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Morphological Variability and Chemical Composition of Essential Oils from Nineteen Varieties of Basil (*Ocimum basilicum* L.) Growing in Sudan

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Abstract: This study characterized the essential oil compositions of 19 accessions of basil, of which 14 are grown in Sudan as ornamental plants, 3 were introduced from abroad as seeds and 2 were collected from wild Sudanese basil. All were collected as seeds and grown at the University of Gezira farm. Interesting morphological variability among the accessions was noted and recorded in photos. The essential oil content varied from 0.33 to 0.47% in fresh leaves and from 0.13 to 0.4% in fresh flowers. The essential oil components were separated and/ or identified by TLC, GC and GC-MS. Chemical variability among Sudanese basil essential oil was extremely broad. According to the major constituent the basil accessions were classified into 7 groups, namely, high methyl chavicol (>50%), high linalool (>50%), high geraniol (>50%), linalool- methyl cinnamate, linalool-geraniol, methyl cinnamate- linalool and eugenol-linalool. Such classification of Sudanese basil oils is much needed if international marketing of this oil(s) is contemplated.

Key words: Essential oil, extraction, herb, morphological, seed, aromatic

INTRODUCTION

Basil (*Ocimum basilicum* L.), locally known in Sudan as rihan, is an aromatic plant that grown in Sudan as a wild plant and is also cultivated for ornamental purposes. There is no use for basil herb in Sudan; apart from limited folk medicinal applications e.g., use as anti-malarial by Southern Sudanese, or insecticidal use in Western Sudan. Sudanese basils, particularly cultivated ornamental types, show notable variation in chemical composition as judged by odour. Basil is cultivated worldwide as a culinary herb, it is also a source of essential oil for use in foods, flavors and fragrances as well as garden ornamental. The essential oil of basil has therapeutic properties shown stimulant, cephalic, tonic, antidepressant and antibacterial, antifungal, anti spasmodic and antiviral activity in test tube studies (Farnsworth *et al*., 1992). It is also believed to act as a carminative, relieving intestinal gas and as a mild diuretic, though these actions have yet to be definitively proven. Basil with all of its varieties is a popular herb known for its flavorful foliage. The popularity of basil has led to the introduction of many products into the marketplace (Simon *et al*., 1999; Simpson *et al*., 1996). The fresh or dried leaves add a distinctive flavor to many foods, such as Italian style tomato sauces, pesto sauce and salad dressing (Karwowska, 1997). The essential oils and oleo-resins may be extracted from leaves and flowers and used for flavoring in liqueurs and for fragrance in perfumes and soaps. Variable uses of basil are depending on available varieties. For fresh market production, select basil with good flavor and attractive, dark green or purple foliage is used. Scented basils, such as lemon, licorice and cinnamon basil, are used fresh or dried in potpourri, jellies, honeys, vinegars and baked goods. For production of dried leaves or essential oils for the international market, French, American or Egyptian basil may

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be grown. There are also several ornamental type basils (Stuart, 1990). Basil contains a strong-scented essential oil composed primarily of chemical compounds such as eugenol, thymol and estragole. Basil also has what are known as chemotypes, minor variations among plants that contain significantly different mixes of constituents. The exact components of basil oil vary widely, being affected not only by these chemotypes but also by factors such as the time of day of harvest. This may account for some of the variability in scientific research and reports of medicinal efficacy of basil from culture to culture (Martin *et al*., 2003).

Basils have many cultivars, often named by the type of aroma they emit. Basils may look almost identical but have distinct aromas, yet others which appear different may exhibit a similar aroma (Simon *et al*., 1990). 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. More about this could be found in reviews by Keita *et al*. (2001). The use and production of basil essential oil is expanding in the international market according to Lawrence (1988, 1992). The essential oil composition of basil oils is considerable importance in the international market e.g. linalool and methyl chavicol are desired in European sweet basil (Cavalcanti *et al*., 2004). The essential oil composition has been reported for basils from different countries e.g. U.K, Brazil (Silva *et al*., 2003) and Italy (Marotti *et al*., 1996). Also, according to the chemical composition and geographical origin, Lawrence (1988) classified *Ocimum basilicum* types into three groups: European type, Exotic or Reunion type and African type. No research was carried out to evaluate the essential oil variation in basils growing in Sudan. The main objective of this study is to chemically characterize the essential oils of Sudanese basils as world trade demands specific chemical constituents.

