



## Antioxidant activity and total phenolic content of essential oils and extracts of sweet basil (*Ocimum basilicum* L.) plants

Adel F. Ahmed<sup>a,b,\*</sup>, Fatma A.K. Attia<sup>c,d</sup>, Zhenhua Liu<sup>a,c</sup>, Changqin Li<sup>a,c</sup>, Jinfeng Wei<sup>a,c,\*</sup>, Wenyi Kang<sup>a,c,\*</sup>

<sup>a</sup> National R & D Center for Edible Fungus Processing Technology, Henan University, Kaifeng 475004, China

<sup>b</sup> Medicinal and Aromatic Plants Researches Department, Horticulture Research Institute, Agricultural Research Center, Egypt

<sup>c</sup> Joint International Research Laboratory of Food & Medicine Resource Function, Henan Province, Kaifeng 475004, China

<sup>d</sup> Department of Ornamental, Medicinal and Aromatic Plants, Faculty of Agriculture, Assiut University, Egypt

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### ABSTRACT

The present study was conducted to evaluate the chemical composition and antioxidant activity of the essential oils and ethanol extracts of *Ocimum basilicum* L. obtained from Assiut, Minia and BeniSuef of Egypt. The major constituents of sweet basil essential oils from three locations were linalool, estragole, methyl cinnamate, bicyclosiquiphellandrene, eucalyptol,  $\alpha$ -bergamotene, eugenol,  $\gamma$ -cadinene and germacrene D by the method of GC–MS. The relative concentration of these compounds varies. The basil extracts contained appreciable levels of total phenolic contents and exhibited good DPPH radical scavenging capacity higher than that of essential oils. The highest TPC (82.45 mg PE/g) and maximum radical scavenging activity with IC<sub>50</sub> value (1.29 mg/mL) was obtained from Minia basil extract. High correlation between antioxidant activity and total phenolic contents of basil extracts was observed. High variation in free radical scavenging activity of essential oils was found. The essential oil from Minia basil showed high activity in DPPH radical scavenging with IC<sub>50</sub> (11.23 mg/mL) and contained the highest content of phenolic (41.3 mg PE/g). On contrary, low correlation between antioxidant activity and total phenolic contents of basil essential oils from different locations. The results of the present investigation demonstrated significant variations in the antioxidant activities of sweet basil essential oils and extracts from Egypt.

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### 1. Introduction

Antioxidants have been widely used as food additives to avoid the degradation of the foods. Also, antioxidants have an important role in preventing a variety of lifestyle-related diseases and aging because these are closely related to the active oxygen and lipid peroxidation [1]. Current research of free radicals confirmed that food

rich in antioxidants play an essential role in reducing the risk of incidence of cardiovascular diseases as well as other chronic diseases and certain types of cancer [2,3]. A large number of plant species have already been tested for potential antioxidant activity [4,5]. *Ocimum basilicum* L., named commonly as sweet basil, is a popular culinary herb belonging to the Lamiaceae family is originally native to India and other Asian regions. Nowadays, it is cultivated all over the world [6].

Traditionally, the basil leaves are used in folk medicine as a remedy for a large number of diseases, including cancer, convulsion, diarrhea, epilepsy, gout, nausea, sore throat, toothaches, and bronchitis [7–9]. It is also a source of essential oil containing biologically-active constituents which possess antioxidant and antimicrobial properties [6–11].

The chemical composition of basil oil has been the subject of several studies. Basil oils have been classified into four chemotypes according to their chemical composition and geographical source. The European type, cultivated in Europe, USA, and Africa,

\* Corresponding authors at: National R & D Center for Edible Fungus Processing Technology, Henan University, Kaifeng 475004, China.

E-mail addresses: [adelfahmi.2008@yahoo.com](mailto:adelfahmi.2008@yahoo.com) (A.F. Ahmed), [weijinfeng20112011@hotmail.com](mailto:weijinfeng20112011@hotmail.com) (J. Wei), [kangweny@hotmail.com](mailto:kangweny@hotmail.com) (W. Kang).

