Journal of Applied Pharmaceutical Science Vol. 6 (07), pp. 038-042, July, 2016
Available online at http://www.japsonline.com
DOI: 10.7324/JAPS.2016.60705
ISSN 2231-3354

Essential oil composition and variability of *Artemisia herba-alba* Asso. growing in Tunisia: comparison and chemometric investigation of different plant organs

Sana Bellili [a,b], Wissal Dhifi [c], Abdulrahman Ben Khsif Al-Garni [d], Guido Flamini[e], Wissem Mnif[a,d,*]

[a]University Manouba, ISBST, BVBGR-LR11ES31, Biotechpole Sidi Thabet, 2020, Ariana, Tunisia. [b]Faculty of Sciences of Bizerte, Jarzouna - Bizerte - 7021, University of Carthage, Tunisia. [c]UR Ecophysiologie Environnementale et Procédés Agroalimentaires, Biotech Pole de Sidi Thabet. Université de la Manouba, Tunisie. [d]Faculty of Sciences and Arts in Balgarn PO BOX 60 Balgarn- Sabt Al Olaya 61985, University of Bisha, Saudi Arabia. [e]Department of Pharmaceutical Sciences, Bioorganic Chemistry and Biopharmaceutics, University of Pisa, Via Bonanno 33, 56126, Pisa, Italy.

ARTICLE INFO

Article history:
Received on: 27/01/2016
Revised on: 03/03/2016
Accepted on: 15/05/2016
Available online: 28/07/2016

***Key words**:*
Artemisia herba-alba; GC-MS; chemical variability; curcumen-15-al.

ABSTRACT

This study was conceived to investigate the composition of four essential oils (EOs) extracted by hydrodistillation from four parts (leaves, stems, leaves/stems, roots) of *Artemisia herba-alba* growing wild in the Center of Tunisia. For this, *Artemisia herba-alba* aerial and roots parts were shade dried with ventilation at room temperature. Then, plant different parts were cut into small pieces and subjected to hydrodistillation using a Clevenger-type apparatus. The gas chromatography (GC) analyses were accomplished with a HP-5890 Series II instrument. The main results showed a total of 152 compounds detected and identified by GC and GC-MS and accounting for 91.3-99.7% of the whole oil. The four oils were characterized by the predominance of monoterpene derivatives (68.2-99.5%) and the major volatile constituent was *α*-thujone (18.2-45.5%). Qualitative and quantitative differences between the four essential oils have been noted for some compounds. The main compounds of leaves essential oil were α-Thujone (45.5%), β-Thujone (11.4%), trans-sabinyl acetate (10.1%), 1,8-Cineole (7.4%) and camphor (6.8%). α-Thujone (27.5%) was also the main compound in the essential oil of leaves/stems, followed by camphor (22.9%), 1,8-cineole (8.3%), β-thujone (8.2%) and camphene (5.6%). The essential oil of stems was dominated by α-Thujone (28%) followed by β-Thujone (11.4%) and chrysantenone (11%). In the essential oil of roots, α-thujone was less represented (18.2%), followed by camphor (14.6%) and curcumen-15-al (14.3%). It is important to mention that curcumen-15-al has been reported for the first time in *Artemisia herba-alba* oil Our results revealed avariability in the chemical composition and the yield of the EOs from *Artemisia herba-alba*. Moreover, curcumen-15-al is a new chemotype first found in *Artemisia herba-alba* from Tunisia.

INTRODUCTION

The genus *Artemisia* is one of the largest and most widely distributed genera of *Asteraceae* family includes 400 species (Judd *et al.*, 2002). *Artemisia* species are of great socio-economic thanks to their antioxidant potential besides antimicrobial and anti-parasital activities of their essential oils (Eos). *Artemisia herba-alba* is a medicinal and aromatic dwarf shrub that grows wild in arid and semi-arid areas of the Mediterranean basin, extending into northwestern Himalayas (Mohamed *et al.*, 2010). In Tunisia, *Artemisia herba-alba* is found from the mountains around Jebel Oust to the south of the country (Mighri *et al.*, 2009). Herbal tea from this plant has been used as analgesic, antibacterial, antispasmodic and hemostatic agents (Laid *et al.*, 2008).