MATERIALS AND METHODS

Plant Material

Basil seeds used in these studies were obtained from different parts of Sudan (i.e., Elfashir, Nyala, Elobeid, Eldueim, Khartoum, Wad Medani, Kassala, Halfaelgadida, Port Sudan and Dongola). Commercial basil accessions seed were obtained from Germany and the United Arab Emirates (UAE). Table 1 shows geographical sources of collected basil seed accessions and corresponding plant habitat. Seeds of basil accessions were directly sown on 60 cm wide ridges at the University of Gezira, research farm at Wad Medani, Sudan. Observations were made on growth and flowering of the plants weekly.

Table 1: Geographical sources of collected basil seed accessions used in the study and corresponding plant habitat

Accession No.	Geographical source of seeds	Growth habitat of the plant
1	$Khartoum_1$ botanical gardens (Sudan)	Cultivated (ornamental)
2	$Nishishiba_1$, wad medani (Sudan)	Cultivated (ornamental)
3	$Khartoum_2$ botanical gardens (Sudan)	Cultivated (ornamental)
6	Elfashir (Sudan)	Cultivated (ornamental)
7	id-Hussain, $khartoum_3$ (Sudan)	Cultivated (ornamental)
8	Wad medani (Sudan)	Cultivated (ornamental)
9	$Kassala_1$ (Sudan)	Cultivated (ornamental)
10	$Kassala_2$ (Sudan)	Cultivated (ornamental)
11	Elobeid (Sudan)	Cultivated (ornamental)
12	Nyala (Sudan)	Cultivated (ornamental)
13	Portsudan (Sudan)	Cultivated (ornamental)
14	Dongola (Sudan)	Cultivated (ornamental)
15	Halfa elgadida (Sudan)	Cultivated (ornamental)
16	$Nishishiba_2$, wad medani (Sudan)	Cultivated (ornamental)
17	$Germany_1$ (Europe)	Cultivated (ornamental)
18	$Germany_2$ (Europe)	Cultivated (ornamental)
19	United arab emirates (Asia)	Cultivated (ornamental)
20	$Nishishiba_3$, wad medani (Sudan)	Wild
21	Eldueim (Sudan)	Wild

Essential Oil Extraction and TLC Fractionation

Leaves and flowers of plant material (150 g) were subjected to steam distillation. The extraction was carried out at a rate not exceeding 3 mL m^{-1}, distillation was continued for between 1 ½ and 4 h. The volume of the obtained essential oil was calculated as a percentage volume per weight (% v/w). The essential oils were dried over anhydrous Na_2SO_4, stored in a dark bottle and kept at 4°C until analysis. Silica gel G and GF60 were used to separate basil oil constituents under standard conditions.

GC, GC-MS Analysis

The essential oils composition was determined by Gas Liquid Chromatography (GLC). A PYE UNICAM Gas chromatograph GCD, with a Flame Ionization Detector (FID) and computing integrator, was employed in all analysis. Hydrogen was used for the flame; Oxygen-free nitrogen was the carrier gas. Column (1.2 m) was packed with the liquid phase Polyethylene Glycol Succinate (PEGS) on celite (100-120 mesh). GC conditions were: capillary column: fused silica (poly dimethyl siloxane, 0.25 μm film thickness) 30 m×0.25 i.d; temperature program: 50°C (5 min^{-1}), 50-250 °C (4.5°C min^{-1}), 250°C (10 min^{-1}); carrier gas, He at 100 kPa, linear velocity of 20 cm min^{-1} ; injection port split/splitting (splitting ratio 1:30) at 250°C; injection volume, 0.05 μL. MS conditions were: ionization EI at 70 eV; m/z range, 30-300°C; scan rate sec^{-1}; ionization chamber at 180°C, transfer line at 280°C. Tetradecane was used as internal standard. Compounds were identified by comparison of their mass spectra, Kovat's retention indices (KI) and their Retention Time (RT), with those of standards (authentic) samples and /or the MS library.

