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Habitat Effect on the Essential Oils, Phenolics and Flavonoids of the Medicinal Weed *Apium graveolens* L.

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Abstract

The present study aims to determine the relationship between soil chemical characteristics and the yield, qualitative and quantitative composition of the essential oils, as well as, phenolic and flavonoid content of the *Apium graveolens* L. (*Apiaceae*) aerial parts and fruits. Field study indicated that *Apium graveolens* L. is widely distributed in the Nile Delta coast namely, sandy fertile cultivated lands, banks of irrigation canals, Orchards, reclaimed lands and waste land. Soil analysis indicated that *A. graveolens* L. grow in a wide range of soil variables such as conductivity, calcium carbonates, organic carbon, chlorides and potassium, sodium, calcium and magnesium cations. The volatile constituents were analyzed by GC/MS. The detected compounds were identified by their retention times and mass spectral data, as well as comparison with published data or with reference compounds and mass spectrometric libraries of REPLIB and MAINLIB. Significant differences in the proportion of volatile constituents from oils of different habitat were detected. Besides, the phenolic and flavonoid content of the aerial parts and fruits varied widely according to habitat type. Hence, great attention must be paid to the type of soil and cropping strategies, to obtain satisfactory yields of high quality products, respecting their safety and medicinal value.

Keywords: *Apiaceae*, *Apium graveolens* L., GC-MS, phenolic compounds, soil variables, volatile oils

Introduction

Apiaceae (Umbelliferae) is a unique family in the flowering plants due to the characteristic inflorescences and fruits, besides the distinctive chemistry reflected in odour, flavour and even toxicity of many of its members. Several umbellifers plants were known to ancient Chinese and Mexican Indian civilization, as well as, to the Egyptians, Greeks and Romans of the Mediterranean basin [1].

Apiaceae is a cosmopolitan family comprising 446 genera and over 3540 species which makes this family one of the largest taxon among higher plants [2]. Plants of family Apiaceae are usually used medicinally as a cure for gastrointestinal complaints and cardiovascular ailments. They are also used as antispasmodics, sedatives and source of resins, gum resins, flavouring agents, foods and even poisons [3].

A. graveolens L. (celery) belongs to the family Apiaceae is a hapaxanthic herb, grown as a biennial and under certain conditions, as an annual with height of 60 to 90 cm. It has a shallow tape root system the stem is branched succulent and ridged. The leaflets are ovate to

sub orbicular three lobes 2-4.5 cm. The inflorescence is a compound umbel. The flowers are small and white. The fruit is schizocarp, with two mericarps [4]. It is native of Eurasia and grown as a wild plant. It prefers soils containing sodium chlorides and, therefore, was grown on mainly coastal regions. Today, celery is widely cultivated in the temperate zones as an important garden crop [5].

Celery has been used as a food, and at various times both the whole plant and the seeds have been consumed as a medicine. Celery seed is used as a flavouring agent, either as a whole seed or as celery salt; the ground powder mixed with salt. Volatile oil obtained from seeds is used in the perfume and pharmaceutical industries [6]. It is reported to possess several nutraceutical attributes, such as anticoagulation activity of blood plasma and prevention of cardiovascular diseases [7]. Seed oil was used in combination with other herbs, for reduction of blood pressure [8]. The important flavour constituents of the oil responsible for the typical aroma are 3-n-butyl-4,5-dihydrophthalide (sedanenolide), 3-n-butyl phthalide, sedanonic anhydride which are present in very low levels [9].

Limonene is a major constituent of *A. graveolens* L. fruit and aerial parts essential oils. Limonene inhibits the development of spontaneous and chemically induced tumors in pancreas of rodents [10]. Limonene can be also used for relief of heartburn and gastroesophageal reflux disorder because of its gastric-acid neutralizing effect and improvement of peristalsis [11].

Phenolic compounds are secondary metabolites which synthesize in plants. They possess biological properties such as: antioxidant, antiapoptosis, anti-aging, anticarcinogen, anti-inflammation, anti-atherosclerosis, cardiovascular protection, improvement of the endothelialfunction, as well as inhibition of angiogenesis and cell proliferation activity [12]. The antimutagenic, antibacterial, antiviral, anti-inflammatory and antithrombotic actions of flavonoids are well characterized [13].

Due to the high economic potentialities of *Apium graveolens* L. in particular the medicinal value, the present study was undertaken to add more information on its associated flora as well as volatile oil yield, composition and the phenolic and flavonoid content of the aerial parts and fruits in relation to soil variables. This will be useful to the optimal feasibility of the cultivation of *A. graveolens* L. as medicinal plant. Results will be important as an indication of the potential economic utility of *A. graveolens* L. as a raw material for useful pharmaceutical phenolic and flavonoidal compounds as well as oil component, such as Limonene.