** Corresponding Author*
Wissem Mnif, LR11-ES31 Laboratory of Biotechnology and Valorisation of Bio-GeoRessources, Higher Institute of Biotechnology of Sidi Thabet, BiotechPole of SidiThabet, 2020, University of La Manouba, Tunisia.
Email:w_mnif@yahoo.fr

Further, the plant is widely used in traditional medicine for the treatment of diabetes, bronchitis, diarrhea, hypertension, and neuralgias (Tahraoui *et al.*, 2007; Mahomoodally *et al.*, 2013). EOs of this species are known for its therapeutic disinfectant, anthelminthic and antispasmodic virtues (Hatimi *et al.*, 2001). The aim of this paper is to provide more information on the chemical composition of the EOs extracted from different parts of *A. herba-alba* collected in the Center of Tunisia.

MATERIAL AND METHODS

Plant material

Artemisia herba-alba aerial (leaves and stems) and roots parts were collected from Chrarda locality in the Center of Tunisia (Fig. 1). Plant identification was carried out by Pr. MA Nabli, botanist at the Faculty of Sciences of Tunis-Tunisia. All samples were shade dried with ventilation for 15 days at room temperature. The plant used parts was cut into small pieces and subjected to hydrodistillation using a Clevenger-type apparatus (Clevenger, 1928) for 4 h. The oil was collected and stored at 4°C in amber vials before analysis.

Fig 1. Origin of *Artemisia herba-alba* plant grown in Tunisia.

Gas Chromatographic-Mass Spectral Analysis

The GC analyses were accomplished with a HP-5890 Series II instrument equipped with HP-WAX and HP-5 capillary columns (30 m × 0.25 mm, 0.25 µm film thickness). The temperature program was as follows: 60°C for 10 min, ramp of 5°C/min up to 220 °C; injector and detector temperatures 250°C; carrier gas nitrogen (2 mL/min); detector dual FID; split ratio 1:30; injection of 0.5 µL. The identification of the constituents was performed, for both columns, by comparison of their retention times with those of pure authentic samples and by mean of their linear retention indices (L.R.I) relative to the series of *n*-hydrocarbons. The relative proportions of the essential oils constituents were percentages obtained by FID peak-area normalization. GC–EIMS analyses were performed with a Varian CP- 3800 gas chromatograph equipped with a DB-5 capillary column (30 m × 0.25 mm, coating thickness 0.25 µm) and a Varian Saturn 2000 ion trap mass detector. Analytical conditions were as follows: injector and transfer line temperature 220 and 240 °C, respectively; oven temperature was programmed from 60 to 240 °C at 3 °C/min; carrier gas helium at 1 mL/min; injection of 0.2 µL (10% hexane solution); split ratio 1:30. Identification of the constituents was based on comparison of the retention times with those of the authentic samples, comparing their L.R.I. relative to the series of *n*-hydrocarbons and on computer matching against commercial (NIST 98 and ADAMS) and home-made library mass spectra, built up from pure substances and components of known oils and MS literature data (Adams, 2009).

