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# Chemical Composition of the Essential Oil of *Teucrium yemense* Deflers

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**Abstract:** The chemical composition of the essential oil (EO) obtained by hydrodistillation from the leaves of *Teucrium yemense* Deflers was determined by GC-MS. Twelve compounds accounting to 77.7% of the total oil were identified. Sesquiterpene hydrocarbons (73.9%) were the predominant portion of the oil with δ-cadinene (34.9%), β-caryophyllene (22.7%), α-humulene (6.1%), and α-selinene (5.4%) as the main constituents.

**Keywords:** *Essential oil, Teucrium yemense, δ-cadinene, GC-MS.*

## 1. Introduction

The genus *Teucrium* which belongs to the family Lamiaceae, includes 300 species widespread all around the world. In flora of Yemen, this genus is represented by three endemic species: *T. balfouri* Vierh, *T. sokotranum* Vierh and *T. yemense* Deflers. The *species* are used in Yemeni folk medicine as antispasmodic and insect repellant. *T. yemense* is an aromatic plant possessing sessile oblanceolate leaves and dense terminal heads of white flowers [1, 2]. Phytochemical studies revealed the presence of iridoid glycosides in the aerial parts of *T. yemense* [3], and showed that the reported essential oils (EOs) of *Teucrium* genus were found to be rich in α pinene and or β-pinene [4, 5, 6, 7, 8, 9, 10], 3-octanol and or linalool [11, 12], sabinene and or limonene [4, 7, 8], β- caryophyllene and or germacrene D [4, 6, 9, 11, 12,13, 14, 15, 16, 17, 18, 19, 20], α-cadinol [8, 10, 22, 23, 24, 25, 26], T-cadinol [8, 13, 27], δ-cadinene [6, 7, 8,10, 14, 17, 24, 25, 28, 29, 30**],** α humulene [6, 13, 15, 28, 31].

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caryophyllene oxide [10,12, 16,], 8-cedren-13-ol [15], E-β-farnesene [16, 17, 20] (Tab.1 and 2). *Teucrium* species were found to possess a wide range of biological activities such as antioxidant, antimicrobial, antifungal, larvicidal [11, 21, 26, 29 31, 32, 33,34, 35], antispasmodic, antinociceptive [36, 37], anti-inflammatory, antiulcer [38,39], hypoglycemic [40], antiacetylcholine esterase[41] and hepatoprotective [42] activities. Some of these effects are attributed to the presence of the EOs.
In the framework of our investigation on the chemical composition of the EOs from Yemeni and Soqotraen aromatic plants [43], we report here for the first time the chemical composition of the EO from the endemic Yemeni plant, *T. yemense*.

## 2. Materials and Methods

### *2.1. Plant Material*

The leaves of *T. yemense* were collected from Taiz town, (Sabir Mountain, altitude 1300 m) in April 2005.The plant was taxonomically identified at the Centre of Soqotra Archipelago Conservation and Development Program (SCDP), Yemen. A voucher specimen (*Teucrium* (YMP- La17) of the plant material has been deposited at the Pharmacognosy Department, Aden University, Yemen.

### *2.2. Essential Oil extraction*

Dried leaves (20 g) of *T. yemense* were hydrodistilled for 3 h in a Clevenger type apparatus according to European Pharmacopoeia to yield 0.45% (w/w) of a pleasant smelling EO. The obtained EO was dried over anhydrous $Na_2SO_4$ and stored at 4 °C before analysis. The EO was subjected to GC-MS-analysis.

### *2.3. Gas Chromatography-Mass Spectrometry*

Analytical GC-MS system consisted of an Agilent 6890N gas chromatograph and a mass selective detector (Agilent®5973 Network MSD). Injection was done with Agilent®7683 Series Injector (Split 1:40 at 250 C, 2.0 µl; carrier gas: helium 1.1 mL/min (60 kPa) at 110ºC; pressure rise: 6 kPa/min). The MS operated in the electron impact mode with an ionization energy of 70eV. The oven program started with 1min at 70°C, the oven temperature was increased at 3°C/min to 220°C. Full scan mass spectra were acquired from 45-650 m/z at a rate of 4.5 scans/s and with a 5.00 min solvent delay. Chromatography was performed using a 30 m DB-5 column (J&W Scientific, Folsom, USA) with 0.25 mm i.d. and 0.25 µm film thickness.
The detected compounds were identified by processing of the raw GC-MS data with ChemStation G1701CA software and comparing with NIST mass spectral database 2.0 d (National Institute of Standards and Technology, Gaithersburg, USA) and from retention times and mass spectra of standard compounds. Relative amounts of detected compounds were calculated based on the peak areas of the total ion chromatograms (TIC).