Materials and methods

Study area

Damietta Province is a part of the Nile Delta, it located in the downstream part of the Damietta branch of the River Nile at 31^{o} 25' 10" north to 31^{o} 48' 54" east N-32^{o} 30' longitude to the north east of the Nile Delta region of Egypt. The total average area of Damietta Province is about 1029 Km^{2} and the total agricultural area is about 115892 feddans [14]. The present study was carried out at five locations in Damietta (Fig. 1). The climate of the study area is typically Mediterranean type and belongs to the arid province which is characterized by a short dry period [15]. The annual mean rainfall at Damietta is 102mm. The air temperature varies from 13.3 ^{o} C to 27.4 ^{o} C with warm summer and mild winter. Relative humidity varies from a minimum of 69 % during summer to a maximum of 84 % during winter [16].

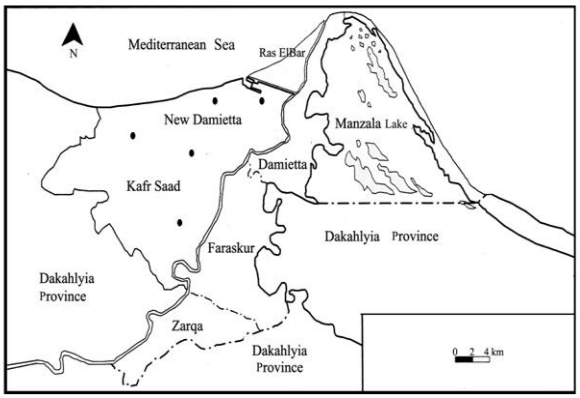

Fig. 1 Location map of Damietta showing the different habitats where *Apium graveolens* and soil samples were collected.

Apium graveolens L. was collected from five sites represented five different habitats types in Damietta. These habitats were namely: Irrigation canal banks (I), Orchards, cultivated with date palm trees and guava, (II), Sandy fertile cultivated lands, cultivated with vegetables like tomato, (III), reclaimed lands, cultivated with guava, (IV) and waste lands (V).

Field study

Five individuals of *Apium graveolens* L. were sampled and soil samples were collected from the rhizosphere of the target species. In each habitat the associated species were recorded and voucher specimens were identified and deposited in the Herbarium of the Botany Department, Faculty of Science Damietta University, Egypt. Identification and nomenclature of the plants were following [17-20].

Laboratory analyses

Soil samples were air dried, passed through 2 mm sieve and analyzed for pH, conductivity (EC), calcium carbonates, chlorides, bicarbonates and the organic carbon, following the procedures of United States Salinity Laboratory [21-23]. Concentrations of the cations: Na^+ ,K^+ ,Ca^{+2} and Mg^{+2} were determined using a Corning 410 Flame Photometer Model Jenway PFP7 [24].

Essential oil isolation

Essential oils from each plant material (50 g) were freshly powdered and steam-distillated for about 6 hours. The obtained oil was dried over anhydrous sodium sulfate. The steam distilled oils were subjected to GC/MS analysis.

GC/MS analysis of the essential oils

GC/MS analysis for the essential oils was carried out using Thermo Focus GC/DSQII MS plus equipped with a capillary column TR5 5% phenyl methyl polysiloxane column (30 m x 0.25 mm i.d. x 0.25 um film thickness) (Thermo Electron Corporation). Temperature programming was performed at a rate $3^oC\ min^{-1}$ from 50^oC-275^oC then adjusted at 275 ^oC. Carrier gas (Helium) flow rate was 20 ml min^{-1}., separation oven temp. 220 ^oC, surge pressure 3 kPa, ionization potential, 70 eV and m/z 40 to 350.

Volatile components identification

The different components were identified by their retention times and mass spectral data, as well as comparison with published data [25,26] or with reference compounds and mass spectrometric libraries of REPLIB and MAINLIB. The percentage composition of the components of the oil was determined by peak area measurements.

Total phenols and total flavonoids estimation.

Total phenolic content was estimated by the Folin–Ciocalteu method [27]. Two hundred micro liters of diluted sample were added to 1 ml of 1:10 diluted Folin–Ciocalteu reagent. After 4 min, 800 µl of saturated sodium carbonate (75 g l^{-1}) was added. After 2 h of incubation at room temperature (23 °C), the absorbance at 765 nm was measured. Gallic acid (0–500 mg l^{-1}) was used for the standard calibration curve. The results were expressed as gallic acid equivalent (GAE) g^{-1}dry weight of sample, and calculated as mean value ± SD (n = 3).