RESULTS AND DISCUSSION

The EO yields were respectively of 1.86%, 0.42%, 0.25% and 0.1% for the leaves, the leaves/stems, the stems and the roots, respectively. According to Haouari and Ferchichi (2009), the oil yield varied between 0.68% and 1.93% in EOs of *Artemisia herba alba* growing in the South of Tunisia. The chemical composition of the analyzed oils is reported in Table 1. Altogether, 152 compounds were identified in these four EOs, accounting for 99.7%, 99.7%, 98.7% and 91.3% of the whole oils, respectively. All the EOs obtained from the different parts were characterized by a high content of *α*-Thujone. It is important to announce that in the EOs of roots, α-Thujone was less represented (18.2%), followed by camphor (14.6%) and curcumen-15-al (14.3%). Curcumen-15-al has been reported for the first time in *Artemisia herba-alba* oil and the correspondent oil should be considered as a new chemotype. *α*-Thujone has been reported as the major constituent of the *Artemisia herba-alba* essential oil originating from Tunisian semi-arid and south region (Akrout, 2004; Kadri *et al.*, 2011), Jordan (Hudaib and Aburjai, 2006), Algeria (Belhatta *et al.*, 2014), Morocco (Paolini *et al.*, 2010) and Israel (Fleisher *et al.*, 2002). This monoterpenic cetone confers to this plant its characteristic smell of Mentha and its bitter taste. Furthermore, leaves EO was characterized by the highest *α*-Thujone amount (45.5%). *β*-Thujone (11.4%) was the second component followed by *trans*-sabinyl acetate (10.1%), 1,8-cineole (7.4%), camphor (6.8%) and isoborneol (3.4%). The main components of this oil differed from those reported by Akrout et *al.* (2010), and according to them, *β*-Thujone was the main component of the oil extracted from the leaves of *Artemisia herba-alba* growing in the South of Tunisia. Furthermore, in this oil, oxygenated terpenes were the most represented compounds (93.8%), but oxygenated monoterpenes prevailed over oxygenated sesquiterpenes (93.3% vs. 0.5%, respectively). Terpene hydrocarbons were present in lower amount (5.7%) divided between monoterpene (4.6%) and sesquiterpene hydrocarbons (1.1%).

Haouari and Ferchichi (2009) reported that the main components were cineole, thujones, chrysanthenone, camphor, borneol, chrysanthenyl acetate, sabinyl acetate, davana ethers and davanone in Eos of Artemisia herba alba growing in the South of Tunisia. They also reported Twelve samples characterized by monoterpenes as major components amounting to more than 57% of the total oil, three had last three samples had approximately the same percentage of monoterpenes and sesquiterpenes.

In addition, non-terpene oxygenated compounds were scarcely detected (0.2% for (*z*)-Jasmone) and phenylpropanoids were present only in traces (eugenol and methyl eugenol). In the EO of leaves/stems, the main compounds were *α*-Thujone (27.5%) and camphor (22.9%) followed by 1,8-cineole (8.3%), *β*-Thujone (8.2%) and camphene (5.6%). It should be noted that camphor had the highest percentage in this oil. Also, in this oil, oxygenated monoterpenes represented the main constituents (87.4%) whereas monoterpene hydrocarbons were more represented, in particular bicyclic monoterpenes (9.7%), but their percentage (12.1%) was considerably lower than that of oxygenated monoterpenes. On the other hand, sesquiterpenes were particularly absent, either as hydrocarbons (only present as trace amounts) or oxygenated derivatives (0.2% for globulol). Non-terpene oxygenated compounds were detected only in trace amounts.

Table 1: Composition (in% of the total identified EO) [a] of the essential oils of leaves, leaves/stems, stems and roots of *Artemisia herba-alba* from center Tunisia.

