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Chemotypes investigation of *Lavandula* essential oils growing at different North African soils

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Abstract
The chemical composition of the hydrodistilled essential oil of *Lavandula augustifolia* Mill., collected from Batna (Eastern Algerian), was analyzed by GC and GC/MS. 32 components representing 89.6% of the essential oil were detected with 1,8-cineole (29.4%) and camphor (24.6%) as the major components. A comparative study on the compositions of essential oils of *Lavandula* growing at different North African soils is investigated.

Keywords: Lavandula ; Lamiaceae; essential oil; 1,8-cineole; camphor

1. Introduction
Lavandula genus (Lamiaceae) is a source of eco-friendly herbs because of their insecticidal activity due to their 1,8-cineole and camphor content [1;2]. This genus consists of about 20 species and over 100 varieties [3]. In Algerian flora, there are five species from which three are endemic [4]. Lavender is one of the most useful medicinal plants, it is an important source of essential oils that are widely used in fragrance industry including soap, colognes and other cosmetics [5]. The essential oils of *Lavandula* are antiseptic [6], relaxant [7] anti-inflammatory [8] and are used against headaches and scabies [6]. In continuation of our works on bioactive Lamiaceae [9-26], the present work deals with the investigation of the chemical contents of the essential oil of *Lavandula augustifolia* Mill., collected from Batna (Eastern Algerian) together with a comparative study of the compositions of essential oils of *Lavandula* species grown at North Africa.

2. Experimental
Plant material
Flowering aerial parts of *Lavandula augustifolia* Mill., were collected in May 2012, from Batna (Eastern Algerian). A voucher specimen was deposited at the herbarium of the University of Constantine 1, Algeria (LOST La.05.12).

Extraction
The hydrodistillation of fresh flowering aerial parts (100 g) of *Lavandula augustifolia*, for 3h in a Clevenger-type apparatus, according to the British Pharmacopeia, yielded 2.0 % of a yellow good smell essential oil.

GC and GC/MS
GC analysis was performed on a Shimadzu GC17A gas chromatograph equipped with a cross-linked DB5-MS column (40 m × 0.18 mm, film thickness 0.18 μm). The oven temperature was programmed as isothermal at 60°C for 5 min, then raised to 275°C at 5°C/min and held at this temperature for 5 min. Helium was used as the carrier gas at a rate of 1 ml/min. GC/MS was performed using a Shimadzu QP5050 mass selective detector. Operating conditions were the same as for the analytical GC. The MS operating parameters were as follows: ionization potential, 70 ev; ionization current, 2 A ion source temperature, 200ºC; resolution, 1000. scan time, 5 s; scan mass range, 40–400 u; split ratio, 1:10.

Identification of components
Essential oil components were identified based on their retention indices (determined with reference to a homologous series of normal alkanes), and by comparison of their mass spectral fragmentation patterns with those reported in the literature [27-29] and for the major components.

3. Results and discussion

32 compounds were determined in the essential oil, representing 89.6% of total oil content. The main constituents of the essential oil were found to be 1,8-cineole (29.4%) and camphor (24.6%) (Table1).

Table 1: Chemical composition of the essential oil of *Lavandula augustifolia* collected from Batna.

	Compound[a]	RI[b]	(%)
1	α-Thujene	930	1.0
2	α-Pinene	939	1.6
3	Camphene	954	1.5
4	β-Pinene	979	3.2
5	β-Phellandrene	1030	0.7
6	3-δ-Carene	1031	1.0
7	**1,8-Cineole**	**1031**	**29.4**
8	*tert*-Butylbenzene	990	2.6
9	*cis*-Sabinene hydrate	1070	0.6
10	α-Terpinolene	1089	0.4
11	Linalool	1097	1.1
12	*trans*-Thujone	1114	2.7
13	α-Campholenal	1126	0.4
14	*trans*-Sabinol	1142	0.7
15	**Camphor**	**1146**	**24.6**
16	Pinocarvone	1165	0.5
17	β-Fenchyl alcohol	1168	1.9
18	Borneol	1169	4.1
19	Terpinene-4-ol	1177	1.3
20	Cryptone	1186	1.0
21	Shisofuran	1198	1.1
22	Verbenone	1205	0.1
23	Isobornylformate	1239	0.4
24	Bornyl acétate	1289	0.3
25	Dodecamethylcyclohexanesiloxane	1349	0.2
26	*trans*-Caryophyllene	1419	1.2
27	*trans*-α-Bergamotene	1435	0.8
28	*δ*–Germacrene	1485	0.1
29	Viridiflorol	1497	3.3
30	γ-Cardinene	1523	0.7
31	Humulene oxide II	1604	0.4
32	α-Cadinol	1654	0.7
	Total (%)		**89.6**

