rows. Water was supplied daily by drip irrigation, and extra fertilizers (N P K) were applied. Both locations were kept weed-free by cultivation and hand weeding.

Determination of seed content

To determine the seed content of *C. sativum*, 400 g of seeds were collected. Oil extraction and preparation of seeds involved the following: drying of seeds, crushing, and extraction. Solvents such as carbon dioxide and propane were used to facilitate oil extraction. Gas liquid chromatography was used to determine the seed content. Seed content analyses were performed at The National Center for Agricultural Research and Technology Transfer (NCARTT) chemist’s lab, Amman, Jordan. The protein content of *C. sativum* was analyzed in fecundated and non-fecundated seeds using the international standard method (SOP: 130M01-006) (Table 1).

Table 1 - Analyzed constituents for *Coriandrum sativum*

	Standard method used
Seed constituent	
Ash	SOP: 130M01-009
Moisture	SOP: 130M01-010
Oil	SOP: 130M01-001
Proteins	SOP: 130M01-006
Trace elements	
Mg - Mn - Cu	SOP NO :131M02-005
Ca - K	SOP NO :131M02-002
Oil constituent	
Fatty acids	COI/T.20/Doc. No. 24 (2001) – AOCS Ch 2-91 (1997)

The seed contains the essential oils based on the analysis applied (Table 2).

3. Results

Seed content

Seeds for testing (for fatty acid composition, essential oils and mineral contents) were chosen from both locations. Moisture content was not significantly different among treatments. Protein values were significantly different among pollination treatments and ranged from 13.01 to 15.78%. Oil content was low in all seeds and varied from 5.61 to 7.40%. Ash values ranged between 6.26 and 6.51% (Table 2). Oleic acid was significantly the most concentrated 80.10% (Table 3). All mineral contents

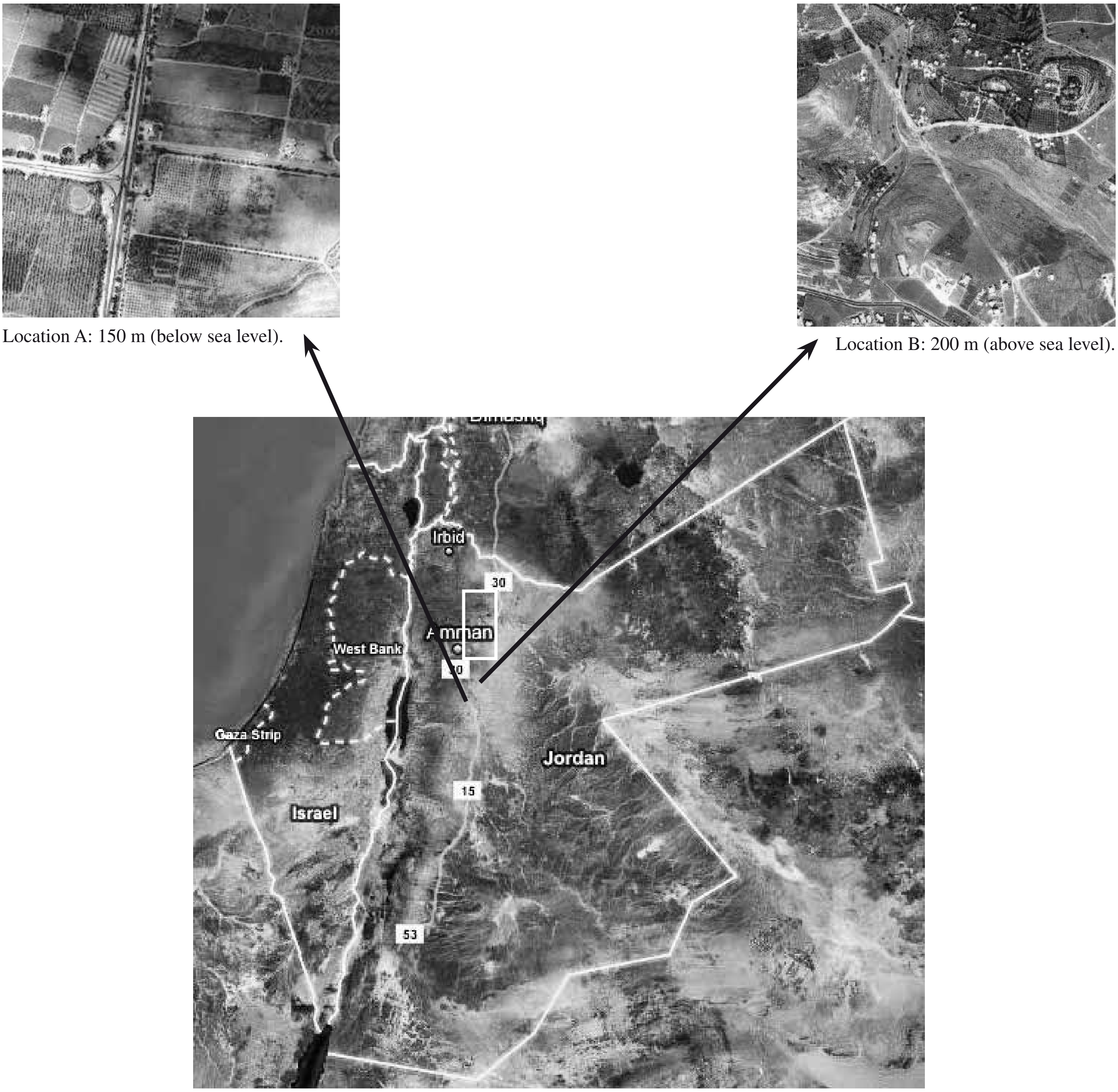

Fig. 2 - Research sites (53, 15, 30, 30, are the Main International Highway).