Total flavonoid content was determined using a colorimetric method described by [28]. A dose of 0.25 ml of the extract was mixed with 1.25 ml of distilled water in a test tube, followed by adding 75 µl of a 5% $NaNO_2$ solution. After 6 min, 150 µl of a 10% $AlCl_3$.6H2O solution was added and allowed to stand for another 5 min before adding 0.5 ml of 1 M NaOH. The mixture was brought to 2.5 ml with distilled water and mixed well. The absorbance was measured immediately against the blank at 510 nm using a UV-Visible Spectrophotometer. The results were calculated and expressed as micrograms of catechol equivalents (mg of CAE g^{-1} dry weight of sample) using the calibration curve of catechol. Linearity range of the calibration curve was 10 to 1000 µg ml^{-1} (r= 0.99).

Statistical analysis

Analysis of variance (ANOVA) was performed by using SPSS program (2009) (version 18). Means were separated according to the Tukey's multiple range tests. Pearson's correlation (r) was performed using SPSS program (version 18).

Results

Apium graveolens L. had a wide range of habitats in the Nile Delta. *Apium graveolens* L. was collected from five sites represented five different habitats types. These habitats were namely: Irrigation canal banks (I), Orchards, cultivated with date palm trees and guava, (II), Sandy fertile cultivated lands, cultivated with vegetables like tomato, (III), reclaimed lands, cultivated with guava, (IV) and finally waste lands (V).

Total number of associated plant species

growing with *Apium graveolens* L. was 16 species related to 8 families. Asteraceae comprises 4 species (25 %) of the total recorded species 3 annuals *Sonchus oleraceus*; *Chicorium endivia* and *Conyza aegyptiaca* and 1 perennials *Pluchea discoridis*, followed by *Fabaceae* (18.75%), included two annuals *Trifolium resupinatum* and *Meliotus indicus* one perennial *Lotus glaber*. *Poaceae* (12.5%) *Cynodon dactylon*; *Phragmites australis* 2 annual species. *Polygonaceae* (12.5%) and *Chenopodiaceae* (12.5%) had 2 annual species also. *Cyperaceae*, *Apiaceae* and *Euphorbiaceae* had 1 species *Emex spinosa; Rumex dentatus* belonging to Polygoniaceae, Chenopodiaceae also had 2 annuals *Chenopodium murale*; *Beta vulgaris*, while *Apiaceae, Euphorbiaceae* and *Cyperaceae* each had only one species each (6.25%) of the total recorded species. *Apiaceae* and *Euphorbiaceae* each had an annual species *Ammi majus*, and *Euphorbia peplum* and while the perennial species *Cyperus rotundus* L. belongs to family Cyperaceae.

Life forms of the associated species with *Apium graveolens* L. were mainly therophytes (68.75%), followed by geophytes (18.75), phanerophytes and hemicryptophytes each (6.25%).

The pH of soil supporting *Apium graveolens* L. ranged from 6.6 to 7.1. EC ranged from 2.45 to 4.15 (mS cm^{-1}) .$CaCO_3$ percentages ranged from 6.96 to 30.58%. The O.C content of soil supporting *Apium graveolens* L. ranged from 0.32 to 1.76%. Bicarbonates ranged from 0.04 to 0.14%.Cl^- ion ranged from 0.07 to 0.35%. Na^+ content of soil supports *Apium graveolens* L. ranged from 8.86 to 11.36 mg 100 g^{-1} soil. K^+ content ranged from 7.23 to 8.8 mg 100 g^{-1} soil. Mg^{+2} content ranged from 5.76 to 11.23 mg 100 g^{-1} soil. Ca^{+2} content of soil supports *Apium graveolens* L. ranged from 3.33 to 6.2 mg 100 g^{-1} soil (Table 1). Analysis of variance (ANOVA) results (Table 1) revealed that the mean values of all the measured variables were significantly different at probability level of less than 0.001 and bicarbonates percentage of the soil samples of *Apium graveolens* L. which showed significant difference at a probability level equal 0.001, except potassium content of the soil samples of *Apium graveolens* L. which had non significant difference at a probability level of 0.064.