[a] RI (retention index) measured relative to n-alkanes (C_6-$C2_4$) using a HP-5MS column
[b] Compounds listed in order of their RI

From the literature, essential oils compositions of *Lavandula* growing at North Africa (Table 2) have been reported. We have divided the works on the basis of the geographical distribution of the species in Algeria (Tables 3a-b), Morocco (Table 4) and Tunisia (Table 5). Compared with essential oils of Algerian *Lavandula* (Tables 3a-b), the present essential oil is similar to the essential oils of *L. angustifolia* grown at Kabyle region (La1) [30] and *L. dentata* (Ld1-Ld4) [33-35] only with the main presence of 1,8-cineole (5.0%-38.4%) and to the essential oils of *L. stoechas* from Constantine (Ls2), Tlemcen (Ls3), Jijel (Ls5), Blida (Ls11), Ain Defla (Ls13) and Chlef (Ls14) with the presence of the chemotype couple 1,8-cineole/camphor (10.3%/11.3%) [44], (18.9%/18.1%) [45], (8.7%/5.8%) [46], (7.5%/8.7%) [46], (5.7%/13.2%) [46] and (7.9%/14.5%) [46], respectively. The essential oil of *L. dentata* (Ld2[b]), growing at Tlemcen, is the highest 1,8-cineole content [34]. Tables 3a-b show clearly that Algerian *L.* angustifolia and *L. dentata* essential oils are 1,8-cineole chemotype whereas *L. stoechas* essential oils are fenchone/camphor chemotype. Among the latter, the essential oil of Ls1 is the highest camphor content (22.4%) whereas the essential oil of Ls8 is the richest fenchone content (36.8%). Compared with Algerian *Lavandula* essential oils, the presently reported essential oil of *L. angustifolia* is the highest camphor content.

Table 2: Codes and origins of reported *Lavandula* essential oils of North Africa