Table 2 - Essential oil component and percentage in seed of *C. sativum*

Main component	Total essential oil (%)
1. Linalool	66.7
2. Alpha-pinene	9.8
3. Gamma-terpinene	8.3
4. Geranylacetate	3.3
5. Camphor	3.0
6. Geraniol	1.9

Table 3 - Main components and mineral contents in seed of *C. sativum*

Seed content	
Moisture	8.30 %
Ash	6.31 %
Protein	15.78 %
Oil	7.40 %
Magnesium	0.34 %
Calcium	0.40 %
Potassium	1.46 %
Manganese	18.80 mg/kg
Cupper	11.60 mg/kg

Table 4 - Fatty acid content in seed of *C. sativum*

Fatty acid	Trivial name	Systematic name	Percentage
C 14:0	Myristic acid	Tetradecanoic acid	0.10
C 16:0	Palmitic acid	Hexadecanoic acid	3.33
C 16:1	Palmitoleic acid	*cis*-9-Hexadecenoic acid	0.42
C 17:0		Hexadecanoic acid	0.03
C 17:1		Desaturation of *cis*-9-Hexadecenoic acid	0.04
C 18:0	Stearic acid	Octadecanoic acid	0.88
C 18:1, n-7	Vaccenic acid	*cis*-11-Octadecenoic acid	80.10
C 18:2	Linoleic acid	*cis*-9, 12-Octadecadienoic acid	14.63
C 18:3	α –Linolenic acid	*cis*-9, 12, 15-Octadecatrienoic acid	0.29
C 20:0	Arachidic acid	Eicosanoic acid	0.09
C 22:0	Behenic acid	Docosanoic acid	0.03
C 20:1	Gadoleic acid	*cis*-9-Eicosenoic acid	0.04
C 24:0	Lignoceric acid	Tetracosanoic acid	0.02

varied significantly among seed samples; manganese and copper were the most prevalent minerals. Linalool acid is the common essential oil in Coriander and was determined to be 66.7%. Fatty acid composition varied significantly among the seeds from the selected locations. (Table 4) The fatty oil of Coriander is of considerable interest because of the high level of petroselinic acid, which has potential non-food applications in oleo chemistry.

Protein percentage in Coriandrum sativum *seeds*

The protein percent in treated fecundated seeds in *Coriandrum sativum* was 14.9% of the total dry mass, whereas in non-fecundated seeds it was 4.7%.

4. Conclusions

Coriander is an annual herb and is common in the Middle Eastern and Mediterranean cuisine, in which the fresh leaves and dried seeds are the most commonly used parts of the plant. Chemicals extracted from Coriander have also been used as a traditional treatment for diabetes and hyperlipidemia (Chithra and Leelamma, 1997; Gary and Flat, 1999).

Little is known about the metabolic origin of petroselinic acid (18:1), which is an unusual fatty acid that occurs primarily in seeds of the Umbelliferae plant families (Tsevegsuren *et al*., 2004).

Petroselinic acid is of potential industrial significance because of unsaturation at C-6. Through chemical cleavage at its double bond, petroselinic acid can be used as a precursor of both lauric acid, which is a component of detergents and surfactants, and adipic acid, which is the monomeric component of nylon (Avato *et al*., 2001). Adipic acid is used for the manufacture of a wide range of polymers including high grade engineering plastics and it has a global market in excess of 2.5 million tons worth over £1 billion.

Many previous studies have shown that petroselinic acid is the major constituent of the seed oils of many species of Umbelliferae such as parsley or coriander and ranges from 15% up to 85% (Cahoon *et al*., 1992; Tsevegsuren *et al*., 2004). Keeping with this, the present study illustrated that the major component of the seed oil of coriander tested was petroselinic acid (18:1) and it represented to 80% of the total fatty acid content.

Recently, derivatives or polymers from under-utilized fatty acids such as petroselinic acid have been regarded as a new raw material, representing an important oleochemical material for the food, cosmetics, chemistry and pharmaceutical industries (Avato *et al*., 2001). Additional recent uses include the use as a green vegetable by some ethnic groups and flavoring for dishes and foods such as pickles and sauces.

Although many studies have focused on the seed content in *Coriandrum sativum,* the percent of protein of the total dry mass in fecundated and non fecundated seeds has not been pointed out. In the present study, the protein percent in treated fecundated and non fecundated seeds for *Coriandrum sativum* was low. Protein content in fecundated seeds is more than in non-fecundated seeds, which can be explained by the enzymatic activity of protein synthesis in complete fertilized ovary (embryo) as compared to empty ovary (gamete). In fact, cell division in the fecundated seeds needs more protein in order to complete division.

Finally, further studies are needed to fully determine the seed contents of *Coriandrum sativum*, and to explore the feasibility of growing coriander on a large scale in Jordan. We also believe that the application of advanced plant breeding, together with extensive biochemical studies, could result in more environmentally friendly, high oil, and high petroselinic acid coriander varieties.

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