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Essential Oil Content and Composition of Some *Ocimum* Species Grown in Sudan[1] Ⅱ

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Abstract: This research was conducted to study the variation among some *Ocimum* species grown in Sudan on basis of the essential oil content of their leaves and flowers and oil profiles.Three different plant materials were used in this experiment *i.e.* O. *americanum* (lime), *O.basilicum*(green) and *O.basilicum* (Egyptian). The layout of the experiment was Randomized Complete Block Design with three replicates; treatments were the three *Ocimum* species.The highest oil content of leaves (1.2%) was obtained from *O. americanum* L. (Lime) and *O.basilicum*L. (Green), while the lowest oil content of leaves (1 %) was obtained from *O.basilicum*L. (Egyptian). The highest oil content of flowers (1.7%) was obtained from *O. basilicum* L. (Green), while the lowest oil content of flowers (1 %) was obtained from *O. americanum* L. (Lime). Linalool was the most predominant component in leaves' and flowers' oil of *Ocimum*spp. followed by Eugenol and Eucalyptol (Cineole). Other important components wereCitral, Neral (β-Citral),Caryophyllene,α-Bergamotene, β-Cadinene(-), α-Caryophyllene (Humulene), β-elemene and GermacreneD. Oxygenated monoterpenes were the most predominant components in the oils followed by sesquiterpene hydrocarbons and phenylpropanoids.

Key words:*Ocimum* spp*;*essential oil; oil profile

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INTRODUCTION

The genus *Ocimum* which belongs to the family Lamiaceae, collectively called, basil has long been recognized as a diverse and rich source of essential oil. It is characterized by great variability among its constituent species, including morphology, growth habit, the color of flowers, leaves, stems and chemical composition (Svecova and Neugebauerov 2010).The geographical distribution of the genus *Ocimum* shows three main centers of biodiversity *i.e.* (a) Tropical and subtropical regions of Africa (b) Tropical Asia and (c) Tropical parts of America (Brazil)(Paton *et al.*1999).

The plants are predominantly herbs, shrubs or under shrubs, annuals or perennials in habit. They possess glandular hairs or sessile glands secreting strongly scented volatile oils. Flowers appear to be uniform in the appearance throughout the group but they are of great taxonomic importance for the demarcation of species(Chowdhury *et al*. 2017).

Basil acts principally on the digestive and nervous systems, easing flatulence, stomach cramps, colic, and indigestion. It prevents or relieves nausea, vomiting and kills intestinal worms. It has a mildly sedative action, proving useful in treating nervous irritability, tiredness, depression, anxiety, and insomnia. It may also be taken for migraine and cough. *Ocimum basilicum* reported to be used for treatment of mild headache, cough and infections of upper respiratory tract and prevents food poisoning by microbes when used as preservative (Aladekoyi and Orungbemi 2016).

The essential oil of *O. americanum* was effective against damping-off disease of seedlings caused by fungi, it could control damping-off disease of tomato up to 50% in soil infected with *Pythium aphanidermatum* and up to 43% in soil infected with *P. debaryanum.* The essential oil was not phytotoxic and showed superiority over commonly used synthetic fungicides such as Agrosan G.N. and Captan (Pandey and Dubey 1994).The essential oil of *O. basilicum*exhibited fungi toxic properties against aflatoxin-producing strains of *Aspergillusflavus*and *A. parasiticus* (Pandey *et al*.1983).

Huang *et al.* (2015) investigated the usage of linalool, methyl chavicol, and thymol (components of Ocimum oil for skin protection against all sources of

environmental skin aggressors and treatment of various dermatological disorders. *Ocimum* plants contain large amounts of antioxidants other than vitamin C, vitamin E, flavonoids and carotenoids. The major use of the volatile oils of *Ocimum* species is in cosmetics and food industries. Basil is also used in making flavors and perfumes (Telci *et al.* 2006).
In aromatherapy, it is used for sharpening concentration, for its uplifting effect on depression, and to relieve headaches and migraines (Joshi 2012).
Lawrence *et al.* (1988) found that the main constituents of the essential oil of basil are produced by two different biochemical pathways, the phenyl propanoids (methylchavicol, eugenol, methyleugenol and methyl cinnamate) by the shikimic acid pathway, and the terpenes (linalool and geraniol) by the mevalonic acid pathway.

Harvesting should be done usually on bright sunny days for high and good quality oil. It is not desirable to harvest the crop if there was a rain in the previous day (Smitha *et al.* 2014).The plant part harvested depends upon projected use. When basil is grown for its dried leaves, it is harvested just prior to the appearance of flowers. For essential oil, it is harvested during full bloom (Keita *et al.* 2001).When the plants were harvested at full flowering gave higher essential oil yield than the plants harvested at 50 % flowering and ten days after full flowering (Muni *et al.* 2002)

The still existing uncertainty in the classification within the genus *Ocimum* depends on the fact that species identification relied on morphological characters whose expression is known to be affected by developmental and environmental factors. That is, the taxonomy of basil from different geographical locations is complicated by the presence of many varieties and cultivars of it without significant differences in morphology (Golparvar *et al.* 2015).Hence the objectives of this research were to study the variations in essential oil contents and profiles of three different species of basil grown in Sudan, under different local names, as a means of chemotaxonomy.