Table 1. Means± SD and ANOVA-One way of soil variables of *Apium graveolens* L. in different sites. Means having different small letters are significantly different according to Tukey's test. (E.C= Conductivity, O.C = Organic Carbon, SD= Standard Deviation)

Soil variable	Means± SD in each site					F ratio	P
	I	II	III	IV	V		
pH	6.72±0.02^a	6.81±0.01^a	6.60±0.00^a	7.11±0.01^b	6.61±0.01^a	1124.17	0.000
E.C (mS cm^{-1})	2.45±0.05^a	3.35±0.63^b	4.15±1.17^c	3.10±0.48^d	3.40±0.77^b	524.64	0.000
%$CaCO_3$	30.58±0.53^a	21.75±0.42^b	11.68±0.45^c	6.96±0.25^d	21.63±0.40^b	42.88	0.000
% O.C	1.06±0.03^a	0.32±0.03^b	0.84±0.06^c	1.76±0.12^d	0.18±0.06^e	209.94	0.000
% HCO_3^-	0.11±0.017^a	0.04±0.01^b	0.070.017±^{c}	0.14±0.01^a	0.06±0.01^c	10.10	0.001
Cl^-	0.07±0.00^a	0.17±0.00^b	0.17±0.00^b	0.35±0.00^c	0.19±0.00^b	1599.08	0.000
Na^+ (mg 100 g^{-1} soil)	11.36±0.15^a	8.86±0.05^b	10.40±0.10^c	10.26±0.15^c	9.46±0.05^d	178.76	0.000
K^+ (mg 100 g^{-1} soil)	7.23±0.05	7.93±1.61	7.53±0.15	8.80±0.00	8.80±0.10	2.842	0.064
Mg^{+2} (mg 100 g^{-1} soil)	5.76±0.05^a	11.23±0.15^b	9.13±0.05^c	9.93±0.15^d	10.4±0.10^e	639.35	0.000
Ca^{+2} (mg 100 g^{-1} soil)	3.33±0.15^a	4.16±0.15^b	4.73±0.20^c	5.66±0.15^d	6.20±0.10^e	169.26	0.000

Pearson's correlation coefficients among soil variables in the surveyed sites from which *Apium graveolens* L were collected are illustrated in Table 2. Sixteen of the forty five coefficients highlighted significant correlation. A very high positive correlation coefficient was found between the percentage of soil bicarbonates and sodium of the soil extract (r= 0.860**). Meanwhile, there was a high negative correlation coefficient between sodium content and magnesium content of the soil extract (r=-0.896**).

Of the 21 distinguishable compounds detected across the aerial parts oil samples by GC/MS analysis, limonene was consistently the most abundant (see Table 3). Proportions of this constituent in total aerial parts oil fractions ranged from relatively low value 41.02% for habitat II, through 46.12% for habitat (V), 49.19 for habitat (IV) and 70.7% for habitat (I) respectively to a higher maximum value 84.94% for habitat III. Other principle constituents that

present at much lower concentrations are α-myrcene (9.64-26.30%), α-farnesene (2.65-6.81%) and sedanenolide (4.29-15.57%). These constituents occurred in inverse proportion to the concentration of limonene.

Table 2. Multiple correlation coefficient(r) between soil variables supporting the growth of *Apium graveolens* L. in Damietta. (* = p≤0.05, ** = p≤0.01)

	pH	E.C	%$CaCO_3$	% O.C	% HCO_3^-	Cl^-	Na^+	K^+	Mg^{+2}	Ca^{+2}
pH	1	-0.706**	0.094	0.654**	0.532*	0.284	0.005	0.312	0.298	0.422
E.C (mS cm^{-1})		1	-0.586*	-0.339	-0.391	0.358	-0.254	-0.072	0.131	0.076
%$CaCO_3$			1	-0.384	-0.191	-0.864**	0.146	-0.301	-0.375	-0.471*
%O.C				1	0.860**	0.383	0.597**	0.045	-0.287	0.001
%HCO_3					1	0.290	0.608**	0.061	-0.370	0.066
Cl^-						1	-0.300	-0.531*	0.487*	0.616**
Na^+ (mg 100 g^{-1} soil)							1	-0.384	-0.896**	-0.404
K^+ (mg 100 g^{-1} soil)								1	0.487*	0.659**
Mg^{+2} (mg 100 g^{-1} soil)									1	0.636**
Ca^{+2} (mg 100 g^{-1} soil)										1

Table 3. Volatile oil content from aerial parts of *Apium graveolens* L

Component	Molecular weight	Content % in each site				
		I	II	III	IV	V
α- Pinene	136	0.13	0.93	0.31	0.12	0.13
Camphene	136	0.01	-	-	-	-
α- Myrcene	136	10.42	26.30	-	9.64	9.76
4(10) Thujene	136	-	-	-	-	0.28
α- Phellandrene	136	0.03	-	-	0.20	0.04
Limonene	136	70.7	41.02	84.94	49.19	46.12
Limonene oxide, trans	152	2.20	-	0.02	2.48	4.23
6- Butyl-1,4-cycloheptadiene	150	-	-	3.67	-	-
α-Cyclocitral	152	0.04	-	-	0.15	0.12
Carvone	150	0.72	-	0.12	2.20	3.60
Carvacrol	150	-	-	-	0.09	0.02
α- Farnesene	204	2.65	6.81	4.46	4.77	3.06
Caryophyllene	204	0.33	-	1.18	0.48	-
α- Selinene	204	-	2.25	-	-	1.04
Nerolidol	222	0.01	-	-	0.01	-
Longipinene epoxide	220	1.29	-	-	4.32	1.88
Apiol	222	0.49	-	0.03	1.56	2.64
α- Bisabolol	222	0.84	-	-	1.28	0.78
Sedanenolide	192	4.46	6.06	4.29	6.22	15.57
Sedanolide	194	0.02	-	-	-	-
Dibutyl phthalate	278	0.24	-	-	0.46	0.47
Total		94.58	83.37	99.02	83.17	89.74