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is characterized by linalool and methyl chavicol as the major oil constituents. The Reunion type, located in the Comoros and Seychelles Islands, Africa, and Reunion Island, is characterized by a high concentration of methyl chavicol. Tropical type originated from India, Pakistan, Guatemala, Haiti, and Africa is rich in methyl cinnamate. Another basil chemotype, with eugenol as the main component, is common in North Africa, Russia, Eastern Europe, and parts of Asia [6,12–14]. In addition to these, other basil oils have also been reported which contained various quantities of linalool, camphor, methyl chavicol, methyl cinnamate, and eugenol [15].

Several studies have investigated the chemical composition and antioxidant activity of the essential oil of basil from different origins. However, there are few reports on the antioxidant properties of basil extracts. Therefore, the aim of this study was to evaluate the chemical composition and antioxidant activity of the essential oils and extracts of sweet basil obtained from three locations of Egypt.

## 2. Materials and methods

### 2.1. Plants material

Sweet basil samples (leaves and stems) were collected from 3 locations of Egypt, Assiut, Minia and BeniSuef governorates. The samples were collected during summer 2018 and identified by Dr. Atef A. Kader Department of Medicinal and Aromatic Plants Researches, Horticulture Research Institute, Agricultural Research Center. The current study was conducted during 2018 and 2019 years at National R & D Center for Edible Fungus Processing Technology, Henan University, kaifeng, Henan, China.

**Table 1**  
Assiut basil essential oil composition (%), obtained by GC–MS.

NO.	RT <sup>a</sup>	RA% <sup>b</sup>	Compounds	KI <sup>c</sup>
1	2.9441	0.3169	trans-1,2-dimethyl-Cyclopentane	711.9259
2	3.0193	0.159	Heptane	717.391
3	3.3767	0.1072	methyl-Cyclohexane	743.3648
4	7.1567	0.0664	1S-.alpha.-Pinene	952.7687
5	7.5328	0.0165	Camphene	970.8157
6	8.1252	0.3049	(1S)-β-pinene	999.2418
7	8.3226	0.2377	beta.-Pinene	1008.714
8	9.357	4.0395	Eucalyptol	1059.549
9	9.5356	0.5826	β-ocimene	1068.296
10	10.4189	0.0275	2-carene	1111.008
11	11.1248	31.657	linalool	1143.948
12	11.9522	0.6783	d-Camphor	1182.557
13	13.5695	17.3749	Estragole	1245.218
14	14.9424	0.1428	geraniol	1295.142
15	15.4031	0.556	bornyl acetate	1311.115
16	18.177	3.5959	Eugenol	1405.309
17	19.5781	15.1444	methyl cinnamate	1452.389
18	20.02	3.9469	α-bergamotene	1467.238
19	20.4902	0.2229	γ-murolene	1483.038
20	20.7629	0.438	alpha.-Caryophyllene	1492.201
21	20.9509	0.3936	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	1498.518
22	21.5339	1.5695	germacrene D	1518.519
23	21.9194	0.4077	elixene	1531.766
24	22.0323	0.7574	α-bulnesene	1535.646
25	22.4648	2.4227	γ-cadinene	1550.509
26	23.7906	0.1781	nerolidol	1596.069
27	24.4771	0.8597	(-)-Spathulenol	1620.425
28	26.4329	6.0184	bicyclosesquiphellandrene	1690.25
29	28.9811	0.1057	6-Isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydro-naphthalen-2-ol	1784.513
30	31.3131	0.0775	phytone	1873.362
31	34.9802	0.1869	3-Carene	2023.956
32	36.3437	0.0378	Pyridine-3-carboxamide, oxime, N-(2-trifluoromethylphenyl)-	2081.952
33	40.5187	0.1258	13-Tetradecen-1-ol acetate	-
<b>Total</b>		<b>93.7561</b>		

<sup>a</sup> Retention time.

<sup>b</sup> Value expressed as relative area percentages to total identified compounds.

<sup>c</sup> Retention index: Kovats retention index relative to n-alkanes on column.

### 2.2. Essential oil isolation

Dried basil samples (100 g) were crushed and subjected to hydrodistillation with sterile water (1 L) for 3 h using a Clevenger-type apparatus. The obtained essential oil was dried over anhydrous sodium sulphate, and stored at 4 °C for further use.