MATERIALS AND METHODS

Experimental Site

A field experiment was conducted at the Demonstration Farm of the Department of Horticulture, Faculty of Agriculture, University of Khartoum at Shambat from June 18th 2017 to April 26th 2018.

Plant Materials

Three different plant materials were used in the study, namely *Ocimum basilicum* L. (Egyptian), *Ocimum basilicum* L. (Green), *Ocimum americanum* L. (Lime). These species were used to investigate the variations among them based on oil content of leaves & flowers and oil composition, under Shambat environment.

Experimental Design

The layout of the experiment was Randomized Complete Block Design with three replicates. Treatments were the three *Ocimum* species

Cultural methods

Before the initiation of the experiment, the land was ploughed, harrowed, leveled and divided into three blocks each one contained three experimental units (plots) each plot contained 3 ridges 3m long & 0.7m wide.

Seeds were planted in the nursery in May, 2017 till plants reached transplanting stage. The plants were transplanted in the field on June18th, 2017. Pre-transplanting irrigation was applied, followed by the first irrigation immediately after transplanting. The plants were transplanted on the sholders of the ridges. There were seven plants per ridge at 40 cm spacing, the direction of the ridges were North to South. Irrigation was carried out every 5 days during summer and every 7 days during winter, weeding was done when needed.

Herb preparation for oil extraction

Leaves during flowering stage were picked in the morning from each species as composite samples from the three replications, washed gently to remove the particles of dust, spread in thin layers on clean flat benches under complete shade and well ventilation to ensure good dried material without

any molds or decomposition of the volatile oil quality and quantity.
The flowers were picked at full flowering stage in the morning from each species at all replication and dried in the same way as leaves.
After the completion of drying process for leaves and flowers they were packed in air tight bags kept at room temperature to maintain them until extraction process.

Oil extraction
Oil was extracted by hydro distillation using a Clevenger apparatus, according to the technique of British Pharmacopoeia (GMC 1968).

Oil Preparation
After separation of the oil, anhydrous sodium sulphate was added to remove any excess water, the mixture was shaken vigorously from time to time during a period of 2 hours. The pure sample of oil was stored in sterilized, dry, air tight and opaque glass containers at 4±1°C.

Determination of Oil Composition (Profile)
Oil composition was analyzed using Gas Chromatography- Mass Spectrometry (GC-MS). Sample preparation was performed by taking 10 µL of the volatile oil and dissolving it in 1 ml ethanol, then 10 mg anhydrous sodium sulphate was added to absorb the traces of moisture. The diluted sample was passed through syringe filter, after that 1µL of the sample was injected in the GC-MS.

The analysis of the sample was carried out by using GC-MS model (GC/MS-QP2010-Ultra) from Japans 'Simadzu Company, with serial number 020525101565SA and capillary column (Rtx-5ms-30m×0.25 mm × 0.25 µm).
The sample was injected by using split mode, instrument operation in EI mode at 70 eV. Helium as the carrier gas with purity 99.9993% passed with flow rate 1.69 ml/min, pressure: 100 kPa, linear velocity 47.2 cm/sec. The temperature program was started from 50°C with rate 7°C/min to 180°C then the rate was changed to 10°C/min reaching 280°C as a final temperature degree. The injection port temperature was 300°C, the ion source temperature was 200°C and the interface temperature was 250°C.

The sample was analyzed by using scan mode in the range of 40-500 m/z charges to ratio and the total run time was 30 minutes. Identification of components for the sample was achieved by comparing their retention times and mass fragmentation patterns with those available in the library of the National Institute of Standards and Technology (NIST).

Data analysis
Data recorded were statistically analyzed using the procedure described by Gomez and Gomez (1984). Means separation were performed using the Least Significance Difference (LSD) test.

RESULTS AND DISCUSSION

Oil content of leaves
There was significant difference in oil content of leaves among *Ocimum* spp. (Table1).

Table 1. Oil content of leaves of three *Ocimum* spp. at flowering stage

Treatments	Oil content (%)
O. americanum L. (Lime)	1.2
O. basilicum L. (Green)	1.2
O. basilicum L. (Egyptian)	1
Mean	1.13
SE ±	0.115

The highest oil content of leaves was obtained from *O. americanum* L. (Lime) and *O. basilicum* L. (Green) (1.2 %). The lowest oil content of leaves was obtained from *O. basilicum* L. (Egyptian) (1 %) it was significantly lower than the other two species.

Oil content of flowers

There were highly significant differences in oil content of flowers among *Ocimum* spp. (Table 2)

Table 2.Oil content of flowers of three *Ocimum* spp.

Treatments	Oil content (%)
O. americanum L. (Lime)	1
O. basilicum L. (Green)	1.7
O. basilicum L (Egyptian)	1.6
Mean	1.43
LSD ($P \leq 0.05$)	0.185

The highest oil content of flowers was obtained from *O. basilicum* L. (Green) (1.7 %) it was not significantly different from the *O. basilicum* L (Egyptian) (1.6 %).

The lowest oil content of flowers was obtained from *O.americanum* L. (Lime) (1 %) and so it was significantly lower than the other two species.

Results indicated that there were differences in oil content among leaves and flowers of *Ocimum* spp. The oil content of flowers was higher than leaves in all species except *O. americanum* L. (Lime).

Aburigal *et al.*(2016) reported that essential oils content varied with a range of 0.29 % to 0.33 % for flowers and 0.32 % to 0.48 % for leaves in sweet basil accession *O. basilicum* L. the Silate-Egyptian accession had the lowest essential oil content obtained from leaves and flowers. However, South Darfur accession had the highest oil content but did not significantly differ from Kennana accession.