In the celery fruits volatile oils 15 components were isolated and characterized by GC/MS (Table 4). Limonene was generally the main constituent (81.07-89.81%) and sedanenolide was the second most dominant constituent (4.05-12.41%). 6-butyl-1,4-cycloheptadiene and α-Selinene also occurred in substantial amounts (0.06-4.38%).The quantitative composition of the volatile fraction of the fruits varies widely depending on the region of cultivation.

The yield percentage of the oil from aerial parts and fruits of *Apium graveolens* L. was shown in Table 5.

The total phenol and flavonoid contents of aerial parts and fruits of *Apium graveolens* L. varied widely according to the production area as shown in table 6 and table 7 respectively.

The relationships between soil variables and volatile oil content of *Apium graveolens* L. aerial parts and fruits, (Fig. 2) and (Fig. 3), respectively suggested that soil salinity (EC), calcium carbonates, organic carbon, Na^+, K^+ ,Mg^{+2},Ca^{+2}

and Cl^- are the most important factors affecting the volatile oil content.

Discussion

Field study indicated that *Apium graveolens* L. had a wide range of habitats in Nile Delta namely sandy fertile cultivated lands, irrigation canals [29], Orchards, reclaimed lands and waste land. Soil analysis indicated that *Apium graveolens* L. grow in a wide range of soil variables such as electric conductivity, calcium carbonate, organic carbon, chloride ion, potassium, sodium, calcium and magnesium cations. In the present study there was a significantly correlation between soil variables with each other.

Table 4. Volatile oil content from fruits of *Apium graveolens* L.

Component	Molecular weight	Content % in each site				
		I	II	III	IV	V
α- Pinene	136	0.01	-	0.57	0.54	1.22
α- Myrcene	136	0.30	0.99	0.38	0.82	-
Limonene	136	84.93	88.62	87.42	89.81	81.07
α- Linalool	154	-	-	-	0.06	0.17
cis- Limonene oxide	152	0.02	0.01	0.02	0.02	0.10
6-Butyl-1,4- cycloheptadiene	150	3.67	2.02	2.31	0.77	2.28
α-Terpineol	154	0.01	0.01	-	-	0.05
Carvone	150	0.12	0.09	0.11	0.02	0.05
4- hydroxyl-2- methylacetophenone	150	0.12	0.06	0.07	0.04	1.07
Caryophyllene	204	1.14	0.90	1.03	0.02	0.06
α- Farnesene	204	0.07	0.04	0.05	0.03	-
α- Selinene	204	4.38	2.70	2.57	0.06	0.12
Patchoulane	206	0.03	0.02	0.03	-	0.09
Apiol	222	0.03	0.02	0.02	0.02	0.03
Sedanenolide	192	4.29	4.05	5.01	7.33	12.41
Di-n-octyl phthalate	390	0.04	0.07	0.02	0.09	0.05
Total		99.16	99.60	99.61	99.63	98.77

Table 5. Yield percentage of the oil from aerial parts and fruits of *Apium graveolens* L.

Sites	% Oil yield of aerial parts	% Oil yield of fruits
I	0.2	3.0
II	0.2	2.2
III	0.8	2.0
IV	0.2	1.2
V	0.4	1.5

Table 6. The phenolic and flavonoid contents of the aerial parts of *Apium graveolens* L.

Sites	Phenolics mg (GAE) g^{-1} dry weight of sample	Flavonoids mg (GAE) g^{-1} dry weight of sample
I	36.435	5.943
II	30.075	2.044
III	18.7171	1.115
IV	16.105	2.044
V	35.186	1.672

Table 7. The phenolic and flavonoid contents of the fruits of of *Apium graveolens* L.