### 2.3. Gas chromatography/mass spectrometry analysis of oils

GC–MS analysis was carried out by an Agilent 6890 N gas chromatograph equipped with a capillary column DB-5 ms (30 m × 250 μm × 0.25 μm, Agilent Technologies, USA and coupled with a 5975 B mass selective detector spectrometer from the same company. The front inlet was kept at 250 °C in split mode. The temperature program was as below: the initial column temperature was 60 °C, held for 2 min, and then programmed to 120 °C at a rate of 6 °C per minute and held for 2 min; finally programmed to 230 °C at a rate of 4 °C per minute, held at 5 min. Flow rate of split injection was 1.0 mL per minute. As a carrier gas helium at 1.0 mL per minute was used. The MS detector was used in the EI mode with an ionization voltage of 80 eV. The ion source temperature was at 230 °C. The transfer line was at 280 °C. The spectra were collected over the mass rang (*m/z*) 30–1000. Retention indices were calculated by the retention times of C<sub>6</sub>–C<sub>26</sub> *n*-alkanes that were injected at the same chromatographic conditions. The volatile constituents were identified by comparison of their relative retention indices and their mass spectra with Nist 08.L library of essential oil constituents.

### 2.4. Preparation of basil samples extracts

Dried samples of basil were crushed and extracted by 70% ethanol under 50 °C three times for 9 h totally. The extracts were

filtered under Buchner funnel and concentrated under reduced pressure at 40 °C by a rotary evaporator. The extracts kept at – 40 °C overnight then dried in a freeze dryer then collected and stored at – 4 °C until used for further analyses.

### 2.5. DPPH radical scavenging assay

The method of Kang et al. [16] was used to assay the DPPH radical scavenging activity. The stable free radical DPPH was dissolved in methanol to give a 200 µmol/L solution; 10 µL of the essential oil and extract samples in methanol (or methanol itself as blank control) was added to 175 µL of the methanol DPPH solution. For each test compound, different concentrations were tested (20, 10, 5, 2.5 and 1.25 mg/mL for extracts, 100, 50, 25, 12.5 and 6.25 mg/mL for oils). After further mixing, the decrease in absorbance was measured at 515 nm after 20 min. The actual decrease in absorption induced by the test compound was calculated by subtracting that of the control. The antioxidant activity of each test sample was expressed as an IC<sub>50</sub> value, i.e. the concentration in mg/ml that inhibits DPPH absorption by 50% and was calculated from the concentration-effect linear regression curve. BHT was used for positive control. The DPPH radical scavenging activity of each sample was calculated as the percentage inhibition.

$$\% \text{ Inhibition of DPPH radical activity} = [(A^0 - A^1)/A^0] \times 100\%$$

Where: A<sup>0</sup> is the absorbance of the DPPH itself; A<sup>1</sup> is the absorbance of sample and the positive control.

### 2.6. Determination of total phenolic contents (TPC)

The contents of total phenolic in basil samples extracts and oils were determined spectrophotometrically according to the

Folin-Ciocalteu method of Kang et al. [17] with slight modification. The diluted extract and oil (1.25 and 5 mg/mL methanol), respectively were used in the analysis. A 0.2 mL aliquot of the diluted extract was mixed with 2.5 mL of 10% Folin-Ciocalteu's reagent in water. The mixture was covered and incubated for 2 min in dark place then 2 mL of 7.5% Na<sub>2</sub>CO<sub>3</sub> dissolved in water was added. The mixture was incubated for 1 h at room temperature. The absorbance was measured at 765 nm against blank. The blank had the same constituents except that the extract was replaced by distilled water. Pyrocatechol was used as standard for preparing the calibration curve. The total phenolic content was expressed as mg pyrocatechol equivalents (PE) per g of extract.

### 2.7. Statistical analysis

Data were analyzed statistically using Statistix Version 8.1 software. Differences between means were determined using the least significant difference test at *P* < 0.05. The data are presented as mean ± SD.