RESULTS AND DISCUSSION

Morphological Variability Among Basil Accessions Cultivated at University Farm

In this study 16 accessions of seeds of *Ocimum basilicum* were collected from different parts of Sudan, two accessions were obtained from Germany and one from the United Arab Emirates. Two of the accessions collected in Sudan were wild plants, the rest (14) were from plants grown for ornamental purposes. All throughout the tables and figures of this discussion the accessions are numbered from 1 to 21, assigned before sowing seed in the field. Seeds of accessions number 4 and 5 failed to

Table 2: The quantitative variability parameters of the 19 basil accessions (These parameters were determined at the start of flowering. Days to flowering initial were counted from seed sowing)

Accession No.	Average plant diameter (cm)	Days to flowering initiation	Leaf Length(cm)	Leaf Width(cm)	Average plant height (cm)
1	105	54	7.0	3.8	129
2	61	72	5.3	3.0	74
3	75	71	4.8	2.0	80
6	68	71	6.0	3.0	65
7	58	71	7.0	3.4	47
8	63	64	5.5	3.0	72
9	100	57	5.0	2.3	80
10	86	57	5.0	3.0	65
11	73	57	5.0	2.5	65
12	59	67	6.0	3.0	57
13	105	74	4.8	2.8	78
14	59	65	6.5	2.7	57
15	60	66	5.0	2.8	65
16	63	77	4.8	3.0	66
17	45	70	6.7	3.0	80
18	40	65	9.0	5.8	64
19	69	75	6.5	3.5	65
20	90	60	2.7	0.9	39
21	70	71	4.5	2.4	40

germinate, after several trials and the two numbers were left outs. The photographs show wide morphological variability apparent in leaf size, shape and colour, flower colour, stem colour, inflorescence shape, plant height and growth habit. Quantitative variability parameters have been observed in the morphology of the 19 accessions, viz., plant diameter, days to flowering initiation (from sowing date), leaf length and width, as well as plant height. Average plant height varied from 39 to 129 cm (Table 2). Wild Sudanese *Ocimum basilicum* is dwarf (39 and 40 cm height) compared to the cultivated ornamental types. Days required for the initiation of flowering were different (54 to 77 days).

Leaf size also differed among the accessions. This variability confirms previous study that the aroma of different basil plants greatly differ. Morphological variability was recognized by several authors reporting on *Ocimum basilicum* growing in several geographical zones of the world (e.g. Grayer *et al*., 1996). Differences in morphological forms of *Ocimum basilicum* are a subject amply discussed in the literature. Simon *et al*. (1999) claimed that interspecific hybridization and polyploidy which are common in the genus Ocimum had created taxonomic confusion within the genus. However, basils are sometimes classified according to geographical origin e.g., Egyptian, Reunion basil etc. Darrah (1980) classified *Ocimum basilicum* cultivars into seven groups such as slender, large- leafed, dwarf, purple etc types. It seems that Sudanese basils mostly fall into the slender-type and the purple group.

Essential Oil Content of Leaves and Flowers of Basil Accessions Cultivated in Nishishiba Farm

Basil plants were separated into two parts leaves and flowers, followed by steam distillation of each part. The oil content (%) was expressed on a fresh weight basis. Table 3 shows the essential oil contents of the leaf and flower parts of the different accession. For the leaf part the value ranged from 0.33 to 0.47% for the cultivated- type Sudanese accessions. The three accessions collected from Khartoum (1, 3 and 7) scored a leaf essential oil content of 0.40%. However, the three Wad Medani accessions (2, 8 and 16) were variable scoring 0.33, 0.33 and 0.47%, the latter being the highest value recorded for leaf essential oil content. The two wild- type accessions (from Eldueim and Wad Medani areas) both showed a leaf essential oil content of 0.33%. The accession procured from Emirate seed stores (No. 19) had relatively low leaf essential oil content (0.33%) compared to the Sudanese accessions. The two accessions obtained from German seed stores had even a lower content, both

Table 3: Essential oil content (%) of the fresh leaf and flower parts of the different basil accessions grown in Nishishiba