Constituents	L.R.I. [b]	Leaves	Leaves/stems	Stems	Roots
(E)-2-Hexenal	855	- [c]	-	0.2	0.2
(Z)-Salvene	856	0.7	-	-	-
(E)-Salvene	867	tr	-	-	-
n-Hexanol	868	-	tr [d]	tr	0.2
Heptanal	900	-	-	-	tr
Tricyclene	928	0.2	0.1	tr	tr
α-Thujene	932	tr	0.3	tr	-
α-Pinene	939	-	0.4	0.3	-
Camphene	954	1.5	5.6	0.8	1.5
Thuja-2,4(10)-diene	957	tr	Tr	-	-
Benzaldehyde	962	-	-	tr	0.2
Heptanol	970	-	Tr	tr	tr
Sabinene	977	1.2	3	0.6	0.7
β-Pinene	980	0.2	0.4	0.1	-
6-methyl-5-hepten-2-one	986	-	-	tr	tr
3-Octanone	988	tr	Tr	-	-
cis-meta-mentha-2,8-diene	987	-	-	-	0.3
dehydro-1,8-Cineole	991	tr	-	-	-
Myrcene	993	0.2	0.2	-	-
3-Octanol	994	tr	Tr	-	-
Mesitylene	996	-	-	tr	-
Yomogi alcohol	999	tr	-	-	-
α-Phellandrene	1005	-	-	tr	-
α-Terpinene	1019	0.2	0.4	0.1	Tr
p-Cymene	1028	0.4	1	0.5	0.4
1,8-Cineole	1034	7.4	8.3	1.7	3
Santolina alcohol	1040	tr	-	-	-
Lavender lactone	1042	-	-	-	Tr
Phenyl Acetylaldehyde	1044	-	Tr	tr	0.3
(E)-*β*-Ocimene	1051	-	Tr	-	-
γ-Terpinene	1062	0.4	0.6	0.2	0.2
Artemisia ketone	1065	tr	-	-	-
cis-Sabinene hydrate	1069	0.2	0.5	0.4	0.4
n-Octanol	1071	-	tr	-	Tr
cis-Linalool oxide	1075	tr	tr	tr	0.4
Artemisia alcohol	1086	tr	-	-	-
Terpinolene	1089	tr	0.1	0.1	Tr
6,7-epoxy Myrcene	1090	-	tr	-	-
trans-Linalool oxide	1094	tr	-	-	-
trans-Sabinene hydrate	1098	0.2	0.5	0.6	0.7
Linalool	1100	tr	tr	-	-
α-Thujone	1103	45.5	27.5	28	18.2
1-Octen-3-yl acetate	1113	-	tr	-	-
β-Thujone	1116	11.4	8.2	11.4	5.7
cis-*p*-menth-2-en-1-ol	1122	-	1.5	1.4	1.7
trans-Pinene hydrate	1123	tr	-	-	-
Chrisanthenone	1125	0.5	0.7	11	1.6
Dihydro Sabina ketone	1126	0.7	-	-	-
cis-Limonene oxide	1135	-	tr	-	-
(iso)-3-Thujanol	1138	tr	tr	tr	-
trans-Pinocarveol	1140	2.4	2.7	4.3	3.6
Terpinen-1-ol	1143	-	-	-	Tr
Camphor	1144	6.8	22.9	8	14.6
(neo-iso)-3-Thujanol	1152	tr	-	-	-
(neo)-3-Thujanol	1154	-	tr	tr	Tr
Sabina ketone	1156	0.2	0.3	0.2	0.2
Isoborneol	1158	-	2.8	2.7	2.5
Pinocarvone	1166	0.5	1.1	2.3	1.1
Borneol	1169	3,4	-	-	-
1-Nonanol	1172	-	-	tr	Tr
cis- Pinocamphone	1174	-	tr	tr	Tr
4- Terpineol	1178	0.9	1.4	0.9	1.3
Naphtalene	1180	-	-	-	0.7
a-Thujenal	1182	tr	0.2	0.3	Tr
α-Terpineol	1190	tr	0.2	0.2	0.3
cis-Piperitol	1194	-	-	0.7	0.4
Myrtenal	1195	0.4	0.6	-	0.5
Myrtenol	1196	tr	-	-	-
trans-Piperitol	1205	0.3	0.9	2	1.7
γ-Terpineol	1207	tr	-	0.1	0.2
Vebrenone	1214	tr	-	-	-
trans-Carveol	1221	tr	tr	tr	Tr
Citronellol	1229	-	-	-	0.3
cis-Carveol	1233	tr	-	-	-
Phenol,2-ethyl-6-methyl	1236	tr	-	-	-
cis-Ascaridole	1237	-	tr	tr	-
Cuminaldehyde	1240	0.2	0.2	0.3	Tr
Carvone	1243	tr	0.3	0.3	0.7
Carvotanacetone	1247	tr	tr	tr	-
Piperitone	1258	0.4	1.5	2.1	3.3
Bornyl acetate	1260	0.2	-	-	-
cis-Chrysanthenyl acetate	1263	0.5	0.1	1.1	0.3
Geranial	1278	-	tr	-	-
Isobornyl acetate	1285	0.7	0.7	0.8	0.4
trans-Sabinyl acetate	1291	10.1	4.3	7.2	2.4
trans-Pinocarvyl acetate	1296	tr	-	-	-
Terpinen-4-ol acetate	1300	-	tr	0.1	-
Carvacrol	1301	tr	tr	0.1	Tr
Iso-Ascaridole	1303	tr	tr	tr	-
6-Hydroxy carvotanacetone	1311	-	tr	0.3	Tr
cis-Pinocarvyl acetate	1312	tr	-	-	-
Myrtenyl acetate	1327	tr	tr	-	-
α-Terpinyl acetate	1352	tr	-	-	-
Eugenol	1361	tr	-	tr	-
α-Copaene	1376	tr	tr	tr	-
β-Maaliene	1380	-	-	tr	Tr
α-Isocomene	1386	-	-	tr	Tr
(E)-Jasmone	1391	-	-	tr	-
(Z)-Jasmone	1393	0.2	tr	0.6	0.2
Methyl Eugenol	1404	tr	-	tr	-
β-Isocomene	1407	-	-	tr	-
α-Gurjunene	1409	-	-	-	Tr