## 3. Results and discussion

### 3.1. Chemical composition of essential oils

The chemical compositions of the investigated essential oils of tested basil from three locations; Assiut, Minia and BeniSuef of Egypt are shown in Tables 1–3, respectively. GC–MS analysis of Assiut basil essential oil identified 33 constituents, representing 93.75% of the total oil. The major constituents of the essential oil were linalool (31.65%), estragole (17.37%), methyl cinnamate (15.14%) bicyclosesquiphellandrene (6.01%), eucalyptol (4.04%), α-bergamotene (3.94%), eugenol (3.59%), γ-cadinene

**Table 2**  
Minia basil essential oil composition (%), obtained by GC–MS.

NO.	RT <sup>a</sup>	RA% <sup>b</sup>	Compounds	KI <sup>c</sup>
1	2.8972	0.2212	cis-1,3-dimethyl-Cyclopentane	708.5174
2	2.9442	0.2469	trans-1,2-dimethyl-Cyclopentane	711.9331
3	3.3767	0.1244	methyl-Cyclohexane	743.3648
4	7.1567	0.0587	1S-.alpha.-Pinene	952.7687
5	7.5235	0.0207	Camphene	970.3695
6	8.3227	0.6413	.beta.-Pinene	1008.898
8	9.3288	4.7398	Eucalyptol	1058.168
9	9.5169	0.5332	β-ocimene	1067.38
10	9.8178	0.1873	γ-terpinene	1082.116
7	10.4221	0.3304	2-carene	1111.157
11	11.1154	28.1812	linalool	1143.509
12	11.9335	0.7719	d-Camphor	1181.685
13	13.4474	16.9779	Estragole	1240.778
14	14.9142	0.1334	geraniol	1294.116
15	16.9641	0.0911	2-Acetoxy-1,8-cineole	1364.156
16	18.0831	7.3363	Eugenol	1402.154
17	19.2961	13.3946	methyl cinnamate	1442.913
18	19.9637	4.2091	α-bergamotene	1465.346
19	20.7065	0.3773	.alpha.-Caryophyllene	1490.306
20	20.904	0.5386	β-cubebene	1496.942
21	21.4776	2.4126	germacrene D	1516.584
22	21.8631	0.4015	Patchoulene	1529.832
23	21.9853	0.9028	α-bulnesene	1534.031
24	22.4367	2.6411	γ-cadinene	1549.543
25	23.0573	0.165	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	1570.869
26	23.7531	0.1441	nerolidol	1594.78
27	24.1104	0.1359	β-maaliene	1607.333
28	24.4301	0.37	(-)-Spathulenol	1618.747
29	26.4236	6.8374	bicyclosesquiphellandrene	1689.918
30	31.3132	0.0673	phytone	1874.579
31	33.0527	0.0155	Cyclohexene, 4-(4-ethylcyclohexyl)-1-pentyl-	1944.337
<b>Total</b>		<b>93.2085</b>		

<sup>a</sup> Retention time.

<sup>b</sup> Value expressed as relative area percentages to total identified compounds.

<sup>c</sup> Retention index: Kovats retention index relative to n-alkanes on column.

**Table 3**  
BeniSuef basil essential oil composition (%), obtained by GC–MS.

NO.	RT <sup>a</sup>	RA% <sup>b</sup>	Compounds	KI <sup>c</sup>
1	2.8877	0.2841	Cyclopentane, 1,3-dimethyl-	707.827
2	2.9441	0.4604	trans-1,2-dimethyl-Cyclopentane	711.9259
3	3.3672	0.1933	methyl-Cyclohexane	742.6744
4	6.9874	0.0168	$\alpha$ -thujene	944.6449
5	7.1661	0.1511	1S-.alpha.-Pinene	953.2198
6	7.5328	0.0495	Camphene	970.8157
7	8.0123	0.2527	sabinene	993.8244
8	8.332	1.1792	.beta.-Pinene	1009.354
9	9.3194	5.4865	Eucalyptol	1057.708
10	9.5262	0.7278	$\beta$ -ocimene	1067.835
11	9.8271	0.308	$\gamma$ -terpinene	1082.571
12	10.4289	0.4246	2-carene	1111.475
13	11.0495	27.6454	linalool	1140.434
14	11.8958	0.7278	d-Camphor	1179.925
15	12.7609	1.0138	4-terpineol	1215.815
16	13.3909	15.9668	Estragole	1238.724
17	14.9518	0.2241	geraniol	1295.484
18	15.3843	0.9929	bornyl acetate	1310.476
19	17.9231	2.7891	Eugenol	1396.741
20	19.0421	10.4896	methyl cinnamate	1434.378
21	19.1643	2.1239	methyl eugenol	1438.485
22	19.5311	0.376	Caryophyllene	1450.81
23	19.926	4.5247	$\alpha$ -bergamotene	1464.079
24	20.3867	0.2962	$\gamma$ -muurolene	1479.56
25	20.6876	0.4444	.alpha.-Caryophyllene	1489.671
26	20.8663	0.5842	Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene-	1495.675
27	21.4399	2.3752	germacrene D	1515.289
28	21.8348	0.4021	Patchoulene	1528.859
29	21.9664	0.9519	$\alpha$ -bulnesene	1533.381
30	22.4178	3.2631	$\gamma$ -cadinene	1548.893
31	24.1009	0.1615	$\beta$ -maaliene	1606.994
32	24.4394	0.5432	(-)-Spathulenol	1619.079
33	26.4047	7.0101	bicyclosesquiphellandrene	1689.243
34	31.3225	0.1163	phytone	1874.942
<b>Total</b>		<b>92.2722</b>		