Basil plants cultivated in middle Africa contained from 0.02 % to 2.1 % of essential oil (Tchoumbougnang *et al.*2006). An experiment was conducted on

38 genotypes of sweet basil (*O. basilicum* L). Oil content of the tested accessions varied from 0.07% to 1.92 % in dry herbage (Zheljazkov *et al*. 2008).

Upon comparison with the same varieties from other countries around the world, previous studies on essential oils of *Ocimum* species showed great variations in the essential oil content of *O. basilicum* L. cultivars, the following essential oil yields were reported: 0.29 % to 0.48 % (Aburigal *et al.* 2016), 0.68 % to 0.96 % (Hadipanah *et al.* 2015), and 0.5 % to 4 % (Runyoro *et al.* 2010) Therefore, in the light of previously reported results on the oil content, the investigated *O. basilicum* L. varieties in our study can be classified as of rich oil content varieties.

Rawat *et al.* (2016) studied six varieties of sweet basil (*O. basilicum* L.) and they reported that essential oil contents varied from 0.05 % to 5 % in the dry herbage.

Nurzyńska-Wierdak (2013) reported that the essential oil content for *O. basilicum* L. cultivars as, Sweet (0.97 %), Lime (1 %), Licorice (1.31 %), Lemon (1.18 %), Lettuce leaf (1.10 %), Purple Ruffles (0.90 %), var. cinnamon (1.89 %), var. citridorum (1.02 %), var. minimum "Bush" (1.57 %), var. piperita (0.75 %) and var. purpurascens (1.03 %).

There was variability in essential oil content among *Ocimum* spp. as reflected in the results and the literature findings above. Such variability probably depended on the variety, genetic factor, environmental factor, nutritional & physiological status of the plant, cultivation region, plant part, harvesting time of the day (morning or noon), stage of harvest, drying method, storage period and oil extraction method.

Essential oil composition

The essential oil composition of *Ocimum* spp. was identified by Gas Chromatography-Mass Spectrometry (GC-MS), a total of 100% of *Ocimum* spp. components were identified. Considerable variation in the chemical composition was recorded and a broad spectrum of components which were different in quality and quantity was shown.

The components were categorized into three groups *i.e.* major components (>10 %), minor components (<10 % >1 %) and traces (<1 %) according to Said-Al Ahl *et al*. (2015).

Table 3.Important essential oil components and percentages in leaves & flowers of *O. basilicum* L. (Egyptian).

No	Component name	Formula	Percentage %	
			Leaves	Flowers
1	Linalool	$C_{10}H_{18}O$	28.05	41.50
2	Eugenol	$C_{10}H_{12}O_2$	15.67	4.46
3	Methyleugenol	$C_{11}H_{14}O_2$	2.47	0.28
4	Eucalyptol (Cineole)	$C_{10}H_{18}O$	12.48	5.02
5	α-Bergamotene	$C_{15}H_{24}$	8.18	8.09
6	β-Cadinene(-)	$C_{15}H_{24}$	6.37	7.36
7	γ-Muurolene	$C_{15}H_{24}$	2.78	3.14
8	Germacrene D	$C_{15}H_{24}$	2.74	4.89
9	β-elemene	$C_{15}H_{24}$	2.01	4.61
10	δ-Guaiene	$C_{15}H_{24}$	0.93	2.16
11	α- Caryophyllene (Humulene)	$C_{15}H_{24}$	0.90	1.70
12	Bornyl acetate	$C_{12}H_{20}O_2$	0.90	1.58
	Total components		57	57

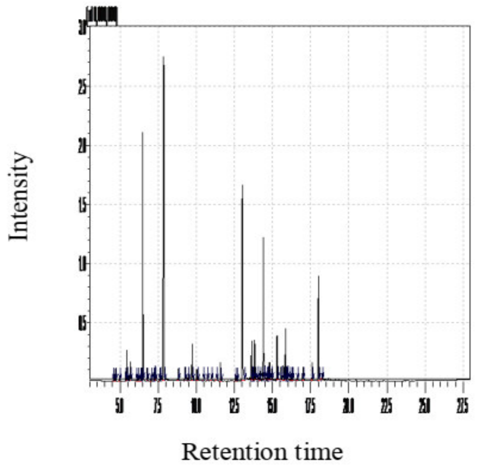

Fig.1. Gas chromatogram of leaves' essential oil of *O. basilicum* L. (Egyptian).

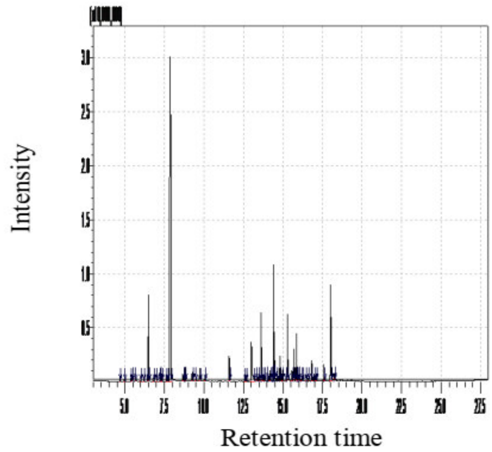

Fig. 2. Gas chromatogram of flowers' essential oil of *O. basilicum* L. (Egyptian).

