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Full Length Research Paper

Chemical analysis and antimicrobial effects of essential oil from *Limoniastrum guyonianum* growing in Tunisia

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Medicinal *Limoniastrum guyonianum* (Plumbaginaceae) growing in Tunisia was studied for the first time for volatiles from leaves, flowers, seeds and roots. The chemical analysis of the essential oil obtained from different organs was performed by gas chromatography-flame ionization detector (GC-FID) and gas chromatography-mass spectroscopy (GC-MS). In roots and leaves oils, monoterpenes were found in almost equal level (22.56 and 26.21%, respectively). (3Z) hex-3-enylmethanoate was detected as the chemotype in roots, while furfural (14.63%), methyl-2,4-dimethylbenzoate (14.70%) and 3-phenylprop-2-enylpentanoate (15.05%) were the most abundant constituents from seeds, leaves and flowers, respectively. Furthermore, antibacterial effects of the indicated oils were evaluated against five sensitive bacteria: *Escherichia coli* ATCC 35218, *Pseudomonas aeruginosa* ATCC 27853, *Staphylococcus epidermidis* NCIMB 8853, *Staphylococcus aureus* ATCC 29213 and *Micrococcus luteus* NCIMB 8166 using both disc diffusion and dilution methods.

Key words: *Limoniastrum guyonianum* Bois, plumbaginaceae, essential oil, gas chromatography-flame ionization detector, gas chromatography-mass spectroscopy, antibacterial effects.

INTRODUCTION

Essential oils are used for medicinal drugs, controlling harmful insects due to their antimicrobial and antifungal activities. Production of bioactive chemical compounds that escape into the environment occurs widely in natural plant communities. In continuation to our contribution to the valorization of natural medicinal plants. Braham et al. (2008), Hammami et al. (2009), the present work is dealing with the chemical and biological studies of *Limoniastrum guyonianum* Bois growing in Tunisia. It is a plant covered with concretions limestone's, of 20 to 40 cm of height, rower, in raised twigs, in linear, semi-cylindrical sheets (leaves), of 30 to 50 mm, (Floc'h, 1983). In south of Tunisia, the herb tea from leaves, branches and galls of *L. guyonianum* Bois has been used as a domestic folk medicine for the remedy of dysentery.

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The importance of roots decoction is considerable owing to its applications as depurative, galls extracts are used for tanning leathers (Fintelmann and Weiss, 2004). During this study, hydrodistillation using clevenger type apparatus has been applied to different organs from *L. guyonianum* Bois collected in Monastir region (Tunisia) and chemical analysis has been performed for the first time using gas chromatography-flame ionization detector (GC-FID) and gas chromatography-mass spectroscopy (GC-MS) experiments. Antimicrobial effects of four samples have been evaluated against five bacteria species. Flowers volatile fraction was the most active against *Staphylococcus epidermidis* NCIMB 8853.

MATERIALS AND METHODS

Plant materials

L. guyonianum (Plumbaginaceae) was collected from Falaise of

Monastir, Tunisia in March 2005. It was identified by Dr. F. Harzallah-Skhiri (Institute Supérieur de Biothechnologie de Monastir) and voucher specimens were deposited in Natural Substances and organic Synthesis Laboratory, Faculty of Sciences of Monastir.

Volatile fractions preparation

Different organs from *L. guyonianum* (fresh flowers 246 g, leaves 351 g, stems 880 g and roots 432 g) were submitted successively to hydrodistillation in a Clevenger-type apparatus during five hours. Volatile fractions were collected and stored in a refrigerator at 4°C before analysis.

GC-FID

Analysis has been investigated using a gas chromatograph HP 5890-series II equipped with: Flame ionisation detector (FID), HP-5 (5% phenyl 195% dimethylsiloxane) 30 m x 0.25 mm, 0.52 µm film thickness fused silica capillary column. The carrier gas was nitrogen ($1.2ml^{-1}$.min). The oven temperature programming was 1 min isothermal at 50°C, then 50 to 280°C at a rate of 5°C/min and held isothermal for 1 min. The injection port temperature was 250°C, detector 280°C. The volume injected is 0.1µl of a 1% solution (diluted in hexane). Percentages of the constituents were calculated by electronic integration of FID peak areas without the use of response factor correction.