Sites	Phenolics mg (GAE) g^{-1} dry weight of sample	Flavonoids mg (GAE) g^{-1} dry weight of sample
I	0.772	Nil
II	0.205	Nil
III	0.091	Nil
IV	3.725	0.373
V	0.772	Nil

The relationships between soil variables and volatile oil content of *Apium graveolens* L. aerial parts and fruits, indicated that soil salinity (EC), calcium carbonates, organic carbon, Na^+, K^+, Mg^{+2},Ca^{+2} and Cl^- are the most important factors affecting the volatile oil content. Some researchers reported that, potassium fertilization increased most vegetative parameters, fruit yield, oil yield, as well as chemical constituents in fruits and leaves especially K^+ content in fennel and other

Umbelliferae plants [30]. Oil content in the seeds of sweet fennel decreased progressively with increase in salinity [31]. Organic fertilizers (2.5 kg m^{-2}) considerably increased oil yield of fennel [32].

In the present study, by the GC/MS analysis for the essential oils of aerial parts of *Apium graveolens* L. indicated that the major component of volatile oil was limonene. Dietary limonene has been shown to be capable of preventing the development and causing the regression of chemically induced mammary carcinomas, causing 80% carcinomas to regress with little host toxicity [33]. At a dose of 100 mg kg^{-1} given to human volunteers, limonene caused no toxicity [33]. D-limonene is well tolerated in cancer patients at a dose that may have clinical activity [34]. As could be expected from its higher limonene content which has a great medicinal values, habitat III, a sandy fertile cultivated lands with EC 4.15 (mS cm^{-1}), calcium carbonate percentage 11.68 %, organic carbon percentage 0.84%, Cl^- percentage 0.17%, Na^+ content 10.4 (mg 100 g^{-1} soil), K^+ content 7.53 (mg 100 g^{-1} soil) and Mg^{+2} content 9.13 (mg 100 g^{-1} soil), is the site of choice for planting of celery aerial parts.