	Plant part (%)	
Accession No.	Leaf	Flower
1	0.40	0.33
2	0.47	0.33
3	0.40	0.26
6	0.40	0.33
7	0.40	0.40
8	0.33	0.33
9	0.40	0.40
10	0.40	0.33
11	0.33	0.40
12	0.40	0.33
13	0.40	0.33
14	0.33	0.40
15	0.40	0.40
16	0.33	0.33
17	0.20	0.20
18	0.20	0.13
19	0.33	0.26
20	0.33	0.33
21	0.33	0.33

having 0.20% of the leaf fresh weight. On the other hand the essential oil content of the fresh flowers varied from 0.26 to 0.4% for the 14 cultivated Sudanese accessions. For the two wilds-type accessions the flowers contained an intermediate value 0.33%. Flowers of the two types of German origin, again, had the lowest values (0.2 and 0.13%). The essential oil content of the leaf reported in the literature on an oil volume/ fresh weight basis varied from as low as 0.04 to 0.7% for *Ocimum* species in general (Simon *et al*., 1990). Sajjadi (2006) reports that the yield of the essential oils obtained from aerial parts of *Ocimum basilicum* cv. purple and *Ocimum basilicum* cv. green in Iran were 0.2 and 0.5%, respectively, being the main essential oil containing part. Charles *et al*. (1990) reported an essential oil content of 1.54, 0.63 and 0.08 (volume/ fresh weight) for the leaf, flowers and stem, respectively, for *Ocimum micranthum* Willd, grown in Indiana (USA). Suchorska and Osinska (2001) studied 5 forms of sweet basils (*Ocimum basilicum*) from Germany, Romains, Hungary and Egypt and reported that the oil content varied from 0.1 to 0.55%. Ntezurubanza *et al*. (1984)found that essential oil content of *Ocimum kilimandscharium* (camphor basil) grown in USA was 0.5-1%. The floral parts of basil accessions contained 0.13 to 0.4% essential oil. The lower value was, again, present in accession no. 18 (German), the higher value (0.40%) was encountered in 5 accessions, all of the indigenous ornamental types. Although the three accessions from Khartoum (1, 3 and 7) showed the same content of essential oil in their leaves, the same content of the flower was different (Table 3).

The leaf part is the major contributor to plant fresh weight, and also contains somewhat higher essential oil content. It is thus the most important morphological part for essential oil production (Table 4).

Essential Oil Constituents of Basil Accessions

GLC separations of the essential oils of basil accessions (introduced or indigenous ornamental and wild types) contained between 5 and 12 components. All were monoterpenes except for some sesquiterpenes, present in small amounts. The major sesquiterpene, bergamontene, was present as the second main component in accessions No. 13 (Port Sudan) and No. 19 (UAE) where it represented 7.3 and 3.1%, respectively (Table 5). Linalool was present in amounts above 3% in all indigenous and introduced ornamental accessions except accession No. 1 (Khartoum$_1$), its amounts reaching close to 80% in one indigenous ornamental basil No. 13 (Port Sudan) and basil introduced from UAE (No. 19). Linalool was present in only trace amount in the two wild accessions (Table 5). The two wild

Table 4: Plant part contribution (%) to total plant-fresh weight for the studied basil accessions (L= leaf, F= flower)

	Plant part				
Basil accession	Leaf	Flower*	Root	Stem	Total for L and F
1	34.49	20.95	06.78	37.77	55.44
2	38.81	10.07	09.00	42.12	48.88
3	39.97	11.54	08.33	40.16	51.51
6	45.44	15.67	05.16	33.73	61.11
7	41.41	10.34	06.19	42.06	51.75
8	41.31	08.25	06.12	44.32	49.56
9	43.10	09.15	03.54	44.21	52.25
10	42.98	11.81	05.00	40.21	54.79
11	39.34	11.34	09.31	40.01	50.68
12	48.30	10.02	01.67	40.01	58.32
13	47.10	08.99	06.71	37.20	56.09
14	30.82	22.91	08.36	37.91	53.73
15	32.82	24.33	07.96	34.89	57.15
16	42.08	10.89	07.12	39.91	52.97
17	37.20	16.20	06.70	39.90	53.40
18	39.10	14.50	06.20	40.20	53.60
19	32.81	20.93	11.40	34.86	53.74
20	20.80	33.00	08.10	38.10	53.80
21	22.37	34.10	07.03	36.50	56.47

*Young flowers that just opened

Table 5: GLC analysis (%) compositions of essential oils of 19 basil accessions cultivated in Nishishiba