## 3. Results and Discussion

Hydrodistillation of the leaves of *T. yemense* gave dark brown oil with pleasant smell. The yield of the oil was 0.45% (w/w). This content is higher than that obtained from the flowering aerial parts (0.1-0.3 w/w) in the case of *T. lusitanicum* and *algarbiensis* [7], but lower than the aerial part–oil content from *T. chamaedrys* (0.97% w/w) [14] and *T. atratum* (1.0% w/w) [27].

The composition of the EO is presented in Table 3, where compounds are listed in order of their elution on DB-5 column.

Twelve compounds were identified in the oil (77.7 % ), of which the major compounds were δ-cadinene (34.9%), β caryophyllene (22.7%), α-humulene (6.1%), α-selinene (5.4%) and two unidentified sesquiterpenes (16.5%). The EO was characterized by a high content of sesquiterpene (90.4%), while monoterpenes accounted for 3.8% of the identified compounds. δ-Cadinene, β caryophyllene, and or α-humulene were found as main components in the EOs of *T. montanum* from Serbia [29], *T. flavum*, *T. chamaedrys* from Iran [13,14], *T.alopecurus* from Tunisia [28] and *T. polium* from Jordan [15]. Besides, δ-cadinene was reported to be one of the main constituents in the EOs of *T ramosissimum* (20.0%) from Tunisia [24], *T. stocksianum* (12.4-13.9%) from UAE [25], *T. libanitis* (5.3-9.7%) from Spain [6], *T. capitatum* (3-9.8%) from Portugal [8], and *T. montanum* (6.3%) from Turkey[17], but the amount of δ-cadinene in the above- mentioned oils was lower than its quantity (34.9%) in our sample. β Caryophyllene (22.7%) as the second major oil component was found in other oils of *T. species* such as *T. turredanum* (16-33%%) from Spain [6], *T. orientale L. var. orientale,* ( 7.2-28.8%), *T. pestalozzae* (27.6%), *T. antitauricum* (27.6%), *T. orientale var. puberulens* (21.7%) *T. chamaedrys subsp. lydium* (19.7%) from Turkey [11, 17, 18, 21], *T. scordium* (22.8%),*T. orientale L. var. orientale,* (9.3%) from Iran [16, 12], *T. salviastrum* (19.1-24.1%) from Portugal [20], *T. fruticans* (12-22%) and *T. scorodonia* L. ssp. *Scorodonia* (25.2%) from Italy [9, 19], while the other main compound α- selinene (5.4%) was reported in the EOs of *T. lusitanicum* (1.5-2%) [7] and *T. ramosissimum* (1%) [32]. α-Humulene as representative compound in the oil with (6.1%), was detected also in oils of *T. marum* (7.2%) [31] *T. turredanum* (4.7-10.1%) [6] and *T. polium* (4.3%) [15].

It is noteworthy that no oxygenated monoterpenes and sesquiterpenes were identified in the oil, but the oil is rich in sesquiterpene hydrocarbons (90%). On the other hand, our results seem to be somewhat different from the previously reported data on the oil composition of some *Teucrium species*. Our sample contained β–pinene and limonene in minor amounts and it was devoid of α-pinene, sabinene, thymol, linalool, carvacrol, germacrene D, T-cadinol, and α-cadinol which constitute the main compounds in the oils obtained from several *Teucrium* species (Table 1, 2). The oils of *T. melissoides* from Iran [4] *T. polium* subsp. *capitatum* from France [5], *T. lusitanicum*, *T. algarbiensis* from Portugal [8] and *T. polium ssp aurasiacum* from Algeria [23] were rich in α-pinene, and β-pinene. α-Pinene was found also in high content in the oil of *T. libanitis* from Spain [6]. The EOs of *T. melissoides, T. flavum*, *T. chamaedrys* from Iran [4, 13, 14 ], *T. orientale L. var. orientale, T. pestalozzae*, *T.antitauricum, T. orientale var. puberulens,* and *T. chamaedrys subsp. lydium* from Turkey [11, 17, 18, 21] contained among the main constituents germacrene D, while in *T. atratum* from Algeria [27] and *T. capitatum* from Portugal [8] was T-cadinol among the most principal compounds of the oil. α-Cadinol was identified among the most abundant compounds in *T. polium sp aurasiacum* [23], *T. leucocladum,*[26] *T. stocksianum.* ssp. *stocksianum* from Iran[22], *T. stocksianum* from UAE [25], *T ramosissimum* from Tunisia [24] and *T. capitatum* from Portugal [8]. The reported results on the analysis of the EOs of several *Teucrium* species showed that the sesquiterpenes group is usually dominant, although the main components may vary (Table 1 and 2). Our results concur with these findings.