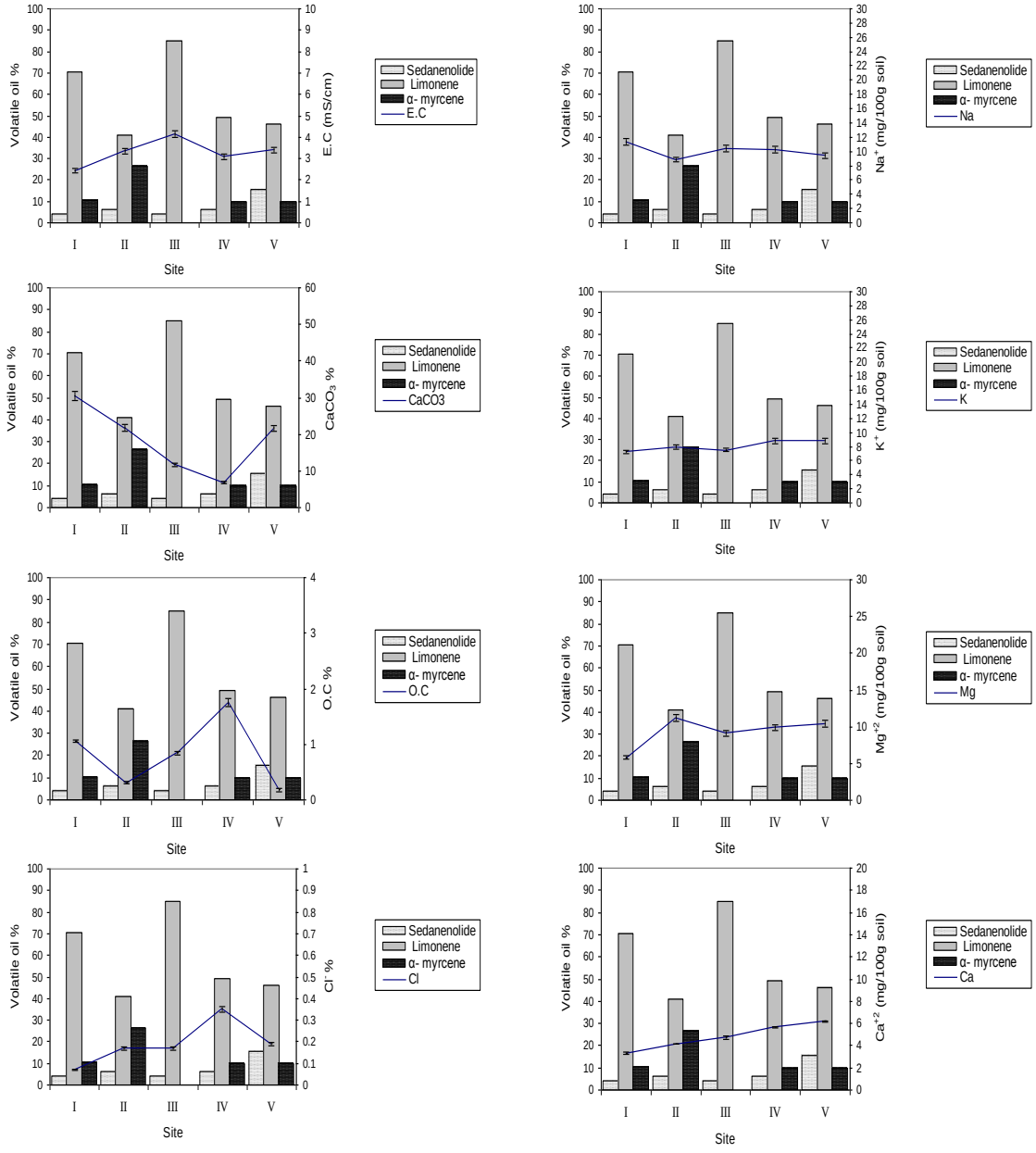

Fig. 2 Soil variables _ volatile oil content relationships of *Apium graveolens* L. aerial parts in different sites. (E.C= conductivity, O.C= organic carbon).

GC/MS analysis for the essential oils of fruits of *Apium graveolens* L. showed that Limonene was generally the main constituent and sedanenolide was the second most dominant constituent [35]. Concerning the high percentage of limonene, habitat IV, reclaimed lands with EC 3.10 (mS cm^{-1}), calcium carbonate percentage 6.96%, organic carbon percentage 1.76%, Cl^- percentage 0.35%, Na^+ content 10.26 (mg 100 g^{-1} soil), K^+ content 8.8 (mg 100 g^{-1} soil) and Mg^{+2} content 9.93 (mg 100 g^{-1} soil), is the site of choice.