	Basil accession																		
Component	1	2	3	6	7	8	9	10	11	12	13	14	15	16	17*	18*	19*	20	21
Cineol	4.15	8.20	8.00	12.25	7.71	4.21	14.33	11.31	9.40	7.92	4.12	5.70	9.52	9.48	6.01	2.04	0.17	4.28	2.13
Cymene	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.21	0.30
Menthanol	-	-	-	-	-	-	0.65	-	-	-	-	-	5.31	1.01	-	-	-	-	-
Linalool	0.23	9.28	6.35	42.8	29.25	44.05	48.86	50.92	40.44	58.72	78.58	26.58	34.9	29.43	3.86	30.76	79.65	0.99	0.01
Caravone	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	t	-
Camphor	0.22	0..54	0.76	2.85	0.28	0.28	1.3	1.14	2.03	5.82	1.03	0.53	0.4	0.91	3.11	3.31	-	8.43	2.49
Caranol	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-
Geranial	3.22	1.01	-	2.60	1.31	4.35	1.30	0.94	6.81	6.61	0.15	1.03	2.99	0.29	18.1	0.86	1.83	11.82	15.44
Geraniol	0.16	7.54	8.64	27.25	1.33	1.76	10.91	26.76	2.14	18.85	4.09	2.00	17.01	0.55	60.1	3.30	-	58.16	61.32
Estragol	77.2	75.1	71.6	-	2.23	8.49	3.42	1.02	2.16	2.03	2.87	2.18	2.28	6.37	0.04	2.08	1.30	0.16	1.82
Thujo	-	-	-	-	-	0.67	0.02	-	-	-	-	8.01	4.02	9.01	-	-	-	8.03	3.01
Cy.citral	-	-	-	-	-	-	t	-	-	-	-	-	t	0.41	-	-	-	0.20	0.41
Eugenol	-	0.81	0.19	0.42	10.35	0.13	5.26	-	9.18	-	-	-	2.64	1.24	0.56	43.31	-	0.05	-
M.cinnamate	-	1.88	-	2.28	22.70	18.42	22.61	-	22.09	4.08	-	42.40	15.05	40.42	10.3	-	-	-	-
M.eugenol	8.71	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	t	t
Bergamotene	-	-	-	-	0.56	-	1.95	1.83	7.06	-	7.33	1.81	2.11	0.09	-	-	3.13	0.35	1.05
Bisabolene	0.42	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	t	t
Isoledene	-	-	-	-	-	-	0.53	-	-	-	-	-	0.01	0.42	-	-	-	t	t

*Foreign accessions, recently introduced for the study accessions (from Wad Medani and ELdueim) had somewhat different essential oil compositions. However, their essential oils had a distinct composition when compared with the indigenous ornamental types in that they contained geraniol as the major component and geranial as the second component, (Table 5). It is noteworthy that one of the German origin accessions had a similar composition, (Table 5). In fact this German origin accession had leaf morphology and nasal scent similar to the two wild accessions. Geraniol was detected in several indigenous ornamental basils in amounts up to 27.3% (Table 5). However, its presence was not associated with its aldehyde derivative, geranial, in these accessions. Significant amounts of geraniol and its putative metabolic relative, geranial were present only in the two wild basils. Methyl eugenol was detected in the essential oil of only one accession where it represented as much as 9.0% of indigenous ornamental type accession No. 1 ($Khartoum_1$). Miele *et al*. (2001) postulated that this compound could be formed in basil from eugenol by a specific methylation involving an S-adenosylmethionine-dependent O-methyltransferase in a manner analogous to its formation in *Ocimum basilicum* L. cv. Genoese Gigante. However, eugenol, the suggested precursor was not detected in the Sudanese accession (Table 5). Similar results were reported in *O. basilicum* i.e. absence of eugenol and presence of its methyl derivative (Miele *et al*., 2001; Ozcan and Chalchat, 2002). An attempt was made to correlate apparent plant morphological characters especially general inflorescence shape and colour with essential oil chemical constituents. No clear-cut correlations were obtained. One generalization that could be made is all pink- coloured accessions contained Linalool in significant amounts especially when looking at indigenous ornamental basils. However, accessions No. 1, 2 and 3, which looked morphologically different, all contained methyl chavicol in relative amounts more than 70% (Table 5). Sajjadi (2006) compared the chemical composition of the essential oils of two varieties of basil, to which the author referred as *Ocimum basilicum* L. cv. Purple and *O. basilicum* cv. green and reported that the dominant component in both varieties was methyl chavicol. Moreover, the green variety was characterized by a high content (46.1%) of citral (neral and geranial). However, citral was not detected in the oil of purple basil by this author. Although methyl chavicol was detected in both pink and green accessions, neral was not detected in pink accessions. In Sudanese basil both the pink and green basil forms are present. However, neral was not detected, while methyl chavicol was detected. We can therefore conclude that the classification of varieties into purple and green ones has no bearing on chemical constituents.