**Table 1.** Main components of the EOs of some *Teucrium* species from Afroasian origin

| compound | Iran | | | | | | | Algeria | | Tunisia | | UAE | Jordan | Turkey | | | | | Egypt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $T_1$ [4] | $T_2$ [13] | $T_3$ [14] | $T_4$ [22] | $T_5$ [16] | $T_6$ [12] | $T_7$ [10] | $T_8$[27] | $T_9$ [23] | $T_{10}$[24] | $T_{11}$[28 | $T_{12}$ [25] | $T_{13}$ [15] | $T_{14}$ [11] | $T_{15}$[17 | $T_{16}$[17] | $T_{17}$[17 | $T_{18}$ [18] | $T_{19}$[26] |
| *α*-Pinene | 27.7 | | 9.1 | | | | 9.4 | | 9.5 | | | | | | | | 5.2 | | |
| Camphene | | | | 20.6 | | | | | | | | | | | | | | | |
| Sabinene | | | | | | | | | | | | | 5.2 | | | 8.9 | 11.3 | | |
| 3-Octanol | | | | | | | | | | | | | | 3.1-18.3 | | | | | |
| *β*-Pinene | 16.4 | | 4.8 | | | | | | 8.3 | | | | | | | | | | |
| Myrcene | | | | 10.2 | | | | | | | | | | | | | | | |
| Limonene | 12.4 | | 1.9 | | | | | | | | | | | | | | | | |
| Thymol | | | 1.8 | | | | | 22.7 | | | | | | | | | | | |
| Linalool | | | | | | 17.0 | | | | | | | | 5.0-30.9 | | | | | |
| 1, 8 -Cineol | | | | | 6.1 | | | | | | | | | | | | | | |
| Carvacrol | | | | 9.9 | | | | 14.0 | | | | | | | | | | | |
| Nerlidyl acetate | | | | | | | | | | | 12.3 | | | | | | | | |
| β-Bourbonene | | | | | | | | | | | | | | 4.5-19.2 | | | | | |
| β-Caryophyllene | 8.9 | 30.7 | 10.5 | | 22.8 | 9.3 | | | | | 8.2 | | 8.7 | 7.2-28.8. | 27.6 | 9.1 | | 27.6 | |
| α-guaiene | | | | | | | | | | | 10.3 | | | | | | | | |
| E-β-Farnesene | | 2.2 | | | 10.4 | | | | | | | | | | | | 5.5 | | |
| Z-β-Farnesene | | | 12.2 | | | | | | | | | | | | | | | | |
| α-humulene | | 8.4 | 1.5 | | | | | | | | 12.3 | | 4.3 | | | | | | |
| Germacrene D | 10.2 | 21.3 | 16.5 | | | | | | | | | | 6.8 | 6.2-14.0 | 13.8 | 27.9 | 5.8 | 28.2 | |
| δ-Cadinene | | 4.9 | 7.4 | | | | | | | 20.0 | 13.4 | 12.4-14 | 3.5 | | | | 6.3 | | |
| γ-Cadinene | | 1.1 | | | | | 7.4 | | | | | | | | | | | | |
| Patchouli alcohol | | | | | | | | | | | | | | | | | | | 31. |
| Germacradien-4-α-ol | | | | | | | | | | 8.68 | | | | | | | | | |
| Elemol | | | | | | | 6.9 | | | | | | | | | | | | |
| Caryophyllene oxide | | 3.8 | | | 8.6 | 33.5 | 10.6 | 5.6 | | | | | | | | | | 7.5 | |
| T- Cadinol | | 6.9 | | | | | | 45.8 | | | | | | | | | | | |
| α-Cadinol | | | | 19.7, | | | 5.5 | 5.0 | 46.8 | 10.0 | | 12-14.6 | 2.6 | | | | | | 9-21 |
| 3- β-OH-α-muurolene | | | | | | | | | 22.5 | | | | | | | | | | |
| 8-Cedren-13-ol | | | | | | | | | | | | | 24.8 | | | | | | |
| Phytol | | | | | | | | | | | | | | 0.7-27.8 | | | | | |