GC/MS

Analysis of the volatile compounds was run on a Hewlett-Pakard GC/MS system (GC: 5890 series II, MSD 5972). The fused-silica HP-Innowax capillary column (30 m x 0.25 mm with a film thickness of 0.25 µm) was directly coupled to the MS. Helium was the carrier gas having a flow rate of 1.2 ml^{-1}.min. Oven temperature was programmed as follows (50°C for 1min, 50 to 280°C at 5°C/min) and subsequently, held isothermal for 20 min. Injector port is 0.1 µl of a 1% solution (diluted in hexane). Mass spectrometer: HP5972 recording at 70eV, the scan time is 1.5 s, mass range is 40 to 300 amu. Software adopted to handle mass spectra and chromatograms was a Chemstation.

Identification of volatile compounds

Different constituents from the indicated oils have been investigated by comparison of their mass spectra with those of computer library (Wiley 275 library). Further confirmation was done from retention index data generated from a series of alkanes retention indices (relative to C_9-C_{28}) (Adams, 1995).

Biological tests

Antibacterial assay, disc diffusion method

Antibacterial activity of the volatile fractions was screened against five pathogenic bacteria (Table 2). The inhibitory effect on bacterial growth was determined using agar-disc diffusion assay (Boussaada et al., 2008; Bagamboula and Uyttendaele, 2004). The bacterial cultures were first grown on Muller Hinton agar (MH) plates at 37°C for 18 to 24 h prior to seeding onto the nutrient agar. One or several colonies of the respective bacteria were transferred into API suspension medium (bioMerieux) and adjusted to 0.5 McFarland turbidity standards with a Densimat (bioMerieux) (Saïdana et al., 2008). The inoculate of respective bacteria were streaked into MH agar plates using a sterile swab and were then dried at 37°C during 15 min. A sterile filter disc having 6 mm of diameter was placed on the MH agar surface and 7 µl of the essential oil was dropped onto each Whatman paper disc, (Bel et al., 2008). The treated Petri dishes were incubated at 37°C for 18 to 24 h. Antibacterial activity was evaluated by measuring the clear zone surrounding the Whatman paper.

Antibacterial assay, dilution method

The minimal inhibitory concentrations (MIC) of volatile fractions were determined using Muller Hinton broth (MHB) dilution method (Fernandes et al., 2007). All tests were performed in MHB supplemented with DMSO 5%, (Lavallée et al., 2010). Bacterial strains were cultured overnight in MHB at 37°C. Tubes of MHB containing various concentrations of oils were inoculated with 10 µl bacterial inoculums and adjusted to 106 to 107 CFU/ml. They were incubated under shaking conditions (120 rpm) at 37°C for 24 h, (Saïdana et al., 2008; Boussaada et al., 2008). Control tubes without tested samples were prepared. The essays were performed in triplicate. MIC is defined as the lowest concentration preventing visible growth (Hammer et al., 1999; Delaquis et al., 2002). To determine minimal bactericidal concentrations values (MBC), (Fernandes et al., 2007), a lapful 10 µl of tested samples were streaked on the surface of TSA agar medium discs in order to visualize no bacterial growth. The discs were incubated at 37°C during 18 to 24 h (Canillac and Mourey, 2002). MBC is defined as the concentration to which 99.9% or more, the initial inoculums are killed (Fernandes et al., 2007; Canillac and Mourey. 2002).

RESULTS AND DISCUSSION

Volatiles from roots, seeds, leaves and flowers of *L. guyonianum* Bois were obtained after hydrodistillation in a Clevenger-type apparatus with $1.4.10^{-2}$, 1.10^{-2}, $2.5.10^{-2}$ and $2.8.10^{-2}$% yields, respectively. Chemical analysis of the volatiles from different organs, was performed by GC-FID and GC-MS. Composition of the oils can be seen in Table 1. Thirty five constituents were identified in roots essential oil representing 87.28% of the total volatiles, 25.67% from which are terpenoids. The chemical classes represented in roots oil were as follows: 2.43% amines, 2.78% alcohols, 13.33% ketones, 29.84% esters, 1.41% ethers, 21.71% aldehydes, 4.73% sulphur derivatives, 3.11% fatty acids, 2.3% anhydrides and 5.64% of phenolic derivatives. (3Z) hex-3-enylmethanoate has been identified as the chemotype of the oil. On the other hand, thirty one components were identified in seeds essential oil, this fraction was characterized by a high content of non terpenic compounds 78.34% containing mainly esters and aldehydes (31.52 and 18.64%, respectively).