Some worker were also analysed the content and chemical composition of essential oil from two forms of sweet basil (*Ocimum basilicum* L.), to which the author referred as purple basil and green basil and reported that linalool was isolated at the highest percentage (71.25%) in UK. Methyl chavicol was not found in the purple form, but was isolated at low percentages in the green basil form. Silva *et al*. (2003) studied essential oils of *Ocimum basilicum* L., *Ocimum basilicum* var. minimum L. and *Ocimum basilicum* var. purpurascens grown in north-eastern Brazil and the author reported that *Ocimum basilicum* var. minimum represented a true methyl chavicol chemotype, while the other two species belonged to linalool chemotypes. Marotti *et al*. (1996) studied the essential oil composition of ten Italian basil cultivars of *Ocimum basilicum* in relation to morphological characteristics and they reported that the oils were characterized by the presence of methyl chavicol, linalool and eugenol. Two chemotypes each had their own suite of morphological characters, whereas 2 groups of cultivars, with different morphological parameters belonged to the same chemotype (linalool and eugenol).

Chemical Classification of Sudanese Basils

We attempted to classify the basil accessions analysed according to the major essential oil constituents present. Table 6 shows the major three constituents in the essential oil of each of the 19 accessions. The accessions were classified into 7 classes where either one essential oil constituent dominated in proportions exceeding 50% of the oil constituents or/otherwise, the first two major constituents designed the group, the more dominant compound named first. The major 7 classes were:

Table 6: Top three components in all basil accessions cultivated in Nishishiba (LG= long, green flower; CP= compact, pink flower; LP = long, pink flower; P* = faint pink)

Accession	Inflorescence	First component	Second component	Third component
1	LG	Estragol (77.2%)	M.eugenol(8.71%)	Cineol (4.15)
2	LP	Estragol (75.1%)	Linalool (9.28%)	Cineol (8.20%)
3	LP*	Estragol (71.6%)	Cineol (8.00%)	Linalool (6.35%)
6	LG	Linalool (42.8%)	Geraniol (27.25%)	Cineol (12.25%)
7	LG	Linalool (29.25%)	M.cinnmate (22.7%)	Eugenol (10.35%)
8	LP	Linalool (44.05%)	M.cinnmate (18.42%)	Estragol (8.49%)
9	LP	Linalool (48.86%)	M.cinnamate (22.61%)	Cineol (14.33%)
10	CP	Linalool (50.92%)	Geraniol (26.76%)	Cineol (11.31%)
11	LP	Linalool (40.44%)	M.cinnmate (22.09%)	Cineol (9.40%)
12	LP	Linalool (58.72%)	Geraniol (18.85%)	Cineol (7.92%)
13	LP*	Linalool (78.58%)	Bergamotene (7.33%)	Geraniol (4.09%)
14	LP	*M cinnamate* (42.4%)	Linalool (26.58%)	Thujol (8.01%)
15	LG	Linalool (34.9%)	Geraniol(17.01%)	Mcinnmate(15.05%)
16	CP	Linalool (40.43%)	Linalool (29.43%)	Cineol (9.48%)
17	LG	Geraniol (60.1%)	Geranial (18.1%)	Mcinnamate(10.34%)
18	LG	Eugenol (43.3%)	Linalool (30.76%)	Geraniol (3.30%)
19	CP	Linalool (79.65%)	Bergamotene (3.13%)	Geranial (1.83%)
20	LG	Geraniol (58.16%)	Geranial(11.82%)	Camphor (8.0%)
21	LG	Geraniol (61.32%)	Geranial(15.44%)	Thujol (3.0%)