<sup>a</sup> Retention time.

<sup>b</sup> Value expressed as relative area percentages to total identified compounds.

<sup>c</sup> Retention index: Kovats retention index relative to n-alkanes on column.

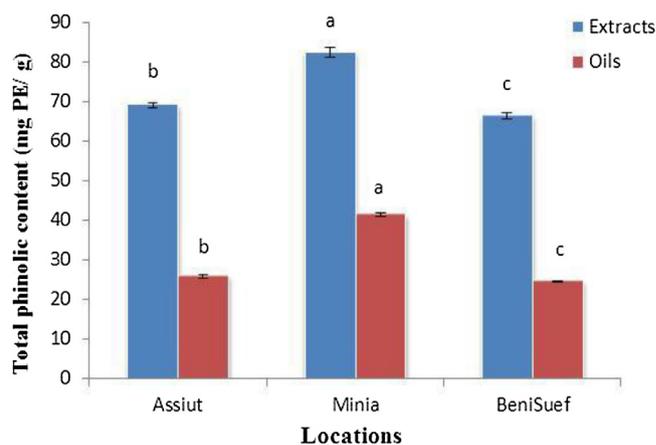
(2.42%) and germacrene D (1.56%). 31 constituents were identified from Minia basil essential oil, representing 93.20% of total oil. Linalool (28.18%), estragole (16.97%), methyl cinnamate (13.39%), eugenol (7.33%), bicyclosesquiphellandrene (6.83%), eucalyptol (4.73%),  $\alpha$ -bergamotene (4.20%),  $\gamma$ -cadinene (2.64%) and germacrene D (2.41%) were the major constituents of the essential oil tested. Whereas, 34 constituents, representing 92.27% of total oil were identified for BeniSuef essential oil by GC–MS analysis and the major constituents were, linalool (27.64%), estragole (15.96%), methyl cinnamate (10.48%), bicyclosesquiphellandrene (7.01%), eucalyptol (5.48%),  $\alpha$ -bergamotene (4.52%),  $\gamma$ -cadinene (3.26%), eugenol (2.78%), and germacrene D (2.37%). As a result, the composition of three basil essential oils was varied.

The variation in chemical compositions of essential oils may be probably due to environmental conditions. Linalool and methyl chavicol and methyl cinnamate as the major oil constituents of essential oils. Our results in agreement to the previous results reported by Simon et al. [6] and Chenni et al. [18], linalool and methyl chavicol as the major oil compounds of essential oil from Egypt. However, Ismail [19] reported linalool, 1,8-cineole, eugenol, and methyl cinnamate as the major components of Egyptian basil essential oil.

A high diversity in the constituents of basil essential oil with different chemotypes from many regions of the world have been previously investigated; As reported by Nurzyńska-Wierdak et al. [20], linalool, geraniol, and 1,8-cineole are the major compounds in basil leaf essential oil of Poland. These results are consistent with those obtained in previous works in Oman, Hanif et al [11] and Brazil, Oliveira et al. [21]. Marotti et al. [12] reported the presence

of linalool, methyl chavicol, and eugenol as main components of Italian basil essential oil.

Klimankova et al. [22] reported linalool and eugenol are the major compounds of basil essential oil native to Czech Republic corroborating with Guinea, Keita et al. [23], as well as Reunion, Lucchesie et al. [24]. It was also reported that four major compounds characterize the basil essential oil of Austria: linalool, methyl chavicol, methyl cinnamate, and  $\gamma$ -cadinol, Politeo et al. [25]. These results



**Fig. 1.** Total phenolic content in basil extracts and essential oils at different locations. Data are mean  $\pm$  SD ( $n = 3$ ). Columns in figure that are headed with the different letter are significantly different ( $P < 0.05$ ) according to the least significant difference test.