Code	**species (fresh flowering aerial parts)**	**Locality**	**Ref**
La1	*L. angustifolia* Mill.	Algeria (Kabyle region)	[30]
La2	*L. angustifolia* Mill.	Tunisia (Sfax)	[31]
Lco	*L. cornopifolia* Poir.	Tunisia (Sidi Bouzid)	[32]
Ld1	*L. dentata* L.	Algeria (Cherchel)	[33]
Ld2	*L. dentata* L.	Algeria (Tlemcen)	[34]
Ld3	*L. dentata* L.	Algeria (Honaine, Tlemcen)	[35]
Ld4	*L. dentata* L.	Algeria (Beni-Saf, Tlemcen)	[35]
Ld5	*L. dentata* L.	Morroco (Northern)	[36]
Ld6	*L. dentata* L.	Morroco (Taforalt, Talazart)	[37]
Ld7	*L. dentata* L.	Tunisia (Grombalia greenhouse)	[38]
Ll1	*L. latifolia* Med.	Tunisia (Bizerte)	[39]
Lm1	*L. multifida* L.	Morroco (Errachidia)	[40]
Lm2	*L. multifida* L.	Morroco (Northern)	[41]
Lm3	*L. multifida* L.	Morroco (Nekkata; Tetuan)	[42]
Lm4	*L. multifida* L.	Tunisia (Sidi Bouzid)	[32]
Lm5	*L. multifida* L.	Tunisia (Grombalia greenhouse)	[38]
Ls1	*L. stoechas* L.	Algeria (Central Algeria)	[43]
Ls2	*L. stoechas* L.	Algeria (Constantine)	[44]
Ls3	*L. stoechas* L.	Algeria (Tlemcen)	[45]
Ls4	*L. stoechas* L.	Algeria (Skikda)	[46]
Ls5	*L. stoechas* L.	Algeria (Jijel)	[46]
Ls6	*L. stoechas* L.	Algeria (Boumerdes)	[46]
Ls7	*L. stoechas* L.	Algeria (Lakhdaria)	[46]
Ls8	*L. stoechas* L.	Algeria (Ain Bessem)	[46]
Ls9	*L. stoechas* L.	Algeria (Guerrouma)	[46]
Ls10	*L. stoechas* L.	Algeria (Tagedit)	[46]
Ls11	*L. stoechas* L.	Algeria (Blida)	[46]
Ls12	*L. stoechas* L.	Algeria (Medea)	[46]
Ls13	*L. stoechas* L.	Algeria (Ain Defla)	[46]
Ls14	*L. stoechas* L.	Algeria (Chelef)	[46]
Ls15	*L. stoechas* L.	Tunisia ((Grombalia greenhouse)	[38]
Ls16	*L. stoechas* L.	Tunisia (Kair-Ouam)	[47]
Lsa1	*L. stoechas ssp atlantica*	Morocco (Oulinès, Rabat)	[48]
Lsa2	*L. stoechas ssp atlantica*	Morocco (Northern)	[49]
Lsl	*L. stoechas ssp lineana*	Morocco (Northern)	[49]
Lss1	*L. stoechas ssp stoechas*	Morocco (Sidi Allal El Bahraoui, Rabat)	[48]
Lss2	*L. stoechas ssp stoechas*	Tunisia (Korbous Montain, Cap Bon region)	[32]

Table 3a: Percentage of major components (≥ 5%) of essential oils of *L. angutifolia* and *L. dentata* from Algeria

Compound[a]	Percenge %					
	La1 [30]	Ld1 [33]	Ld2 [b] [34]	Ld2 [c] [34]	Ld3 [35]	Ld4 [35]
α- Pinene						4.2-7.7
β-Pinene		-	6.1	12.4	6.0-9.3	14.4-26.0
1,8-Cineole	37.8	38.4	48.0	18.3	21.5-36.3	0.9-5.0
Linalool		-	-	5.4		
trans-Pinocarveol		-	-	7.6		6.7-9.3
Pinocarvone						3.5-5.3
Myrtenal						4.8-6.5
β-Caryophyllene	20.9	-	-	-	-	-

[a] Compounds listed in order of their RI; [b] Cluster 1: analysis using K-means clustering; [c] Cluster 2: analysis using PCA (principal component analysis).

Three species are found in Morocco, *L. dentata*, *L. multifida* and *L. stoechas*. From table 4, it appears that the essential oils from *L. dentata* collected from Northern Morocco (Ld5) [36] and from Taforalt (Ld6) [37] are different, except with the main presence of 1,8-cineole. Ld6 essential oil is exceptionally mainly characterized by α-pinene (7.8%-8.4%), β-pinene (27.1%-30.1%), pinocarveol (8.6%-14.8%) and myrtenal (6.8%-8.8%). Differently from Algerian *Lavandula* essential oils, 1,8-cineole is not a chemotype of *Lavandula* essential oils growing at Morocco, it has been found as a main component (1.2-26.0%, 5.5% and 8.6%), only in the essential oil of *L. dentata* (Ld5, Ld6) [36;37] and *L. stoechas* subsp. *stoechas* (Lss1) [48], respectively. Camphor (1.2-72.0%, 24.0%, 72.8%) seems to be a chemotype of essential oils of Ld5 [36], *L. stoechas ssp. atlantica* (Lsa2) and *L. stoechas ssp. lineana* (Ls1), growing at Northern Morocco [49], respectively.