Furfural was the most abundant constituent in seeds volatile fraction. Esters were found in almost comparative levels in leaves and flowers essential oils (40.74 and 41.68%, respectively). Terpenes represented 36.4% of the constituents of leaves oil and 21.04% of those from flowers. Methyl-2,4-dimethylbenzoate (14.70%) and 3-phenylprop-2-enylpentanoate (15.05%) were the major

Table 2. Antimicrobial effects of *Limoniastrum guyonianum* oils at a concentration of 20 mg.mL^{-1}.

Bacteria/ samples of oils	Roots	Seeds	Leaves	Flowers
Escherichia coli ATCC 35218	-	-	-	-
Pseudomonas aeruginosa ATCC 27853	-	-	-	-
Micrococcus luteus NCIMB 8166	6	6	6	6
Staphylococcus epidermidis NCIMB 8853	-	-	-	-
Staphylococcus aureus ATCC 29213	-	**7**	**7**	**8**

Table 1. Chemical composition (%) of *L. guyonianum* roots, stems, leaves and flowers oils.

No	Compounds	RI polar	Roots (%)	Stems (%)	Leaves (%)	Flowers (%)	Identification
1	2-methylprp-2-enal	973	8.54	-	-	-	MS.RI
2	Methyl-2-methylbutanoate	1007	1.08	2.93	-	-	MS.RI
3	Hexan-3-one	1049	1.68	1.26	-	-	MS.RI
4	ethylbenzen	1252	-	-	-	2.11	MS.RI
5	(*3Z*) hex-3-enylmethanoate	1254	9.18	-	-	-	MS.RI
6	2-methylbutyl-2-methylbutanoate	1285	3.15	-	-	-	MS.RI
7	2-methylbutyl-3-methylbutanoate	1296	2.56	-	-	-	MS.RI
8	4,8-dimethylnona-1,3,7-trien	1297	-	3.08	-	-	MS.RI
9	(*3E*)-Hex-3-enylethanoate	1311	-	-	-	1.30	MS.RI
10	2,3-dimethyl-1,4-diazin	1318	2.43	-	-	-	MS.RI
11	Nonan-3-one	1354	-	2.01	-	-	MS.RI
12	2,6-dimethylhept-5-enal	1356	3.79	-	1.82	-	MS.RI
13	butylhexanoate	1408	2.07	-	-	1.82	MS.RI
14	Hexyl-2-methylbutanoate	1424	1.71	-	-	-	MS.RI
15	ethyloctanoate	1425	-	1.18	-	-	MS.RI
16	Prop-2-enyldisulfide	1435	-	3.4	-	-	MS.RI
17	1-(methylthio)-ethylprop-2-enyldisulfide	1437	1.73	-	-	-	MS.RI
18	furfural	1462	-	14.63	1.15	-	MS.RI
19	(*2E*) hex-2-enylbutanoate	1465	1.18	-	-	-	MS.RI
20	2-isopropyl-5-methylcyclohexanone	1477	-	3.04	-	-	MS.RI
21	di-prop-2-enyldisulfide	1489	-	1.04	-	-	MS.RI
22	1-methyl-3-propyltrisulfide	1494	1.47	2.00	-	-	MS.RI
23	5-methyl-2-(1-methyl-1-enyl)cyclohexylethanoate	1585	-	-	3.43	-	MS.RI
24	3-isopropyl-2,6-dimethylphenol	1586	-	-	-	8.17	MS.RI
25	5-methyl-2-(1-methyleth-1-enyl) cyclohexanone	1588	1.76	-	-	-	MS.RI
26	2-methyl-5-(1-methyleth-1-enyl) cyclohexanone	1614	-	-	-	2.00	MS.RI
27	5-isopropylbicyclo [3.1.0]hexan-2-one	1627	1.57	-	-	-	MS.RI
28	benzylformate	1674	-	1.31	-	-	MS.RI
29	1,7,7trimethylbicyclo[2.2.1]heptan-2-ylpropanoate	1675	1.34	-	-	-	MS.RI
30	(3Z) Non-3-en-1-ol	1687	1.36	-	-	-	MS.RI
31	benzylethanoate	1714	-	1.1	3.65	-	MS.RI
32	3,4-dimethylfuran-2,5-dione	1730	2.3	5.17	-	-	MS.RI
33	(2E, 4Z) deca-2,4-dienal	1744	8.31	-	-	-	MS.RI
34	2-(1-hydroxy-1-methylethyl)-5-methylcyclohexanone	1769	1.00	-	-	-	MS.RI
35	Benzyl-2-methylpropanoate	1771	-	6.2	-	1.37	MS.RI
36	3,7-dimethyloct-6-enylbutanoate	1786	1.00	2.12	-	-	MS.RI
37	(2E)-3,7-dimethylocta-2,6-dienyl-2-methylpropanoate	1788	-	-	2.59	-	MS.RI
38	hexyloctanoate	1802	-	-	-	1.01	MS.RI
39	2-methyl-5-(1-methyleth-1-enyl) cyclohex-2-enol (carveol)	1804	1.42	1.55	-	-	MS.RI

Table 1. Contd.