β-Caryophyllene	1418	tr	-	-	-
p-Cymen-7-ol acetate	1423	-	tr	tr	-
(E)-Geranyl acetone	1454	-	-	-	Tr
Alloaromadendrene	1461	-	tr	tr	-
β-Chamigrene	1475	tr	tr	-	Tr
Germacrene D	1480	0.7	tr	0.2	Tr
(E)-*β*-Ionone	1485	-	-	-	0.2
β-Silinene	1489	tr	-	-	-
Valencene	1492	-	-	-	Tr
Bicyclogermacrene	1494	0.4	tr	0.2	-
trans-*γ*-Cadinene	1513	-	tr	-	Tr
Cubebol	1515	-	-	0.2	-
β-Curcumene	1516	tr	-	-	-
δ-Cadinene	1524	tr	tr	-	-
Italicene epoxide	1549	-	-	tr	-
Ledol	1565	-	tr	-	-
trans-Nerolidol	1566	tr	-	0.3	-
Germacrene D-4-ol	1574	-	-	tr	-
Spathulenol	1576	0.5	tr	1.5	0.6
Caryophyllene oxide	1581	tr	tr	0.5	0.6
Globulol	1583	-	0.2	-	0.5
Viridiflorol	1590	-	-	0.3	-
β-Copaen-4-*α*-ol	1591	tr	tr	0.4	0.2
Carotol	1594	-	-	0.4	-
epi Cedrol	1596	-	-	0.2	0.4
Humulene epoxide II	1607	tr	-	-	-
β-Himachalene oxide	*1616*	-	-	0.2	-
epi-10-*γ*-Eudesmol	1620	-	-	-	0.2
1-epi-Cubenol	1628	tr	tr	-	0.2
5-Cedranone	1630	-	-	0.1	-
γ-Eudesmol	1631	-	-	-	0.2
β-Cedren-9-one	1632	-	-	0.4	-
Epoxy-Allo-Aromadendrene	1634	tr	-	-	0.2
Cubenol	1641	-	-	0.3	-
Tau-Cadinol	1642	-	tr	0.3	0.3
β-Eudesmol	1649	tr	-	tr	0.4
Selin-11-en-4*α*-ol	1652	-	-	-	0.2
α-Eudesmol	1654	tr	-	tr	-
α-Cadinol	1655	-	-	-	0.6
Valerianol	1658	-	-	0.2	-
Valeranone	1675	-	-	0.3	0.5
Ishwarone	1682	-	-	0.2	-
Acorenone	1693	-	-	0.2	0.4
Germacrone	1694	-	-	0.3	0.2
Mayurone	1710	-	-	-	0.5
Curcumen-15-al	1713	-	-	0.3	14.3
Cyclocolorenone	1761	-	-	tr	0.3
Benzyl benzoate	1763	-	-	tr	-
14-oxy-*α*-Muurolene	1769	-	-	tr	-
Heneicosane	2100	-	-	-	0.3
Total identified(%)		99.7	99.7	98.7	91.3