As shown in Table 3 and Fig. 1, there were three major components in leaves' oil of *O. basilicum* L. (Egyptian) *i.e.* Linalool was the highest (28.05 %) followed by Eugenol (15.67 %) and Eucalyptol (Cineole) (12.48 %).

Leaves' oil of *O. basilicum* L. (Egyptian) was rich in oxygenated monoterpenes which represented 45% of total oil components *e.g.* Linalool, Eucalyptol (Cineole) and L-α-Terpineol. Monoterpene hydrocarbons represented 4.82% of total oil components.

Phenylpropanoids represented 18.14 % of total oil components (Eugenol and Methyleugenol).Moreover, sesquiterpene hydrocarbons represented 28.87 % of total oil components *e.g.* α-Bergamotene, β-Cadinene(-), γ-Muurolene, Germacrene D, β-elemene. Oxygenated sesquiterpenes were detected in trace percentages which represented 0.63 % of total oil components

As shown in Fig. 2. & Table 3, Linalool was the major (41.50 %) component detected in flowers' oil of *O. basilicum* L. (Egyptian) followed by α-

Bergamotene (8.09 %) and β-Cadinene(-) (7.36 %) which were detected in minor percentages.

Flowers' oil of *O. basilicum* L. (Egyptian) were rich in oxygenated monoterpenes which represented 50.49 % of total oil components *e.g.* linalool, Eucalyptol (Cineole) and Bornyl acetate. Monoterpene hydrocarbons represented 1.38 % of total oil components, each component of them detected in trace percentages. Sesquiterpene hydrocarbons represented 40.48 % of total oil components *e.g.* α-Bergamotene, β-Cadinene(-), Germacrene D, β-elemene, γ-Muurolene, δ-Guaiene and α-Caryophyllene (Humulene).
Oxygenated sesquiterpenes were detected in trace percentages which represented 0.79 % of total oil components.Phenylpropanoids represented 4.74 % of total oil components(Eugenol and Methyleugenol). Total components detected were 57 in each of leaves and flowers.

Table 4.Important essential oil components and percentages in leaves & flowers of *O. basilicum* L. (Green).

No	Component name	formula	Percentage	
			Leaves	Flowers
1	Linalool	$C_{10}H_{18}O$	29.42	34.88
2	Eugenol	$C_{10}H_{12}O_2$	19.88	5.64
3	Eucalyptol (Cineole)	$C_{10}H_{18}O$	13.01	5.50
4	α-Bergamotene	$C_{15}H_{24}$	7.58	8.09
5	β-Cadinene(-)	$C_{15}H_{24}$	5.97	7.94
6	L-α-Terpineol	$C_{10}H_{18}O$	2.84	1.18
7	γ-Muurolene	$C_{15}H_{24}$	2.50	3.66
8	Germacrene D	$C_{15}H_{24}$	2.10	5.22
9	β-elemene	$C_{15}H_{24}$	1.40	5.16
10	Methyleugenol	$C_{11}H_{14}O_2$	1.54	0.36
11	δ-Guaiene	$C_{15}H_{24}$	0.69	2.44
12	α- Caryophyllene (Humulene)	$C_{15}H_{24}$	0.73	2.17
13	Bornyl acetate	$C_{12}H_{20}O_2$	1.36	1.82
	Total components		48	58

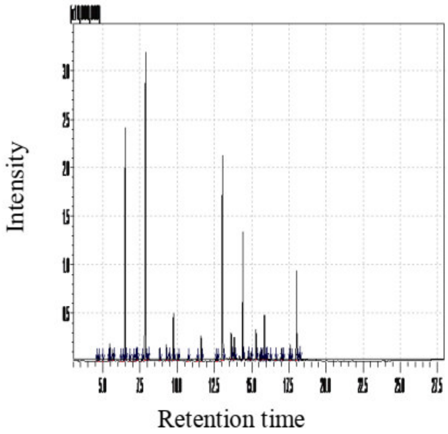

Fig. 3. Gas chromatogram of leaves' essential oil of *O. basilicum* L. (Green).

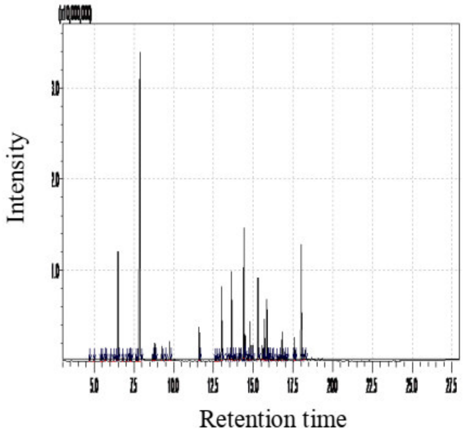

Fig. 4. Gas chromatogram of flowers' essential oil of *O. basilicum* L. (Green).

Table 4 and Fig. 3 indicate that there were three major components in leaves' oil of *O. basilicum* L. (Green) *i.e.* Linalool was the highest (29.42 %) followed by Eugenol (19.88 %) and Eucalyptol (Cineole) (13.01 %). Leaves' oil of *O. basilicum* L. (Green) were rich in oxygenated monoterpenes which represented 48.57 % of total oil components *e.g.* Linalool, Eucalyptol (Cineole), L-α-Terpineol and Bornyl acetate. Monoterpene hydrocarbons represented 2.89 % of total oil components, each component of them detected in trace percentages. Moreover, sesquiterpene hydrocarbons represented 23.81% of total oil components *e.g.* α-Bergamotene, β-Cadinene (-), γ-Muurolene, Germacrene D and β-elemene. Oxygenated sesquiterpenes were detected in trace percentages which represented 0.51 % of total oil components. Phenylpropanoids (Eugenol and Methyleugenol) represented 21.42% of total oil components.