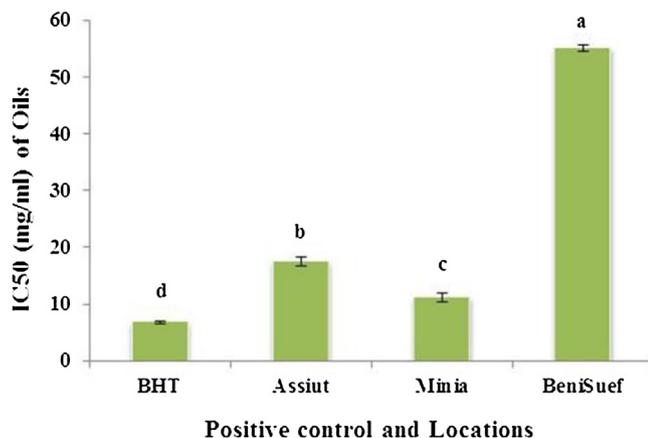
are in agreement with those obtained in previous works in Bulgaria (Opalchenova et al. [26] and USA Lee et al. [27]. Linalool was reported as the main component in *O. basilicum* essential oil from Romania, Benedec et al [28].

The major compounds of essential oil extracted from Algeria leaves of basil, were linalool, linalyl acetate, elemol, and geranyl acetate Hadj-Khelifa et al. [29]. Regarding Pakistan basil, Hussain et al. [5] reported four major compounds were found: linalool, epi-cardinol, -bergamotene, and -cadinene. Concerning basil from Turkey, Chalchat et al. [30] cited three major compounds: methyl chavicol, limonene, and p-cymene. In addition, Iranian basil essential oil is rich in methyl chavicol, Shirazi et al. [31] as well as Thailand basil essential oil, Bunrathep et al. [32].

On the other hand, Purkayastha and Nath [33] reported that camphor, followed by limonene and -selinene were the major compounds in *O. basilicum* essential oil from Northeast India. However, methyl cinnamate was the first major compound from French Polynesia basil leaf essential oil, Adam et al. [34]. These variations in the constituents of basil essential oil between countries may be probably due to environmental conditions and genetic factors, different chemotypes, and the nutritional elements of the plants, as well as other factors that can influence the oil composition.

### 3.2. Total phenolic contents of essential oils and extracts

The total phenolic contents (TPC) for basil essential oils and extracts from different locations of Egypt are presented in Fig. 1. The results indicated that the phenolic contents in different essential oils and extracts varied significantly. In among essential oils the highest TPC (41.3 mg PE/g) was obtained from Minia basil essential oil followed by 25.91 and 24.61 mg PE/g for Assiut and BeniSuef basil essential oils, respectively. The TPC of extracts exhibited similar trends to TPC of essential oils. The highest TPC



**Fig. 2.** DPPH radical scavenging assay of basil essential oils at different locations. Data are mean  $\pm$  SD ( $n = 3$ ). Columns in figure that are headed with the different letter are significantly different ( $P < 0.05$ ) according to the least significant difference test. BHT used as a positive control.

**Table 4**  
The major constituents (%) in basil essential oils.

Oil constituents	Assiut	Minia	BeniSuef
Linalool	31.657	28.1812	27.6454
Estragole	17.3749	16.9779	15.9668
methyl cinnamate	15.1444	13.3946	10.4896
bicyclosquiphellandrene	6.0184	6.8374	7.0101
Eucalyptol	4.0395	4.7398	5.4865
$\alpha$ -bergamotene	4.9469	4.2091	4.5247
Eugenol	3.5959	7.3363	2.7891
$\gamma$ -cadinene	2.4227	2.6411	3.2631
germacrene D	1.5695	2.4126	2.3752

(82.45 mg PE/g) was obtained from Minia basil extract followed by 69.12 and 66.48 mg PE/g for Assiut and BeniSuef basil extracts, respectively. In general, basil extracts exhibited higher contents of phenolic than that of essential oils. This difference in the amount of TPC may be due to varied agroclimatic (climatical, seasonal, geographical) conditions of the locations.