No	Compounds	RI polar	Roots (%)	Stems (%)	Leaves (%)	Flowers (%)	Identification
40	1,2-dimethoxy-4-methybenzene	1805	-	-	5.40	-	MS.RI
41	2-methyl-5-(1-methyleth-1-enyl)cyclohex-2-enylethanoate	1814	-	-	-	2.12	MS.RI
42	Ethyl-2-hydroxybenzoate	1816	2.36	2.95	-	-	MS.RI
43	Methyl-2,4-dimethylbenzoate	1821	-	-	14.70	-	MS.RI
44	2-hydroxy-3-methylcyclopent-2-enone	1835	-	2.94	-	-	MS.RI
45	2-acetyl-5-methyloxol	1845	-	1.54	-	-	MS.RI
46	Dihydro-β-ionone	1852	4.81	-	-	-	MS.RI
47	2-phenylethyl-2-methylpropanoate	1855	-	5.03	4.43	1.04	MS.RI
48	Prop-2-enylpropyldisulfide	1866	1.53	-	-	-	MS.RI
49	3-isopropyliden-4a,5-dimethyldecahydronaphtalene	1867	-	-	-	3.15	MS.RI
50	1-(7, 7-dimethylbicyclo [3.1.1] heptanyl)methanol	1871	-	1.02	8.12	-	MS.RI
51	(2Z)-3-phenylprop-2-enal	1889	-	1.17	-	-	MS.RI
52	2-(4'-methylcyclohex-3'-enyl)propan-1-ol	1905	-	1.02	1.26	1.16	MS.RI
53	4,7-dimethyl-1-(1'-methylethyl)-1,2-dihydronaphthalene	1917	-	-	1.05	-	MS.RI
54	3,7-dimethylocta-2,6-dienyl-3-methylbutanoate	1918	2.04	-	-	-	MS.RI
55	2-ethylhexanoic acid	1953	1.07	-	-	-	MS.RI
56	(2E) 3,7-dimethylocta-2,6-dienylpentanoate	1965	-	-	5.11	2.66	MS.RI
57	3-hydroxy-2-methyl-4H-pyran-4-one	1966	-	1.11	-	-	MS.RI
58	pentadecanal	2002	1.07	-	-	-	MS.RI
59	1-(1,5-dimethylhex-4-enyl)-4-methylcyclohex-3-enol	2014	-	-	2.74	-	MS.RI
60	(2E)-3-phenylprop-2-enal	2019	-	-	-	1.69	MS.RI
61	2-phenylethylpentanoate	2037	-	-	1.37	-	MS.RI
62	Pentyl-2-hydroxybenzoate	2075	-	-	-	4.53	MS.RI
63	Hexadecane-2-one	2091	2.51	1.1	-	-	MS.RI
64	1,2,4-trimethoxybenzene	2099	-	-	-	1.65	MS.RI
65	(3Z) hex-3-enylbenzoate	2106	-	-	-	4.98	MS.RI
66	1-(4-methoxyphenyl)ethanone	2113	-	-	-	1.35	MS.RI
67	Oct-7-enoic acid	2150	-	-	-	2.36	MS.RI
68	(2E) hex-2-enylbenzoate	2168	1.06	2.65	1.90	2.91	MS.RI
69	4-isopropylphenol	2177	-	-	-	1.39	MS.RI
70	2-methoxy-4-(prop-1-enyl)phenol	2184	2.30	-	-	-	MS.RI
71	Decahydro-6-isopropyl-4,8a-dimethylnapht-1-ol	2216	-	-	-	1.10	MS.RI
71	(3Z) hex-3-enyl-2-hydroxybenzoate	2232	-	1.59	-	-	MS.RI
73	2-methoxy-4-(prop-2-enyl)phenylethanoate	2260	-	-	-	1.94	MS.RI
74	(2E) 3-phenylprop-2-en-1-ol	2264	-	-	9.62	-	MS.RI
75	2-formyl-1,1,5-trimethylcyclohexa-2,4-dien-6-ol	2293	-	-	2.13	1.82	MS.RI
76	(Z) 3,7-dimethylocta-2,6-dienoic acid	2298	2.04	-	-	-	MS.RI
77	(*2E*) 3,7-dimethylocta-2,6-dienoic acid	2312	-	1.72	-	-	MS.RI
78	2-(4-methoxyphenyl) ethanol	2342	-	-	1.33	-	MS.RI
79	3-phenylprop-2-enylpentanoate	2347	-	-	-	15.05	MS.RI
80	2,3-(1',2'-dimethoxy-3'-allyl)benzyliden-1,4-dioxolane	2369	-	-	-	1.17	MS.RI
81	Benzoic acid	2424	-	1.44	-	1.01	MS.RI
82	benzophenone	2466	-	-	-	7.10	MS.RI
83	(*9Z*) Ethyloctadec-9-enoate	2472	-	-	-	1.89	MS.RI
84	4-(prop-2-enyl)-2-dimethoxyphenol	2493	-	-	-	1.43	MS.RI
85	5-hydroxymethylfurfural	2515	-	2.84	-	-	MS.RI
86	(*9Z,12Z,15Z*) ethyloctadeca-*9,12,15*-trienoate	2614	-	-	-	1.97	MS.RI