$T_1$: *T. melissoides*, $T_2$ *T. flavum* $T_3$: *T. chamaedrys*, $T_4$ *T. stocksianum Boiss. ssp. stocksianum*, $T_5$: *T. scordium*, $T_{6:}$ *T. orientale . var. orientale*, $T_{7:}$ *T. persicum* $T_8$: *T. atratum* $T_9$: *T. polium sp aurasiacum*, $T_{10}$: *T ramosissimum*, $T_{11}$: *T.alopecurus*,, $T_{12}$: *T. stocksianum*, $T_{13}$ *T. polium*, $T_{14}$: *T. orientale L. var. orientale,* $T_{15}$*: T. pestalozzae*, $T_{16}$*:T' sandrasicum,* $T_{17:}$ *T. montanum,* $T_{18:}$*T.antitauricum,* $T_{19:}$ *Teucrium leucocladum*

**Table 2.** Main components of the EOs of some *Teucrium* species from European Origin

| Compound | Portugal | | | | Spain | | Italy | | | France | Serbia |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$T_1$[ 7]** | **$T_2$ [7]** | **$T_3$ [8]** | **$T_4$ [20]** | **$T_5$ [6]** | **$T_6$ [6]** | **$T_7$ [31]** | **$T_8$ [9]** | **$T_9$ [19]** | **$T_{10}$ [5]** | **$T_{11}$ [29]** |
| *α*-Pinene | 8.3 | 0.8-8.5 | 7.7 | | 9.9-21.2 | | | | | 28.8 | |
| Sabinene | 7.2 | 2.1-9.6 | 1.1-11.2 | | 5.8-6.6 | | | | | | |
| *β*-Pinene | 10.2 | 2.5-11.9 | 1.3-10.3 | | | | | 7-21 | | 7.2 | |
| *β* -Myrcene | | | | | | | | 13 | | | |
| *p*-Cymene | | | | | | | | | | 7.0 | |
| Limonene | 11.8 | 1.2-11.5 | | | | | | | | | |
| Dolichodial | | | | | | | 9.4 | | | | |
| β-Caryophyllene | | | | 19.1-24.1 | | 16-33 | | 12-22 | 25.2 | | 4.4 |
| Isocaryophyllene | | | | | | | 20.2 | | | | |
| E-β-Farnesene | | | | 26.1-29.2 | | | | | | | |
| α-humulene | | | 1.8-2.7 | | | 4.7-10.1 | 7.2 | | | | 2.0 |
| Germacrene D | 7.6 | | | 13.7-21.6 | | | | 18-24 | | | |
| Germacrene B | | | | | | | | | 26.2 | | |
| β-Selinene | | 1.6-4.0 | | | | | | 7 | | | 8.2 |
| α-Selinene | | 1.5 - 2 | 0.6 | | | | | | | | |
| α- Santalene | | | | | | | 11.0 | | | | |
| β-Sesquiphellandrene | | | | | | | 11.2 | | | | 3.3 |
| cis γ-bisabolene | | | | | | 4.6-6.9 | | | | | |
| β-Bisabolene | | | | | | | 14.7 | | | | |
| γ- Cadinene | | | 0- 5.5 | | | | | | | | |
| δ-Cadinene | 3.0 | 2-7.3 | 3-9.8 | | 5.3-9.7 | | | | | | 17.2 |
| Elemol | 2.5 | 2.6-12.0 | 2.6-12 | | | | | | | | |
| t- Cadinol | | | 3.0-24..1 | | | | | | | | |
| α-Cadinol | | | 1.6-9.8 | | 0.9-6.0 | | | | | | |
| τ-Cadinol | | | | | 1.1-11.8 | | | | | | |
| β-Bisabolol | | | | | | 6.4-8.3 | | | | | |