### 3.3. DPPH radical scavenging assay of essential oils and extracts

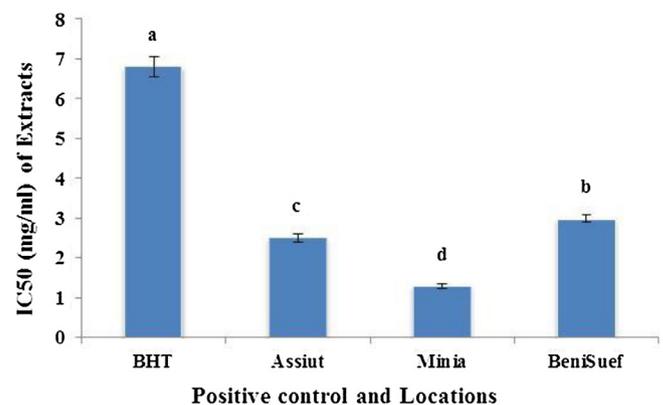
Free radical scavenging activities of the basil essential oils and extracts were measured by DPPH assay. Free radical scavenging capacity increased with increasing essential oil and extract concentrations. In Fig. 2, basil essential oils from different locations exhibited good radical scavenging activity but lower than that of synthetic antioxidant BHT ( $IC_{50} = 6.80$  mg/mL). The highest radical scavenging activity was recorded by Minia essential oil with  $IC_{50}$  value (11.23 mg/mL) followed by 17.52 and 55.15 mg/ml for Assiut and BeniSuef essential oils, respectively.

These variations were probably due to differences in environmental condition. Low correlation ( $R^2 = 0.441$ ) was found between antioxidant activity data from DPPH assays ( $IC_{50}$ ) and total phenolic contents of basil essential oils from different locations (Fig. 4). This result can be concluded that antioxidant activity of basil essential oils is not limited to phenolic. It may also come from the presence of other antioxidant secondary metabolites.

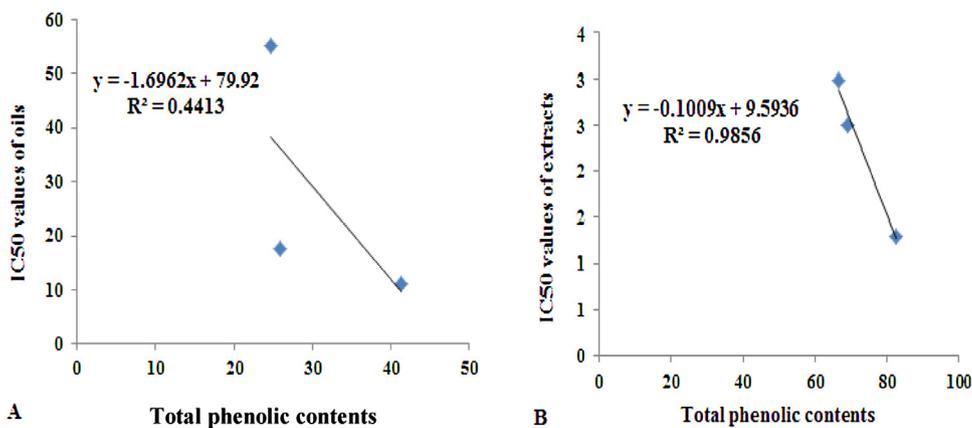
In this study the increment in radical scavenging activity of Minia essential oil was probably due to an increase of eugenol content which recorded higher concentration about 2 times and 3 times than that of Assiut and BeniSuef essential oils, respectively, as illustrated in Table 4. However eugenol was not the main component of oils. Our findings are in agreement with Politeo et al. [25] who clearly suggests that the antioxidant capacity ( $IC_{50} = 1.4$  g/L) of basil essential oil from Austria is due only or mainly to the presence of eugenol (5.9%) in its chemical composition and that other constituents do not have significant effect on eugenol capacity.

The same finding was reported by Pripdeevch et al. [35] who observed that the essential oil of *O. basilicum* from Thailand (linalool/eugenol chemotype) exhibited high scavenging ability of DPPH radicals ( $IC_{50} = 26.53$  g/mL). Also, Dabire et al. [36] reported that the decrease in the rate of eugenol in essential oil of *O. basilicum* causes a decrease of its antioxidant power. Lee et al. [27] also found that eugenol (0.896 mg/g) was the main contributor of the antioxidant activity of volatile extract of basil collected from USA than major components.