constituents of leaves and flowers volatile fractions, respectively. Comparative study of the oils from *L. guyonianum* organs was performed by GC-FID and GC-MS, differences in composition were detected, in the

Table 3. Antibacterial effects of *L. guyonianum* oils - dilution method.

	Roots oil		Seeds oil		Leaves oil		Flowers oil	
	MIC ($\mu g.ml^{-1}$)	MBC ($\mu g.ml^{-1}$)	MIC ($\mu g.ml^{-1}$)	MBC ($\mu g.ml^{-1}$)	MIC ($\mu g.ml^{-1}$)	MBC ($\mu g.ml^{-1}$)	MIC ($\mu g.ml^{-1}$)	MBC ($\mu g.ml^{-1}$)
E. coli ATCC 35218	20	-	20	-	20	-	20	-
M. luteus NCIMB 8166	20	-	20	-	20	-	20	-
S. epidermidis NCIMB 8853	20	-	20	-	20	-	20	-
S. aureus ATCC 29213	20	-	20	-	20	-	20	-

other hand, 2-(4-methylcyclohex-3-enyl) propanol has been identified as common monoterpenol constituent of roots, leaves and flowers (Table 3). In general, it was found that proportions of sesquiterpenes increased in the order stems (completely absent), roots (3%), flowers (7%) and leaves (10%), whereas the proportions of monoterpenes decreased from leaves to roots, flowers and stems (26, 23, 10 and 6%). Additionally it was noted that non terpenic derivatives were present in large amount in stems (79%), flowers (65%), roots (61%) and leaves (47%), respectively.

Biological assays showed that *L. guyonianum* prevented visible growth of all tested bacteria at a lower concentration (MIC=0.02 $mg.ml^{-1}$). This may be attributed to the abundance of esters and aldehydes. In fact, aldehydes are known in literature for their significant antibacterial effects (Chang and Chan, 2001). However, in many cases, the whole volatile fraction is shown to be more active than its major constituents, this suggested that the contribution of the less abundant components should be considered as well as the synergistic effect between all components, (Gill et al., 2002). As an example, furfural carboxaldehyde is the chemotype of stems essential oil (14.63%), this compound is cited in literature to have antimicrobial effects, the same aldehyde is less abundant in leaves (1.15%) and quite absent in roots and flowers active volatile fractions. In addition, we noticed that the results of both disc diffusion and dilution tests for the antimicrobial effects are slightly different. The MIC appears to be lower than the concentration that inhibits bacterial growth in disc diffusion method. This may be explained by the fact that the size of the inhibition zone does not reflect the real antibacterial effectiveness of any compound. This depends and is affected by the solubility of the oil and the diffusion range in the agar. Comparing to other plants, *L. guyonianum* volatile fractions having an MIC equal to 0.02 $mg.ml^{-1}$ are more active than *Limonium echioïdes* and *Suaeda fruticosa* belonging to the same Plumbaginaceae family and having an MIC of 0.5 $mg.ml^{-1}$, (Saïdana et al., 2008).