$T_1$: *T. algarbiensis* $T_2$: *T .lusitanicum*, $T_3$ : *T. capitatum*, $T_4$: *T. salviastrum*, $T_5$ : *T. libanitis*, $T_6$: *T turredanum*, $T_7$ *T. marum*,$T_8$:*T. fruticans*, $T_9$:*T. scorodonia* L. ssp. *scorodonia*, $T_{10}$:*T.polium subsp. capitatum*, $T_{11}$ *T.montanum,* $T_{12}$ *T. divaricatum*

**Table 3.** Main Components of EOs from the leaves of *Teucrium yemense*

| RI | Compounds[a] | (%) |
|---|---|---|
| 986 | α-Pinene | 0.96 |
| 1001 | Δ-3-Carene | 1.4 |
| 1023 | Limonene | 0.55 |
| 1130 | 1,3,8 p-Menthatriene | 0.92 |
| 1383 | α-Copaene | 0.11 |
| 1393 | β-Bourbonene | 0.33 |
| 1431 | β-Caryophyllene | 22.7 |
| 1468 | α-Humulene | 6.14 |
| 1476 | *allo*-Aromadendrene | 1.98 |
| 1503 | α-Selinene | 5.35 |
| 1536 | Eudesma-3,7(11)-diene | 2.41 |
| 1542 | δ-Cadinene | 34.85 |
| 1603 | Unidentified compound | 4.63 |
| 1661 | Unidentified compound | 11.91 |
| | Total identified | **94.24** |

[a]Compounds listed in order to their elution on the DB-5 columnRetention indices on the DB-5 column relative to $C_{10}$-$C_{20}$ *n*-alkanes

In conclusion, the data reported in our study showed that the EO of *T. yemense* possessed the highest content in sesquiterpene hydrocarbons and in δ- cadinene among the reported *Teucrium* oils. The remarkably high content of sesquiterpene hydrocarbons especially δ- cadinene could be of interest for further phytochemical and biological investigation of *T. yemense*, taking into account that δ-cadinene-rich oils showed marked antimicrobial activity [29].

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## References

[1] G. A. Miller and M. Morris (2004). Ethnoflora of the Soqotra Archipelago. Charlesworth Group, Huddersfield, UK. p. 513.

[2] J. R.I Wood (1997). Handbook of the Yemen Flora, Whitstable Litho Printers Ltd, UK. p. 256.

[3] E. Abdel-Sattar (1998). Iridoids from *Teucrium yemense*. *Arch Pharm Res*. **21**, 785-6.

[4] L. Ahmadi, M. Mirza and F. Shahmir (2002). Essential oil of *Teucrium melissoides* Boiss. et Hausskn. ex Boiss. *J. Essent. Oil Res*. **14,** 355-356.

[5] S. Cozzani, A. Muselli, J. M. Desjobert, A. F. Bernardini, F. Tomi and J. Casanova (2005). Chemical composition of essential oil of *Teucrium polium* subsp. *capitatum* (L.) from Corsica. *Flavour and Fragr. J*. **20**, 436-441.

[6] M. A. Blazquez, I. Perez and H. Boira (2003). Essential oil analysis of *Teucrium libanitis* and *T. turredanum* by GC and GC-MS. *Flavour and Fragr. J*. **18,** 497-501.

[7] C. Cavaleiro, L. R. Salgueiro, M. G.Miguel and A. Proença da Cunha (2004). Analysis by gas chromatography-mass spectrometry of the volatile components of *Teucrium lusitanicum* and *Teucrium algarbiensis*. *J Chromatogr A*. **1033**, 187-190.

[8] T. Antunes, I. Sevinate-pinto, J. G. Barroso, C. Cavaleiro and L. R. Salgueiro (2004). Micromorphology of trichomes and composition of essential oil *Teucrium capitatum*. *Flavour and Fragr. J*. **19**, 336-340.

[9] G. Flamini, P. L. Cioni, I. Morelli, S. Maccioni and G. Monti (2001). Composition of the essential oil of *Teucrium fruticans* L. from the Maremma Regional Park (Tuscany, Italy). *Flavour and Fragr. J*. **16**, 367-369.

[10] K. Javidnia, R. Miri, and A.R. Khosravi (2007). Composition of the essential oil of *Teucrium persicum* Boiss. from Iran. *J. Essent. Oil Res*. **19**, 430-432

[11] A. Yildirim, A. Cakir, A.Mavi, M. Yalcin, G. Fauler, Y.Taskesenligil.(2004). The variation of antioxidant activities and chemical composition of essential oils of *Teucrium orientale L. var. orientale* during harvesting stages. *Flavour and Fragr. J*. **19**, 367-372.