[a] Percentages obtained by FID peak –area normalization.
[b] Linear retention indices (HP-5 column).
[c] Not detected.
[d] tr < 0.1%

Stems EO was characterized by the predominance of *α*-Thujone (28%). *β*-Thujone and chrysanthenone were detected in similar amounts (11.4% and 11%, respectively). camphor and *trans*-sabinyl acetate were detected at significant amounts (8 and 7.2% respectively). Chrysanthenone was found at its highest percentage; however it was scarcely represented in the other EOs with an amount varying from 0.5% to 1.6%. Also, in the stems, monoterpenes were the main class of volatiles (91.2%), followed by sesquiterpenes (6.7%) and no terpenic oxygenated (0.8%). Among monoterpenes, oxygenated ones were more abundant than hydrocarbons (88.5% vs. 2.7%, respectively). Also among sesquiterpenes, oxygenated derivatives were detected in higher percentage (6.3%) than hydrocarbons ones (0.4%). Phenylpropanoids and no terpenic hydrocarbons were represented in traces.

The EO of roots was dominated by *α*-Thujone whose amount was lower than in the other oils (18.2%). Besides, this oil was characterized by high camphor and curcumen-15-al percentages (14.6% and 14.3%, respectively). It seems that curcumen-15-al was exclusive of EO; however it was detected only in very small amount in the stems (0.3%). It should be noted that this oil type was not reported in literature because. It is reported at the first time that such codominance of 3 main components of *α*-thujone, camphor and curcumen-15-al has been reported in *Artemisia herba-alba* oils. Curcumen-15-al should be considered as a new chemotype of *Artemisia herba-alba*. Like *α*-thujone, *β*- thujone was found with a lower percentage than that found in the others examined oils (5.7% vs. 11.4% and 8.2%).

Comparing the four EOs, monoterpenes had the highest amounts in leaves/stems (99.5%), followed by leaves (97.9%), stems (91.2%) and roots (68.2%). Among studied oragns, leaves accumulated the highest amount of oxygenated monoterpenes (93.3%). For sesquiterpenes, the most important percentages were detected in roots (20.8%), followed by stems (6.7%), leaves (1.6%) and leaves/stems (0.2%). Furthermore, the highest value of oxygenated sesquiterpenes was found in the roots (20.8%).

CONCLUSION

Artemisia herba-alba EOs were characterized by qualitative and quantitative differences depending on the part of the plant. The variability was especially related to the proportions of constituents and relatively to the presence of new compounds or the absence of particular ones. It has been suggested that the variation in EO yield and the composition could be due to the activity of enzymes responsible for the biosynthesis of volatile oils (Hendawy and Khaled, 2005).

According to our results, it seems that chemical composition of *Artemisia herba-alba* essential oil varied significantly with the part of the plant. This characteristic should contribute to the understanding of the pharmacological activities of the herb. Furthermore, it must be taken into account when the plant could be used as aroma source and also in its valorization in many industrial sectors in relation to the type of volatiles accumulated.

COMPETING INTERESTS

The authors declare that they have no competing interests.

ACKNOWLEDGEMENTS

This study was funded by the Tunisian Ministry of Higher Education and Scientific Research. Thanks are also to Dr. Sharif Mohammad Shahidullah from Department of English, Faculty of Sciences and Arts in Balgarn, University of Bisha, Saudi Arabia for his contribution in the correction of English language.

REFERENCES

Adams RP. 2009. Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry (4th ed). Allured Publishing Co., Carol Stream, IL: USA.

Akrout A. Essential oil study of some pastoral plants from.Matmata (south Tunisia) [in French]. Cah. Options. Med, 2004; 62: 289-292.