high methyl chavicol (3 accessions), high linalool (4 accessions), high geraniol (3 accessions), linalool-methyl cinnamate (4 accessions), linalool-geraniol (2 accessions), methyl cinnamate-linalool (2 accessions) and eugenol- linalool (1 accession). The last group (eugenol- linalool) was represented by only one accession, namely, No. 18, one of the two accessions of recent German origin, therefore wild and ornamental indigenous basil accession distributed into the other 6 groups. The two wild accessions represented a unique class, that of the high- geraniol type. It is interesting that the other German accession (No. 17) belonged to this class. None of the indigenous ornamental types was included in the wild basil class. The third recently introduced accession No. 19, from UAE, occupied the class of 'high linalool. Lawrence (1992) analyzed more than 200 oils of *Ocimum basilicum* in the Royal Botanic Gardens, UK and classified them into 4 types based on the main constituent: methyl chavicol, linalool, methyl eugenol and methyl cinnamate. Indigenous basil accessions contained all these four groups. However, the author did not detect an eugenol rich accession. Grayer *et al*. (1996) analyzed 16 accessions of *Ocimum basilicum* grown in England and originally obtained from different countries including Italy, Holland, USA, India, Brazil, Yemen, Israel, UK and Thailand. The researchers classified the essential oils of the basils they studied into 5 groups in which the major constituent was linalool, methyl chavicol, a mixture of linalool and methyl chavicol, mixture of linalool and eugenol, or a mixture of methyl chavicol and methyl eugenol. This classification is different from ours in that the linalool- methyl chavicol, linalool- eugenol and methyl chavicol-methyl eugenol classes were not present in Sudanese basils. Another difference is that Sudan basils contained 3 classes not mentioned by Grayer *et al*. (1996), namely, linalool-geraniol, linalool- methyl cinnamate and high (>50%) geraniol classes. Mondello *et al*. (2002) reported that *Ocimum basilicum* from Bangladesh contained linalool and geraniol as the main components. Murillo (2003) reporting on *Ocimum basilicum* Colombia and Bulgaria showed that linalool and methyl cinnamate were the major components of volatile oils, respectively. Linalool and methyl eugenol are the main components of the essential oils of *Ocimum basilicum* cultivated in Mali (Chalchat *et al*., 1999) and Guinea (Keita *et al*., 2000). Mixtures of methyl chavicol and linalool were the main components of the essential oils of *Ocimum basilicum* cultivated in Rwanda (Ntezurubanza *et al*., 1984), Australia (Lachowiez *et al*., 1997), Togo (Sanda *et al*., 1998), Benin (Moudachirou *et al*., 1999) and Nigeria (Kasali *et al*., 2004). Some reported work did not reveal variability among basil accessions in some countries. Chalchat *et al*. (1999) analysed 24 accessions of *Ocimum basilicum* from Mali and reported that they all contained Linalool as the principal constituent.

Some literature reports dealt with only one accession which will not, of course, show the range of variability within the geographic area. For example, Ozcan and Chalchat (2002) reported that an accession of *Ocimum basilicum* from Turkey contained methyl eugenol as the main constituent.

Sajjadi (2006) analysed two cultivated varieties of Iranian *Ocimum basilicum*, purple and green. The purple variety contained mainly methyl chavicol (52.4%) and linalool (20.1%) while the green variety also contained methyl chavicol (40.5%), geranial (27.6%) and neral (18.5%). The purple variety lacked any citral (geranial and neral).The natures of the constituents of basil essential oil are concern in the international market. The world market for basil oil is dominated by two main types, the European and Egyptian basil oils. The European sweet basil cultivated and distilled in Europe, the Mediterranean region and the United States is considered to be of the highest quality, producing the finest odor. Characteristically, the essential oil from this basil contains high concentra-ions of linalool and methyl chavicol (estragole), at a ratio of 2:1 or 3:1. The Egyptian basil oil is similar but with a much higher concentration and ratio of methyl chavicol relative to linalool. Other distinct types of basil oil traded in the international market and which differ in aroma include the Comoro (also called Reunion or African basil oil), originally distilled only on Reunion Isle but now grown and distilled throughout many parts of Africa, Madagascar and the Seychelles Islands which has a licorice and/ or camphoraceous fragrance. Thus indigenous (and ornamental) Sudanese basils display a wide range of differences in their essential oil constituents that comprised several chemical classes. Such variability is distinct when compared with variability reported in the literature for basils growing elsewhere in the world.

Basil is an important culinary herb and essential oil source widely recognized worldwide. Essential oil characterized into 19 accessions of basil. Essential oil components were separated via TLC, GC and GC-MS.

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