As shown in Table 4 and Fig. 4, linalool was the major component (34.88 %) detected in flowers' oil of *O. basilicum* L. (Green), followed by α-Bergamotene (8.09 %) and β-Cadinene(-) (7.94 %).

Flowers' oil of *O. basilicum* L. (Green) were rich in oxygenated monoterpenes which represented 45.69 % of total oil components *e.g.*linalool, Eucalyptol (Cineole), L-α-Terpineol and Bornyl acetate. Monoterpene hydrocarbons represented 1.47 % of total oil components, each component of them detected in trace percentage. Phenylpropanoids (Eugenol and Methyleugenol) represented 6 % of total oil components.

Sesquiterpene hydrocarbons represented 42.09 % of total oil components *e.g.* α-Bergamotene, β-Cadinene(-), Germacrene D, β-elemene, γ-Muurolene, δ-Guaiene and α-Caryophyllene (Humulene). Oxygenated sesquiterpenes represented 3.03 % of total oil components. Total components detected were 48 in leaves and 58 in flowers.

Table 5.Important essential oil components and percentages in leaves & flowers of *O. americanum* L. (Lime).

No	Component name	Formula	Percentage	
			Leaves	Flowers
1	Citral	$C_{10}H_{16}O$	33.23	31.03
2	Neral (β-Citral)	$C_{10}H_{16}O$	27.34	25.99
3	Linalool	$C_{10}H_{18}O$	5.00	5.67
4	α-Bisabolene	$C_{15}H_{24}$	4.63	9.88
5	Caryophyllene	$C_{15}H_{24}$	4.55	7.78
6	3-Cyclohexene-1-carboxaldehyde,2,4,6,-trimethyl	$C_{10}H_{16}O$	3.60	-
7	5-Hepten-2-one,6-methyl	$C_8H_{14}O$	2.37	0.33
8	Germacrene D	$C_{15}H_{24}$	1.49	3.71
9	Cis-Verbenol	$C_{10}H_{16}O$	2.10	0.99
10	α-Bergamotene	$C_{15}H_{24}$	1.82	3.38
11	α- Caryophyllene (Humulene)	$C_{15}H_{24}$	1.70	2.66
	Total components		51	29

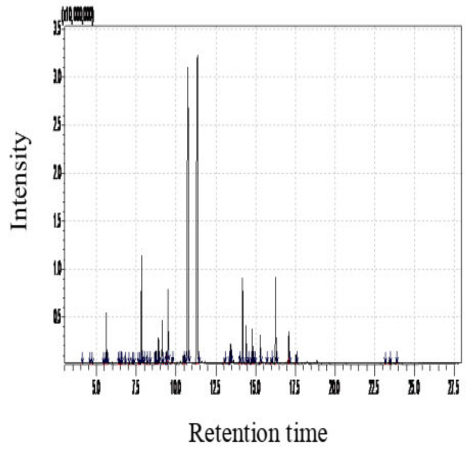

Fig. 5. Gas chromatogram of leaves' essential oil of *O. americanum* L. (Lime).

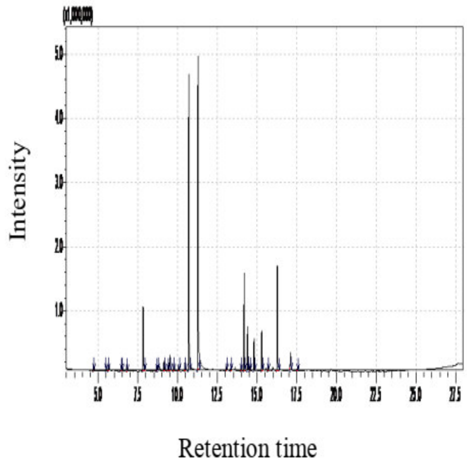

Fig. 6. Gas chromatogram of flowers' essential oil of *O. americanum* L. (Lime).

Table 5 and Fig. 5 show that, there were two major components in leaves' oil of *O. americanum* L. (Lime) *i.e.* Citral was the highest (33.23 %) followed by Neral (β-Citral) (27.34 %).

Leaves' oil of *O. americanum* L. (Lime) was rich in oxygenated monoterpenes which represented 75.63 % of total oil components*e.g.*Citral, Neral (β-Citral),Linalool,3-Cyclohexene-1-carboxaldehydeand Cis-Verbenol. Monoterpene hydrocarbons represented 1.25 % of total oil components, each component of them detected in trace percentage.Sesquiterpene hydrocarbons represented 15.6 % of total oil components *e.g.* α-Bisabolene, Caryophyllene, α-Bergamotene, α-Caryophyllene (Humulene) and Germacrene D. Oxygenated sesquiterpenes were detected in trace percentages which represented 0.41 % of total oil components. Ketone (5-Hepten-2-one,6-methyl) represented 2.37 % of total oil components.