[12] K. Javidnia and R. Miri, (2003). Composition of the essential oil of *Teucrium orientale L. ssp orientale* from Iran. *J. Essen. Oil Res*. **15**, 118-119.

[13] Z. F. Baher and M. Mirza, (2003).Volatile constituents of *Teucrium flavum* L. from Iran. *J. Essent. Oil Res.* **15,** 106-107.

[14] K. Morteza-Semnani; M. Akbarzadeh and B. Rostami (2005). The essential oil composition of *Teucrium chamaedrys* L. from Iran. *Flavour and Fragr. J*. **20**, 544-546.

[15] T. Aburjai, M. Hudaib and V. Cavrini (2006). Composition of the essential oil from Jordanian germander (*Teucrium polium* L.). *J. Essent. Oil Res*. **18,** 97-99.

[16] K. Morteza-Semnani; M. Saeedi and M. Akbarzadeh (2007). Essential oil composition of *Teucrium scordium* L. from Iran. *Acta Pharm*. **57,** 499-504.

[17] K. H. C. Baser, B. Demircakmak and H. Duman (1997). Composition of the Essential oil of three *Teucrium* species from Turkey. *J. Essent. Oil Res*. **9**, 545-549.

[18] K. H. C. Baser, B. Demirci, H. Duman and Z. Aytac (1999). Composition of the Essential Oil of *Teucrium antitauricum*, T.Ekim. *J. Essent. Oil Res*. **11**, 61-62.

[19] S. Maccioni, R. Baldini, M. Tebano, P. L. Cioni and G. Flamini (2007). Essential oil of *Teucrium scorodonia* L. ssp. *scorodonia* from Italy. *Food Chem*. **44**, 1393-1395

[20] C. Cavaleiro, L. R. Salgueiro, T. Antunes, I. Sevinate-Pinto and J. G. Barroso (2002). Composition of the essential oil and micromorphology of trichomes of *Teucrium salviastrum*, an endemic species from Portugal. *Flavour and Fragr. J*. **17**, 287-291.

[21] M. Küçük, C. Güleç, A. Yaşar, O. Üçüncü, N. Yaylı, K. Coşkunçelebi, S. Terzioglu and N. Yaylı, (2006). Chemical Composition and Antimicrobial Activities of the Essential Oils of *Teucrium chamaedrys* subsp. *chamaedrys* , *T. orientale* var. *puberulens* , and *T. chamaedrys* subsp. *lydium. Pharm. Biol*., **44**, 592-599.

[22] K. Jaimand, M. B. Rezae, M. A. Soltanipoor and V. Mozaffarian (2006). Volatile Constituents of *Teucrium stocksianum* Boiss. ssp. *stocksianum* from Iran. *J. Essent. Oil Res*. **18,** 476- 477.

[23] A. Kabouche, ; Z.Kabouche; A. Ghannadi and S.E. Sajjadi (2007). Analysis of the essential oil of *Teucrium polium ssp aurasiacum* from Algeria. *J. Essent. Oil Res*. 2007. **19**, 44-46

[24] S. F. Hachicha, T. Skanji, S. Barrek, Z. G. Ghrabi and H. Zarrouk (2007). Composition of the essential oil of *Teucrium ramosissimum* Desf. (Lamiaceae) from Tunisia. *Flavour and Fragr. J*. **22**, 101-104.

[25] M.H. Al-Yousuf, A.K. Bashir, A. Dobos, K. Veres, G. Nagy, I. Mathe and G. Blunden (2002). The composition of the essential oil of *Teucrium stocksianum* from the United Arab Emirates. *J. Essent. Oil Res*. **14**, 47-48.

[26] A.M El-Shazly and K.T. Hussein (2004). Chemical analysis and biological activities of the essential oil of *Teucrium leucocladum* Boiss. (Lamiaceae). *Biochem. System. Ecol.* **32**, 665-674

[27] A. Kabouche, O. Touafek, A. Nacer, Z. Kabouche and C. Bruneau (2006). Volatile oil constituents of *Teucrium atratum*. Pomel from Algeria. *J. Essent. Oil Res*. **18,** 175-177.