Table 3b: Percentage of major components (≥ 5%) of essential oils of *L. stoechas* from Algeria

Compound[a]	Percentage %													
	Ls1 [43]	Ls2 [44]	Ls3 [45]	Ls4 [46]	Ls5 [46]	Ls6 [46]	Ls7 [46]	Ls8 [46]	Ls9 [46]	Ls10 [46]	Ls11 [46]	Ls12 [46]	Ls13 [46]	Ls14 [46]
p-Cymene	6.5	-	-	-	-	-	-	-	-	-	-	-	-	-
1,8-Cineole	-	10.3	18.9	-	8.7	8.5	-	-	-	-	7.5	-	5.7	7.9
γ–Terpinene	-	11.2	-	-	-	-	-	-	-	-	-	-	-	-
Fenchone	-	-	27.6	11.3	-	24.1	24.1	36.8	16.4	14.6	34.5	26.5	29.9	32.4
Linalool	-	10.7	-	-	-	-	-	-	-	-	7.5	-	5.7	7.9
Camphor	22.4	11.3	18.1	9.8	5.8	-	17.1	15.5	21.8	11.6	8.7	8.9	13.2	14.5
Linalyl acetate	-	15.3	-	-	-	-	-	-	-	-	-	-	-	-
viridiflorol	-	-	-	7.4	37.5	6.8	-	-	7.1	6.4	-	-	5.1	-

[a] Compounds listed in order of their RI

Table 4: **Percentage of major components (≥ 5%) of essential oils of *Lavandula* from Morocco**

Compounds[a]	Percentage %								
	Ld5 [36]	Ld6 [37]	Lm1 [40]	Lm2 [41]	Lm3 [42]	Lsa1 [48]	Lsa2 [49]	Lsl [49]	Lss1 [48]
α-Pinene	-	7.8-8.4	-	-		6.5	-	-	-
Camphene						6.7			
β-Pinene	-	27.1-30.1	-	-		-	-		-
p-Cymene	-	-	-	15.7		-	-		-
1,8-Cineole	1.2-26.0	5.5	-	-		-	-	-	8.6
γ-terpinene	-	-	-	9.5		-	-	-	-
Fenchone	-	-	-	-		9.2	11.5	34.0	30.0
Linalool					7.4				
Camphor	1.2-72.0	-	-	-		39.2	24.0	72.8	18.0
Borneol	1.1-47.0	-	-	-		-	-	5.9	-
Pinocarveol	-	8.6-14.8	-	-		-	-	-	-
Myrtenal	-	6.8-8.8	-	-		-	-	-	-
Thymol	-	-	-	32.0		-	-	-	-
Carvacrol	-	-	66.2	27.8	47.6	-	-	-	-
β-Bisabolene					9.0				
Dodecyl acrylate					8.4				

[a]Compounds listed in order of their RI

The essential oil of *L. multifida* growing at Errachidia (Lm1) is carvacrol chemotype (66.2%) [40], whereas the essential oil of the species growing at Northern Morocco (Lm2) [41] is mainly characterized by *p*-cymene (15.7%), γ-terpinene (9.5%), thymol (32.0%) and carvacrol (27.8%). The essential oil of the species collected from Tetouan (Lm3) is also carvacrol chemotype with the main presence of β-bisabolene (9.0%) and dodecyl acrylamide (8.4%) [42]. Essential oils of *L. stoechas* subspecies Lsa1 [48], Lsa2 [49], Ls1 [49] and Lss1 [48] are fenchone/camphor chemotype (9.2%/39.2%, 11.5%/24.0%, 34.0%/72.8%, 30.0%/18.0%, respectively).
From table 5, concerning the major components of essential oil of *Lavandula* from Tunisia, the couple fenchone/camphor (31.6%/12.4%, 68.2%/11.2%, 34.3%/27.4%) seems to be a chemotype of *L. latifolia* (Ll1), growing at Bizerte [39], *L. stoechas* (Ls16) growing at Kair-Ouam [47] and *L. stoechas* ssp. *stoechas* (Lss2) grown at Korbous Mountain [32], respectively whereas the couple carvacrol/β-bisabolene (18.5%/13.1%, 65.1%/24.7%) is a chemotype of the essential oils of *L. coronopifolia* (Lco) [32] and *L. multifida* (Lm4), collected from Sidi Bouzid [32], respectively. We also distinguish clearly a third chemotype represented by the