The variation in the antioxidant activity of essential oil in different origins has been previously investigated by other researchers.



**Fig. 3.** DPPH radical scavenging assay of basil extracts at different locations. Data are mean  $\pm$  SD ( $n = 3$ ). Columns in figure that are headed with the different letter are significantly different ( $P < 0.05$ ) according to the least significant difference test. BHT used as a positive control.



**Fig. 4.** Linear correlation between the antioxidant activity data from DPPH assays ( $IC_{50}$ ) and the total phenolic content of basil from different locations. (A): Linear correlation between the antioxidant activity and the total phenolic content of essential oils. (B): Linear correlation between the antioxidant activity and the total phenolic content of extracts.

Hadj-Khelifa et al. [29] who reported that *O. basilicum* essential oil from Algeria containing linalool as a major compound exhibited lower antioxidant effects ( $IC_{50} = 83.4$  mg/mL) than the vitamin E ( $IC_{50} = 22.0$  mg/mL). Hussain et al. [5] showed that sweet basil essential oil from Pakistan which is rich in linalool offered antioxidant activity comparable to synthetic antioxidant BHT. However, Bozin et al. [37] found that basil oil containing methyl chavicol (45.8%) and linalool (24.2%) as major components exhibited very strong radical scavenging activity, reducing the DPPH radical formation ( $IC_{50}$ ) in the range of 0.4 g/mL.

Quite a different situation was observed by Mahmoud et al. [38] who found that the main component methyl chavicol exhibit a moderate antioxidant activity (DPPH assay). Also, Dawidowicz et al. [39] which showed that the main component methyl chavicol, do not exhibit antioxidant properties.

Depending on our results and pervious researches we can conducted that the main component does not always determine the antioxidant activity of the examined essential oil. It is possible that components present at lower concentrations might be involved in some type of synergy with other active compounds.

On the other hand the ethanol extracts of basil from different locations exhibited stronger radical scavenging activity than that of synthetic antioxidant BHT ( $IC_{50} = 6.80$  mg/mL). As illustrated in Fig. 3 Minia basil extract recorded the highest radical scavenging activity in among locations with  $IC_{50}$  value (1.29 mg/mL) followed by 2.50 and 2.98 mg/ml for Assiut and BeniSuef extracts, respectively.

On contrary high correlation ( $R^2 = 0.985$ ) between antioxidant activity data from DPPH assays ( $IC_{50}$ ) and total phenolic contents of basil extracts from different locations was observed (Fig. 4). This result suggests that the antioxidant capacity of basil extracts results from the contribution of phenolic contents. Also indicates that the variation in radical scavenging activity was due to differences in phenolic content which recorded higher concentration in Minia basil extract than that of another two locations.

Our findings are in agreement with Javanmardi et al. [40] who reported that 71% of the antioxidant capacity of Iranian *Ocimum* accessions results from the contribution of phenolic compounds. In general, the free radical scavenging activity of ethanol extracts was superior to that of essential oils.

Phenolic compounds are very important plant constituents because of their scavenging ability on free radicals due to their hydroxyl groups. Therefore, the phenolic content of plants may contribute directly to their antioxidant action [41]. Several investigations of the antioxidant activity of plant extracts have confirmed

a correlation between total phenolic content and antioxidant activity [42,43].

#### 4. Conclusions

Our results showed that variations in chemical composition of essential oils of *O. basilicum* obtained from three locations; Assiut, Minia and BeniSuef of Egypt. The basil extracts contained appreciable levels of total phenolic contents and exhibited good DPPH radical scavenging capacity higher than that of essential oils. High correlation between antioxidant activity and total phenolic contents of basil extracts was observed. High variation in free radical scavenging activity of essential oils was found. On contrary, low correlation between antioxidant activity and total phenolic contents of basil essential oils from different locations. The results of the present investigation demonstrated significant variations in the antioxidant activities of sweet basil essential oils and extracts from Egypt and it should be addressed in future research.

#### Declaration of Competing Interest

The authors declare that they have no competing interests.

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