[28] S. F. Hachicha, T. Skanji, S. Barrek, H. Zarrouk and Z. G. Ghrabi (2007). Chemical composition of *Teucrium alopecurus* essential oil from Tunisia. *J. Essent. Oil Res*. **19**, 413-415

[29] N. Vukovic, T. Milosevic, S. Sukdolak and S. Solujic,(2007). Antimicrobial Activities of Essential Oil and Methanol Extract of *Teucrium montanum*. *Evid-Based-Complement-Alternat-Med*. **4**, 17-20.

[30] O. Tzakou , V. Roussis , A. Loukis , C. Harvala , E. M. Galati and M. P. Germanò (1997). Essential Oil Analysis of *Teucrium divaricatum* Heldr. ssp. *divaricatum* Growing in Greece. *Flavour and Fragr. J*. **12**, 113 – 115.

[31] D. Ricci, D. Fraternale, L. Giamperi, A. Bucchini, F. Epifano, G. Burini and M. Curini (2005). Chemical composition, antimicrobial and antioxidant activity of the essential oil of *Teucrium marum* (Lamiaceae). *J. Ethnopharmacol*. **98,** 195-200.

[32] M. Ben Sghaier, I. Chraief, I. Skandrani, I. Bouhlel, J. Boubaker, S. Kilani, A. Neffati, A. Mahmoud, M. Hammami, L. G. Chekri and K. Ghedira (2007). Chemical composition and antimicrobial activity of the essential oil of *Teucrium ramosissimum* (Lamiaceae). *Chem Biodivers*. **55**, 93-8.

[33] J. E. Thoppil, J. Minija, A. Tajo and M. J. Deena (2001). Antimicrobial activity of *Teucrium plectranthoides* Gamble essential oil. *J. Nat. Remedies*. **1**, 155-157

[34] K. B. Salah, M. A. Mahjoup, J. P. Chaumont, L. Michel, J. Millet-Clerc, I. Chraeif, S. Ammar, Z. Mighri and M. Aouni (2006). Chemical composition and in vitro antifungal and antioxidant activity of the essential oil and methanolic extract of *Teucrium sauvagei* Le Houerou . *Nat. Prod. Res.* **20**, 1089-97

[35] V. Saroglou, M. Arfan, A. Shabir, D. Hadjipavlou-Litina and H. Skaltsa (2007). Composition and antioxidant activity of the essential oil of *Teucrium royleanum* Wall. ex Benth growing in Pakistan. *Flavour Fragr. J*. **22**, 154–157

[36] M. Abdollahi, H. Karimpour, M. Esfehani and R. Hamid (2003). Antinociceptive effects of *Teucrium polium* L. total extract and essential oil in mouse writhing test. *Pharmacol. Res*. **48,** 31-35.

[37] H. Parsaee and R. Shafiee-Nick (2006). Anti-Spasmodic and Anti-Nociceptive Effects of *Teucrium polium* Aqueous Extract *Iranian Biomed. J.* **10**, 145-149

[38] B.F. Puntero, H. Peinado and A.M. Villar del Fresno (1997). Anti-inflammatory and antiulcer activity of *Teucrium buxifolium*. *J. Ethnopharmacol*. **55**, 93-98.

[39] M. Tariq, A.M. Ageel, M.A. al-Yahya, J.S. Mossa and M.S. al-Said (1989). Antiinflammatory activity of *Teucrium polium*. Int. J. Tissue React., **11**, 185-188 [40] M. N. Gharaibeh, H. H. Elayan and A.S. Salhab (1988). Hypoglycemic effects of *Teucrium polium.* J. *Ethnopharmacol*. **24**, 93-99.

[41] B. Ahmad, S.M. Mukarram Shah, H. Khan and S. M. Hassan Shah (2007). Enzyme inhibition activities of *Teucrium royleanum*. *J Enzyme Inhib Med Chem*. **22**, 730-2.

[42] T. K. Panovska, S. Kulevanova, I. Gjorgoski, M. Bogdanova and G. Petrushevska (2007). Hepatoprotective effect of the ethyl acetate extract of *Teucrium polium* L. against carbon tetrachloride-induced hepatic injury in rats. *Acta Pharm*. **57**, 241.

[43] N. A. Awadh Ali, M. Wurster, N. Arnold, A. Teichert, J. Schmidt, U. Lindequist and L.Wessjohann (2008). Chemical Composition and Biological Activities of Essential Oils from the Oleogum Resins of Three Endemic Soqotraen *Boswellia* Species. *Rec. Nat. Prod*. **2**, 6-12.