couple of linalool/linalyl acetate (20.5%/34.5%, 47.3%/28.7%, 50.1%/7.3%, 20.3%/64.3%), found in the essential oils of *L. augustifolia* (La2) growing at Sfax [31], *L. dentata* (Ld7) and *L. multifida* (Lm5) and *L. stoechas* (Ls15), growing at Grombolia Green house (North Eastern Tunisia) [38], respectively. Thus, only the essential oil of *L. latifolia* from Bizerte (Ll1) [39] is similar to reported Algerian *Lavandula* essential oils with the main presence of 1,8-cineole (11.7%), fenchone (31.6%) and camphor (12.4%).

Table 5: Percentage of major components (≥ 5%) of essential oils of *Lavandula* from Tunisia.

Compound[a]	Percentage %								
	La2 [31]	Lco [32]	Ld7 [38]	Ll1 [39]	Lm4 [32]	Lm5 [38]	Ls15 [38]	Ls16 [47]	Lss2 [32]
Methylcyclopentane	10.2	-	-	-	-	-	-	-	-
Camphene	-	-	-	-	-	10.1		-	-
Myrcene	-	7.5	-	-	-	-	-	-	-
1,8-Cineole	-	-	-	11.7	-	-	-	-	-
trans-β-Ocimene	-	26.9	-	-	-	-	-	-	-
Fenchone	-	-	-	31.6	-	-	-	68.2	34.3
Linalool	20.5	-	47.3	-	-	50.1	20.3	-	-
β- Thujone	-	-	-	-	-	-	8.9	-	-
Camphor	-	-	-	12.4	-	-	-	11.2	27.4
Lavandulol	-	-	-	8.7	-	-	-	-	-
p-cymene-8-ol	-	-	-	7.7	-	-	-	-	-
Linalyl acetate	34.5	-	28.7	-	-	7.3	64.3	-	-
Carvacrol	-	18.5	-	-	65.1	-	-	-	-
β-Bisabolene	-	13.1	-	-	24.7	-	-	-	-

[a]Compounds listed in order of their RI

Through this investigation on *Lavandula* growing at North Africa, the presently studied essential oil of *L. ang*ustifolia, is the highest content of camphor; it's similar in its camphor/1,8-cineole content to Algerian essential oils of *L. stoechas* (Ls2, Ls3, Ls5, Ls11 and Ls13) and of *L. dentata* from Morocco (Ld3) and *L. latifolia* from Tunisia (Ll1), respectively.
Because of its high content of camphor/1,8-cineole, the present essential oil could find applications in the environmental area as an insecticidal [1;2] and as a green corrosion inhibitor [50;51].

Conclusion

The chemical composition of the hydrodistilled essential oil of *Lavandula augustifolia*, collected from Batna (Eastern Algerian), was analyzed by GC and GC/MS. 32 components representing 89.6% of the essential oil were detected with 1,8-cineole (29.4%) and camphor (24.6%) as the major components. Through this investigation on essential oils of *Lavandula* growing at North Africa, it appears that Algerian *L. angustifolia* and *L. dentata* essential oils are 1,8-cineole chemotype whereas essential oils of *L. stoec*has grown at Algeria and Morocco are fenchone or fenchone/camphor chemotype. Carvacrol is a chemotype of *L. multifida* grown at Tunisia and Morocco. Because of the 1,8-cineole/camphor chemotype of the presently reported essential oil of *L. angustifolia*, with the highest camphor content of North African *Lavandula*, this species may exhibit an interesting insecticidal activity.