As shown in table 5 and Fig. 6, there were two major components in the flowers' oil of *O. americanum* L. (Lime) *i.e.* Citral was the highest (31.03 %) followed by Neral (β-Citral) (25.99 %).

Flowers' oil of *O. americanum* L. (Lime) was rich in oxygenated monoterpenes which represented 66.69% of total oil components *e.g.* Citral, Neral (β-Citral) and Linalool.
Monoterpene hydrocarbons were detected in trace percentages which represented 0.72 % of total oil components. Sesquiterpene hydrocarbons represented 28.81 % of total oil components *e.g.* α-Bisabolene, Caryophyllene, Germacrene D, α-Bergamotene and α-Caryophyllene (Humulene). Total components detected were 51 in leaves and 29 in flowers.

These results are in good agreement with those of most published studies on the chemical composition of *O. basilicum* essential oil in which linalool was found to be the predominant constituent *i.e.* (69 %) (Keita *et al.* 2001) and (41.2 %) (Gurbuz *et al.*2006). Omer *et al.* (2008) analyzed nine *O. basilicum* accessions and found that, the dominant constituent in all samples was linalool, ranging between 19 and 38 % of total oils.
Similar study on the chemical composition of essential oils of numerous *O. basilicum* cultivars growing in Serbia (Beatovic *et al.* 2015)showed that the majority of the basil cultivars were characterized by high linalool contents and belong thus to the linalool chemotype. Linalool as a chemotype of the essential oils of basil varieties was also reported by Aburigal *et al.*(2016).

Part of our results are in good agreement with the result of Said-Al Ahl *et al.* (2015) who evaluated the volatile oil and its chemical constituents of some basil varieties in Egypt and found that, linalool and eugenol exhibited as majors, 1,8-cineol, methyl eugenol and farnesol were represented as minors, and α-pinene, β-pinene, myrcene, ocimene, linalyl acetate and geraniol were considered as traces. Nour *et al.* (2009) confirmed the classification of the essential oil of *O. basilicum* from Sudan as linalool and eugenol chemotype.
Our results are in agreement with the result of Smitha *et al.* (2014) who reported that major essential oil constituents of *O. americanum* was Citral. Moreover, Omer *et al.* (2008) reported that, the most abundant components observed in all basil studies were: linalool (4.15 – 55.26 %); 1,8- cineol (3.69 -21.21 %); t-cadinol (1.58-16.91 %); γ-elemene(0.15-6.13 %); geramacrene (0.12-5.05 %); cadinene (0.68-4.64 %); guaiene (0.48-2.43 %); α humulene

(0.19 – 1.51 %); sabinene (0.10– 1.48 %) and epi-bicyclosesquiphellandrene (0.09 - 1.10 %).

Analysis by (GC) and (GC/MS) revealed that oils of basil plants are monoterpenic (83.4 to 92.4 %). The oxygenated monoterpenes are predominant in the essential oil of *O. canum*(*O. americanum*) (63. 3%) (Belong *et al.* 2013).α-Bisabolene was identified as the second sesquiterpene in the essential oil of *O. americanum* and reached 4.5 %, the percentage of linalool or camphor didn't exceed more than 2 % in the essential oil. The total amounts of monoterpene hydrocarbons accounted for 19 % while the oxygenated components reached 76 % in the identified components (Abd El-Aziz *et al.* 2007).
The *O. basilicum*essential oils exhibited a wide and varying array of chemical components, depending on variations in chemotypes, leaf and flower colors, as well as aroma and origin of the plants (Sajjadi 2006).

Kumar and Tripathi (2011) reported that, oxygenated derivatives of monoterpenes and sesquiterpenes are more important than terpene hydrocarbons as aroma chemicals, because the characteristic odour of essential oils is representative of the combined odours of the oxygenated compounds, such as citral, citronellol, geraniol, linalool and nerol. They are also important starting materials for the synthesis of other aroma compounds. In our results oxygenated monoterpenes were the most predominant components in leaves' and flowers' oil of *Ocimum* plants. Németh (2005) reported that, changes in essential oil composition are affected by enzyme activity or structural changes in tracts that accumulate the essential oil during ontogenesis in the Lamiaceae species. These changes are not influenced by genetic reasons but by other parameters like abiotic factors, phase of development, harvesting time, and storage.
So, the conventional taxonomic evaluation and chemotaxonomy have to be taken together with DNA molecular tools for the best classification of *Ocimum* spp. (Carovic-Stanko *et al*. 2010).

CONCLUSIONS

From the results of this study the following conclusions can be drawn:

- Oil content is highly variable for the studied *Ocimum* spp.
- The essential oil composition is considerably different quantitatively as well as qualitatively among *Ocimum* spp. and varieties.
- Linalool is the most predominant component in leaves' and flowers' oil of *Ocimum* spp. followed by Eugenol and Eucalyptol (Cineole).
- Other important components are Citral, Neral (β-Citral),Caryophyllene, α-Bergamotene, β-Cadinene(-), α-Caryophyllene (Humulene), β-elemene and Germacrene D.
- Oxygenated monoterpenes are the most predominant components in leaves' and flowers' oil of the studied *Ocimum* spp. Followed by sesquiterpene hydrocarbons and phenylpropanoids.

REFERENCES

Abd El-Aziz, S.E.; Omer, E.A. and Sabra, A.S. (2007). Chemical composition of *Ocimumamericanum* essential oil and its biological effects against, *Agrotisipsilon*, (Lepidoptera: Noctuidae). *Research Journal of Agriculture and Biological Sciences* 3(6), 740-747.