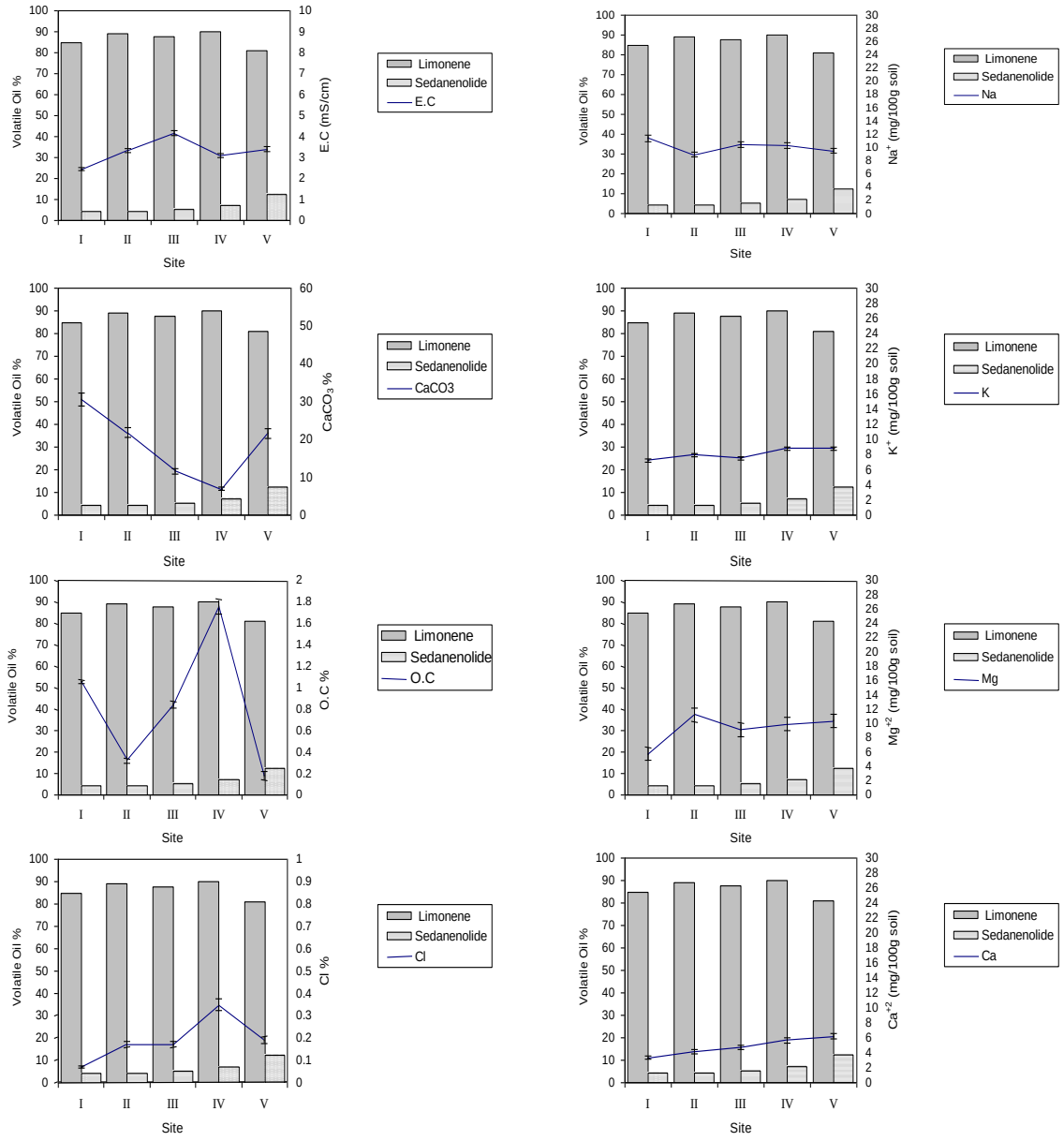

Fig. 3 Soil variables _ volatile oil content relationships of *Apium graveolens* L. fruits in different sites. (E.C= conductivity, O.C= organic carbon).

Maximizing the oil yields had been identified as a powerful means of increasing profitability of the industry, habitat III (sandy fertile cultivated lands) and habitat I (irrigation canal banks) had the highest volatile oils yields of the aerial parts and fruits, respectively.

Arial parts and fruits growing in habitat I (irrigation canal banks) and habitat IV (reclaimed lands), respectively, showed the highest values in total phenol and flavonoid content.

Briefly, this study has attempted to integrate information concerning soil types and chemical features on one hand and plants having some industrial potentialities on the other. It has highlighted the evidence that soil composition and characteristics may affect qualitative parameters

of herbal products. Field study indicated that xerophytes, geophytes, hemicryptophytes and phanerophytes were the main life forms of the associated species with *Apium graveolens* L. The major controlling soil variables affecting the yield and composition of volatile oil and total phenol and flavonoid contents of celery fruits and aerial parts were electric conductivity, calcium carbonate, organic carbon, chlorides, potassium, sodium, calcium and magnesium cations. From the above, the following facts can be concluded: 1) The fruits of *A. graveolens* L. growing in reclaimed lands showed the highest limonene, total phenol and flavonoid contents. 2) The aerial parts of *A. graveolens* L. growing in sandy fertile cultivated lands were characterized by their highest limonene content, while, those growing in irrigation canal banks, showed the highest values in total phenol and flavonoid contents. 3) The growing of *A. graveolens* L. in waste lands greatly affected the quantitative composition of the volatile oils of both fruits and aerial parts as oils exhibited a strong drop in limonene content and a dramatic increase in sedanenolide content. Findings of this research help management and planting of this medicinal plant.

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الملخص العربي

تأثير الموطن على محتوى الزيوت الطيارة والفينولات والفلافونيدات لنبات الكرفس

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تم اختيار نبات الكرفس وهو نبات طبي ينتمي للفصيلة الخيمية. وقد أظهرت الدراسة الحقلية أن النبات يتواجد في خمس بيئات مختلفة بدمياط. تهدف الدراسة إلى الوقوف على أهم العوامل البيئية التي تؤثر على محتوى الزيت الطيار والفينولات والفلافونيدات في الأجزاء الهوائية و الثمار لنبات الكرفس. التحليل الفلوري أظهر أن النباتات الحولية والنباتات الأرضية تعتبر أهم الطرز الظاهرية للأنواع المرافقة للنبات. تم في هذا البحث تحليل الزيت الطيار للأجزاء الهوائية و الثمار للنبات باستخدام كروماتوجرافيا الغاز المقترن بمطياف الكتلة وقد تم التعرف على 21 مركبا للزيت الطيار في الأجزاء الهوائية وكان الليمونين والميرسين والسيدانينوليد هم الأعلى نسبة بالمقارنة بباقي مكونات الزيت الطيار. وتم التعرف على 15 مركبا للزيت الطيار في الثمار وكان الليمونين والسيدانينوليد هم الأعلى نسبة. وقد أوضحت الدراسة أن ملوحة التربة ونسبة كربونات الكالسيوم والكربون العضوي وأيونات الكلور وكاتيونات الصوديوم والبوتاسيوم والكالسيوم والماغنسيوم هم أهم العوامل البيئية التي أثرت على محتوى الزيت الطيار لنبات الكرفس.وبذلك تكون الدراسة قد أشارت إلى أفضل تركيزات لعناصر التربة المراد زراعة النبات بها ليعطي أفضل إنتاجية من الزيت الطيار ذات الأهمية الطبية العالية.والنتائج المتحصل عليها سوف تفيد للتطبيق الزراعي على نطاق اقتصادي عند زراعة نبات الكرفس كنبات طبي.