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References

1. Papachristos D. P., Karamanoli K. I., Stamopoulos, D. C., Menkissoglu-Spiroudi, U., *Int. J. Pest Manag Sci*. 60 (2004) 514.
2. Obeng-Ofori D., Reichmuth, C. H., Bekele, A. J., Hassanali, A., *Int. J. Pest. Manag. Sci.* 44(4) (1998) 203.
3. Kim N. S., Lee, D.D., *J. Chromatogr.* A. 982 (2002) 31.
4. Quezel P., Santa, S., *Nouvelle flore de l'Algérie et des régions désertiques méridionales tome II*. Ed. CNRS, Paris, (1963) 798.
5. Paul J.P., Brophy, J.J., Goldsack, R.J., Fontaniella, B., *Biochem. Syst. & Ecol* .32 (2004) 55.
6. Iserin P., *Encyclopédie des plantes médicinales*. (1997) 110.
7. Takahashi M., Yoshino, A., Yamanaka, A., Asanuma, C., Satou, T., Hayashi, S., Masuo, Y., Sadamoto, K., Koike K., *Nat. Prod. Commun*. 7(11) (2012) 1539.
8. Hajhashemi V., Ghannadi, A., Sharif, B., *J. Ethnopharmacol*. 89 (2003) 67.

9. Touafek O., Nacer, A., Kabouche, A., Kabouche, Z., Bruneau, C., *Chem. Nat. Comp*. 40 (2004) 28.
10. Ghannadi A., Sejjadi, E., Kabouche, A., Kabouche, Z., *Z. Naturforsch C*. 59c (2004) 187.
11. Kabouche A., Boutaghane, N., Kabouche, Z., Seguin, E., Tillequin, F., Benlabed , K., *Fitoterapia* 76 (2005) 450.
12. Kabouche A., Kabouche, Z., Bruneau, C., *Flavr. Fragr. J.* 20 (2005) 235.
13. Kabouche A., Kabouche, Z., Seguin, E., Tillequin, F., Bruneau, C., *Biochem. Syst. & Ecol.* 33 (2005) 813.
14. Kabouche A., Touafek, O., Nacer, A., Kabouche, Z., Bruneau, C., *J. Essent. Oil. Res*. 18 (2006) 175.
15. Kabouche A., Kabouche, Z., Oztürk, M., Kolak, U., Topçu, G., *Food Chem*. 102 (2007) 1281.
16. Kabouche A., Kabouche, Z., Sajjadi, S.E., Ghannadi, A., *J. Essent. Oil. Res*. 19 (2007) 44.
17. Kabouche A., Kabouche, Z., Bioactive diterpenoids of *Salvia species Studies in Natural Products Chemistry* (2008), 35, 753-833. Edited by Atta-u-Rahman, Elsevier.
18. Laggoune S., Kabouche, A., Kabouche, Z., El-Azzouny, M. A., *J. Essent. Oil. Res*. 21 (2009) 67.
19. Kolak U., Kabouche, A., Oztürk, M., Kabouche, Z., Topçu, G., Ulubelen, A., *Phytochem. Anal*. 20 (2009) 320.
20. Kabouche A., Ghannadi, A., Kabouche, Z., *Nat. Prod. Commun*. 4 (2009) 1251.
21. Lakhal H., Kabouche, A., Topçu, G., Kabouche, Z., *Chem. Nat. Comp*. 46 (2011) 964.
22. Laggoune S., Zeghib, A., Kabouche, A., Kabouche, Z., Leon, F., Brouard, I., Bermejo, J., Calliste C.A.,. Duroux, J.L., *Rec. Nat. Prod*. 3 (2011) 238.
23. Ghorab H., Kabouche, A., Kabouche Z., *J. Mater. Environ. Sci.* 5 (1) (2014) 298.
24. Lehbili M., Chibani, S., Kabouche, A., Semra, Z., Smati, F., Abuhamdah, S., Touzani, R., Kabouche, Z., *Der Pharm. Lett*. 5 (2) (2013) 306.
25. Zeghib A., Laggoune, S., Kabouche, A., Semra, Z., Smati, F., Touzani, R., Kabouche, Z., *Der Pharm. Lett.* 5(3) (2013) 206.
26. Lakhal H., Kabouche, A., Alabdul Magid, A., Voutquenne-Nazabadioko, L., Harakat, D., Kabouche, Z., *Phytochemistry* 102 (2014) 145.