Aburigal, Y.A.A.; Hamza, N.B.; Hussein, I.H.; Elmogtaba, E.Y.; Osman, T.H.; Ali, F.I. and Siribel, A.A. (2016). Variability in content and chemical constituents of essential oil of sweet basil (*Ocimumbasilicum*L.) obtained from aerial plant parts. *Advances in Bioscience and Biotechnology* 7, 183-187.

Aladekoyi, G. and Orungbemi, O.O. (2016). Comparative studies of physico-chemical composition and antibacterial activities of essential oil extracted from medicinal plants of scent leaves (*Ocimum basilicum*Lamiaceae and *Ocimum gratissimum* Lamiaceae). *Research Journal of Food Science and Nutrition* 1(1), 28-34.

Beatovic, D.; Krstic-Miloševic, D.; Trifunovic, S.; Šiljegovic, J.; Glamoclija, J.; Ristic, M. and Jelacic, S. (2015).Chemical composition, antioxidant and antimicrobial activities of the essential oils of twelve *Ocimum basilicum* L. cultivars grown in Serbia. *Records of Natural Products* 9(1), 62-75.

Belong, P.; Ntonga, P.A.; Fils, E.B.; Dadji, G.A.F. and Tamesse, J.L. (2013). Chemical composition and residue activities of *Ocimum canum* Sims and *Ocimum basilicum* L essential oils on adult female Anopheles funestus ss. *Journal of Animal &Plant Sciences* 19(1), 2854-2863.

Carovic-Stanko, K.; Orlic, S.; Politeo, O.; Strikic, F.; Kolak, I.; Milos, M. and Satovic, Z. (2010).Composition and antibacterial activities of essential oils of seven *Ocimum* taxa. *Food Chemistry* 119(1), 196-201.

Chowdhury, T.; Mandal, A.; Roy, S.C. and Sarker, D.D. (2017).Diversity of the genus *Ocimum* (Lamiaceae) through morpho-molecular (RAPD) and chemical (GC-MS) analysis.*Journal of Genetic Engineering and Biotechnology* 15(1), 275–286.

G M C (1968).British Pharmacopeia.*General Medicinal Council (GMC).*pp. 1273-1276.The Pharmaceutical Press.17 Bloomsbury Square, London WCI, UK.

Golparvar, A.R.; Hadipanah, A. and Mehrabi, A.M. (2015).Diversity in chemical composition from two ecotypes of (*Menthalongifolia* L.) and (*Menthaspicata* L.) in Iran climatic conditions. *Journal of Biodiversity and Environmental Sciences* 6(4), 26-33.

Gomez, K.A. and Gomez, A.A. (1984).*Statistical Procedures for Agricultural Research*, 2nd edition.John Wiley and Sons Inc. New York.

Gurbuz, B.; Ipek, A.; Basalma, D.; Sarihan, E.O.; Sancak, C. and Ozcan, S. (2006). Effects of diurnal variability on essential oil composition of sweet basil (*Ocimu mbasilicum* L.). *Asian Journal of Chemistry* 18(1), 285.

Hadipanah, A.; Ghahremani, A.; Khorrami, M. and Ardalani, H. (2015).Diversity in chemical composition and yield of essential oil from three ecotypes of sweet basil (*Ocimum basilicum* L.) in Iran.In *Biological Forum - An International Journal*, 7(1), 1802-1805.

Huang, H.C.; Ho, Y.C.; Lim, J.M.; Chang, T.Y.; Ho, C.L. and Chang, T.M. (2015). Investigation of the anti-melanogenic and antioxidant characteristics of *Eucalyptus camaldulensis* flower essential oil and determination of its chemical composition. *International journal of molecular s*ciences 16(5), 10470-10490.

Joshi, S. (2012).*Aromatic and Essential Oil Plants.*S.K. Mehra for random publications. New Delhi.

Keita, S.M.; Vincent, C.; Schmit, J.P.; Arnason, J.T. and Bélanger, A. (2001). Efficacy of essential oil of *Ocimumbasilicum* L. and *O. gratissimum* L. applied as an insecticidal fumigant and powder to control *Callosobruchus maculatus* (Fab.)[Coleoptera: Bruchidae]. *Journal of Stored Products Research* 37(4), 339-349.

Kumar, R. and Tripathi, Y.C. (2011).Getting Fragrance from Plants. In: *Training Manual on Extraction Technology of Natural Dyes & Aroma Therapy and Cultivation Value Addition of Medicinal Plants,* Chemistry and Non Wood Forest Products Division, Forest Research Institute, pp. 1-26. *Dehradun,* India.

Lawrence, B.M.; Mookherjee, B.D. and Willis, B.J. (1988).*Flavors and fragrances: A world perspective*. Elsevier, Amsterdam.

Muni, R.; Dasha, R.; Naqvi, A.A.; Sushil, K.; Ram, D. and Kumar, S. (2002). Effect of plant density and harvesting time on the yield and the quality of essential oil in *Ocimum* species. *Journal of Medicinal and Aromatic Plant Science* 24(2), 393-396.

Németh, E. (2005). Changes in essential oil quantity and quality influenced by ontogenetic factors .*Acta Horticulture* 675, 159-165.