Akrout A, El Jani H, Amouri S, Neffati M. Screening of antiradical and antibacterial activities of essential oils of *Artemisia campestris* L., *Artemisia herba alba* Asso, and Thumus capitatus Hoff. Et Link. Growing wild in the southern of Tunisia. Recent Res. Sci. Technol, 2010; 2: 29–39.

Belhatta R, Amor L, Barroso JG, Pedro LG, Figueiredo CA. Essential oil from *Artemisia herba-alba* Asso grown wild in Algeria: Variability assessment and comparison with an updated literature survey. Arabian Journal of Chemistry, 2014; 7: 243–251.

Clevenger JF. Apparatus for the determination of volatile oil. J. Am. Pharm. Assoc, 1928; 17: 346–349.

Fleisher Z, Fleisher A, Nachbar RB. Chemovariation of *Artemisia herba-alba* Asso. Aromatic plants of the Holy Land and the Sinai. Part XVI. J. Essent. Oil. Res, 2002; 14: 156-160.

Haouari M and Ferchichi A. Essential oil composition of *Artemisia herba-alba* from Southern Tunisia. Molecules, 2009; 14:1585-1594.

Hatimi S, Boudouma M, Bichichi M, Chaib N, Idrissi NG. Evaluation in vitro de l'activité antileishmanienne d'*Artemisia herba-alba* Asso. Thérapeutique, Bulletin de la Société de pathologie exotique, 2001; 94: 29-31.

Hendawy SF, Khalid KA. Response of sage (*Salvia officinalis* L.) plants to zinc application under different salinity levels. J. Applied Sci. Res, 2005; 1: 147-155.

Hudaib M, Aburjai T. Composition of the Essential Oil from *Artemisia herba-alba* Grown in Jordan. J. Essent. Oil. Res, 2006; 18: 301-304.

Judd WS, Campbell CS, Kellogg EA, Stevens PF, Donoghue MJ. 2002. Plant systematics: a phylogenetic approach (2nd ed.) Sinauer Associates Inc., USA.

Kadri A, Chobba IB, Zarai Z, Bekir A, Gharsallah N, Damak M, Gdoura R. Chemical constituents and antioxidant activity of the essential oil from aerial parts of *Artemisia herba-alba* grown in Tunisian semi-arid region. African Journal of Biotechnology, 2011; 10: 2923-2929.

Laid M, Hegazy MEF, Ahmed AA. Sesquiterpene lactones from Algerian *Artemisia herba-alba*. Phytochem. Lett, 2008; 1:85-88.

Mahomoodally FM. 2013. Traditional Medicines in Africa: An Appraisal of Ten Potent African Medicinal Plants. Evidence-Based Complementary and Alternative Medicine. ID 617459. http://dx.doi.org/10.1155/2013/617459.

Mighri H, Akrout A, Neffati M, Tomi F, Casanova J. The essential oil from *Artemisia herba-alba* Asso cultivated in Arid Land (South Tunisia). J. Essent. Oil Res, 2009; 21: 453-456.

Mohamed AH, El-Sayed MA, Hegazy ME, Helaly SE, Esmail AM, Mohamed NS, Chemical Constituents and Biological Activities of *Artemisia herba-alba*. Rec. Nat. Prod, 2010; 4: 1-25.

Paolini J, Ouariachi EME, Bouyanzer A, Hammouti B, Desjobert JM, Costa J, Muselli A. Chemical variability of *Artemisia herba-alba* Asso essential oils from East Morocco. Chem. Pap, 2010; 64: 550–556.

Tahraoui A, El-Hilaly J, Israili ZH, Lyoussi B. Ethnopharmacological survey of plants used in the traditional treatment of hypertension and diabetes in south-eastern Morocco (Errachidia province). J. of Ethnopharmacol, 2007; 110: 105-117.

How to cite this article:

Bellili S, Dhifi W, Al-Garni ABK, Flamini G, Mnif W. Essential oil composition and variability of *Artemisia herba-alba* Asso. growing in Tunisia, comparison and chemometric investigation of different plant organs. J App Pharm Sci, 2016; 6 (07): 038-042.