27. Adams R. P. (1989). Identification of essential oils by ion mass spectroscopy. Academy Press, Inc, New- York.
28. Swigar A. A., Silverstein, R. M. (1981). Monoterpenes, Infrared, Mass, NMR Spectra and Kovats Indices, Aldrich Chem. Co. Milwaukee, WI, USA.
29. Mclafferty F.W., Stauffer, D.B. (1991). *The Important Peak Index of the Registry of Mass Spectral Data*. John Wiley & Son, New York.
30. Djenane D., Lefsih, K., Yangüela, Y., Roncalès, P., *Phytother.* 9(6) (2011) 343.
31. Errafiy N., Ammar, E., Soukri, A., *J. Essent. Oil Res*. 25(4) (2013) 339.
32. Messaoud C., Chograni, H., Boussaid, M., *Nat. Prod. Res*. 26(21) (2012) 1976.
33. Dob T., Dahmane, D., Agli, M., Chelghoum, C., *Int. J. Aromather*. 15(2) (2005) 110.
34. Bousmaha L., Boti, J.B., Atik Bekkara, F., Castola, V., Casanova, J., *Flav. Fragr. J.* 21 (2006) 368.
35. Bousmaha L., Atik Bekkara, F., Tomi, F., Casanova, J., *J. Essent. Oil Res*. 17 (2005) 292
36. Ilidrissi A., Bellakhdar, J., Berrada, M., Holeman, M., *Colloq. Int. Plant. Aromat. Med. Maroc*. 1st (1985) 213.
37. Imelouane B., Elbachiri, A., Wathelet, J.P., Dubois, J., Amhamdi, H., *W. J. Chem.* 5(2) (2010) 103.
38. Msaada K., Salem, N., Tammar, S., Hammami, M., Saharkhiz, M. J., Debiche, N., Limam, F., Marzouk, B., *J. Essent. Oil Bear. Plants* 15 (6) (2012) 1030.
39. Alatrache A., Jamoussi, B., Tarhouni, R., Abdrabba, M., *J. Essent. Oil Bear. Plants* 10(6) (2007) 446.
40. Znini M., Paolini, J., Majidi, L., Desjobert, J.M., Costa, J., Lahhit, N., Bouyanzer, A., *Res. Chem. Interm.* 38 (2012) 669.
41. El Rhaffari L., Ismaili-Alaoui, M., Belkamel, J., Jeannot, V., *Int. J. Essent. Oil Therapeutics* 1(3) (2007) 122.
42. Douhri B., Douhri, H., Farah, A., Idaomar, M., Skali Senhaji, N., Abrini, J., *Int. J. Innov. Scien. Res*. 1 (2) (2014)116.
43. Dob T., Dahmane, D., Agli, M., Chelghoum, C., *Pharm. Biol.* 44(1) (2006) 60.
44. Barkat M., Laib, I., *J. Pharmacog. Phytother*. 4(7) (2012) 96.
45. Mohammedi Z., Atik, F., *J. Nat. Tech*. (2011) 34.
46. Benabdelkader T., Zitouni, A., Guitton, Y., Jullien, F., Maitre, D., Casabianca, H., Legendre, L., Kameli, A., *Chem. Biodiver*. 8(5) (2011) 937.
47. Bouzouita N., Kachouri, F., Hamdi, M., Chaabouni, M.M., Ben Aissa, R., Zgoulli,. Thonart, S. P., Carlier, A., Marlier M., Lognay, G.C., *J. Essent. Oil Res*., 17 (2005)584.
48. Zrira S., Benjilali, B., *J. Essent. Oil. Res.* 15(2) (2003) 68.
49. Bellakhdar J., Berrada, M., Holeman, M., Ilidrissi, A., *Colloq. Int. Plant. Aromat. Med. Maroc*. 1 (1985) 197.
50. Laqhaili A., Hakiki, A., Mossaddak, M., Boudalia, M., Bellaouchou, A., Guenbour, A., El Morhit, M., Hammouti B., *J. Chem. Pharm. Res*. 5(12) (2013) 1297.
51. Rekkab S., Zarrok, H., Salghi, R., Zarrouk, A., Bazzi, L., Hammouti, B., Kabouche, Z., Touzani, R., Zougagh, M., *J. Mater. Environ. Sci.* 3(4) (2012) 613.