Nour, A.H.; Elhassein, S.A. and Osman, N.A. (2009).Repellent activities of the essential oils of four Sudanese accessions of basil (*Ocimum basilicum*L.) against *Anopheles* Mosquito.*Journal of Applied Sciences* 9 (14), 2645-2648.

Nurzyńska-Wierdak, R. (2013). Morphological and chemical variability of *Ocimum basilicum*L. (Lamiaceae). *Modern Phytomorphology* 3, 115-118.

Omer, E.A.; Said-Al Ahl, H.A.H. and Hendawy, S.F. (2008). Production, chemical composition and volatile oil of different basil species/ varieties cultivated under Egyptian soil salinity conditions. *Research Journal of Agriculture and Biological Sciences* 4(4), 293-300.

Pandey, R.S.; Bhargava, S.N.; Shukla, D.N. and Dwided, D.K. (1983). Control of Pestalotia fruit rot of guava by leaf extracts of two medicinal plants. *Revista Mexicana De Fitopatologia* 2, 15-16.

Pandey, V.N. and Dubey, N.K. (1994).Antifungal potential of leaves and essential oils from higher plants against soil phytopathogens.*Soil Biology and Biochemistry* 26(10), 1417–1421.

Paton, A.; Harley, R.M. and Harley, M.M. (1999).Ocimum: an overview of classification and relationships. In *Basil* pp.11-46.Amsterdam CRC Press.

Rawat, R.; Negi, K.S.; Mehta, P.S.; Tiwari, V.; Verma, S.K. and Bisht, I.S. (2016).Study of six varieties of sweet basil (*Ocimum basilicum*L.) and their morphological variations.*Journal of Non-Timber Forest Products* 23(1), 1-6.

Runyoro, D.; Nagassapa, O.; Vagionas, K.; Aligiannis, N.; Graikou, K. and Chinou, I. (2010).Chemical composition and antimicrobial activity of the essential oils of four *Ocimum* species growing in Tanzania. *Food Chemistry* 119(1), 311-316.

Said-Al Ahl, H.A.H.; Meawad, A.A.; Abou-Zeid, E.N. and Ali, M.S. (2015).Evaluation of volatile oil and its chemical constituents of some basil varieties in Egypt.*International Journal of Plant Science and Ecology* 1(3), 103-106.

Sajjadi, S.E. (2006). Analysis of the essential oils of two cultivated basil (*Ocimumbasilicum* L.) from Iran.*DARU Journal of Pharmaceutical Sciences* 14 (3), 128-130.

Smitha, G.R.; Varghese, T.S. and Manivel, P. (2014).Cultivation of *Ocimum*. *Extension bulletin, Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat, India*, 30pp. 1-28.

Svecova, E. and Neugebauerov, J. (2010). A study of 34 cultivars of basil (*Ocimum* L.) and their morphological, economic and biochemical characteristics, using standardized descriptors. *Acta Universitatis*. *Sapientiae*, *Alimentaria*3, 118-135.

Tchoumbougnang, F.; Zollo, P.A.; Avlessi, F.; Alitonou, G.A.; Sohounhloue, D.K.; Ouamba, J.M.; Tsomambet, A.; Okemy-Andissa, N.; Dagne, E.; Agnaniet, H. and Bessiere, J.M. (2006). Variability in the chemical compositions of the essential oils of five Ocimum species from tropical African area.*Journal of Essential Oil Research* 18(2), 194-199.

Telci, I.; Bayram, E.; Yılmaz, G. and Avci, B. (2006).Variability in essential oil composition of Turkish basils (*Ocimum basilicum* L.). *Biochemical Systematics and Ecology* 34(6), 489-497.

Zheljazkov, V.D.; Callahan, A. and Cantrell, C.L. (2008).Yield and oil composition of 38 basil (*Ocimumbasilicum L.*) assessions grown in Mississippi.*Journal of Agricultural and Food Chemistry* 56(1), 241-245.

المحتوي و التركيب الكيميائي للزيوت الطيارة في بعض أنواع و أصناف الريحان التي تزرع في السودان

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المستخلص: أجري هذا البحث لدراسة محتوى الزيوت الطيارة ومكوناتها في بعض أنواع و أصناف الريحان التي تزرع في السودان. استخدمت ثلاثة انواع واصناف للريحان في التجربة. كان تصميم التجربة القطاعات العشوائية الكاملة بثلاثة مكررات والمعاملات كانت انواع وأصناف الريحان.أعلي محتوي زيت في الأوراق (1.2%) رصد في (الليموني) .*O.americanum* L و *O. Basilicum* L. (الأخضر)،أقل محتوي زيت (1%) رصد في (المصري) *O. basilicum* أعلي محتوي زيت في الأزهار (1.7%) رصد في (الأخضر) .*O. basilicum* L و أقل محتوي زيت (1 %) رصد في (الليموني) .*O.americanum* L. Linalool هو أكثر مركب سائد في زيت الأوراق و الأزهار يليه Eugenol و (Cineole) Eucalyptol. إحتوت زيوت الأوراق و الأزهار علي مركبات أخري مهمة و هي: Caryophyllene ، Citral، Neral (β Citral)، α-Bergamotene ، -β (-)Cadinene ، α-Caryophyllene (Humulene) ، β-elemene و D Germacrene. Oxygenated monoterpenes هي أكثر المركبات شيوعا في هذه الزيوت يليها ال sequiterpene hydrocarbons و ال phenylpropanoids .