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REFERENCES

Adams RP (1995). Identification of essential oil components by Gaz Chromatography/Mass spectroscopy. Allured Publishing Corporation Carol stream, IL, USA.

Bagamboula CF, Uyttendaele M (2004). Inhibitory effect of thyme and brasil essential oils, carvacrol, thymol, estragol, linalool and p-cymene towards *shigella sonnei* and *S. flexneri*. J. Food Microbiol., 21: 33-42.

Bel HKF, Ammar S, Saidana D, Daami RM, Cheriaa J, Liouane K, Mahjoub MA, Helal AN, Mighri Z (2008). Chemical composition, antibacterial and antifungal activities of Trichoderma sp. Growing in Tunisia. Ann. Microbiol., 58: 303-308.

Boussaada O, Chriaa J, Nabli R, Ammar S, Saidana D, Mahjoub MA, Chraeif I, Helal AN, Mighri Z (2008). Antimicrobial and antioxidant activities of methanol extracts of *Evax pygmaea* (Asteraceae) growing wild in Tunisia. World J. Microbiol. Biotechnol., 24(8): 1289-1296.

Boussaada O, Ammar S, Saidana D, Chriaa J, Chraif I, Daami RM, Helal AN, Mighri Z (2008). Chemical composition and antimicrobial activity of volatile components from capitula and aerial parts of rhaponticum acaule DC growing wild in Tunisia, Microbiol., Res., 163: 87-95.

Braham H, Ben JH, Mighri Z (2007). Carbohydrates from *Moricandia arvensis* growing in Tunisia. J. Soc. Chim. Tun., 9: 109-111.

Canillac N, Mourey A (2001). Antibacterial activity of the essential oils of picea ecxelsa on listeria, *staphylococcus aureus* and caliform bacteria. Food Control, 18: 261-268.

Chang ST, Chan SPF (2001). Antibacterial activity of leaf essential oils and components from *Cinnamomum osmophloeum*. J. Ethnopharmacol., *77*: 123-127.

Delaquis PJ, Stanich K, Girard B, Mazza G (2002). Antimicrobial activity of individual and mixed fractions of dill, citaro, coriander and eucalyptus essential oils. Int. J. Food Microbiol., 74: 101-109.

Fernandes CJ, O'sullivan MVN, Cai Y, Kong F, Zeng X, Gilbert GL, Kotsiou G (2007). Agar Dilution Method for Detection of Inducible Clindamycin Resistance in *Staphylococcus* spp. Clin Microbiol., 45(12): 4018-4020.

Fintelmann V, Weiss RF (2004). Practical Handbook of Phytoterapie. Vigot. 184.

Floc'h E(1983). Contribution to ethnobotanical studies of the Tunisian Flora. Flora and vegetation program in Tunisia. Official Printing office of the republic of Tunisia.

Gill AA, Delaquis P, Russo P (2002). Evaluation of antilisterial action of cilandro oil on vacuum packed Ham. Food Microbial., *73*: 83-92.

Hammami S, Mighri N, Ben JH, Boughalleb N, Zardi BA, Nefzi A, Abreu P, Mighri Z (2009). Saoussanabiloide a novel antifungal alkaloid from *Echiochilon fruticosum* Desf. Growing in Tunisia. Nat. Prod. Res., 23(16): 1466-1471.

Hammer KA, Carson CF, Riley TV (1999). Antimicrobial activity of essential oils and other plant extracts. J. Appl. Microbiol., 86: 985-990.

Lavallée C, Rouleau D, Gaudreau C, Roger M, Tsimiklis C, Locas MC,

Gagnon S, Delorme J, Labbé AC (2010). Performance of an Agar Dilution Method and a Vitek 2 Card for Detection of Inducible Clindamycin Resistance in Staphylococcus spp. J. Clin. Microbiol., 48(4): 1354-1357.

Saïdana D, Mahjoub S, Boussaada O, Chriaa J, Mahjoub MA, Chéraif I, Daami M, Mighri Z, Helal AN (2008). Antibacterial and Antifungal Activities of the Essential Oils of two Saltcedar Species from Tunisia. J. Am. Oil Chem. Soc., 85(9): 817-826.

Saïdana D, Mahjoub MA, Boussaada O, Chriaa J, Cheraif I, Daami RM, Mighri Z, Helal AN (2008). Chemical composition and antimicrobial activity of volatile compounds of *Tamaryx boveana* (tamariaceae). Microbiol. Res., 163: 445-455.