Essential Oils of Plants Used in Home Medicine in North of Argentina

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Abstract

Essential oils of the medicinal plants *Satureja parvifolia*, *Satureja boliviana*, *Hyptis mutabilis*, *Leonorus sibiricus*, *Lippia turnerifolia*, *Xeroaloysia ovatifolia* and *Acantholippia salsoloides* of north Argentina were analyzed by GC and GC/MS. Seventy-five compounds, representing more than 90% of the oils, were identified. The oils of both populations of *S. parvifolia* studied were characterized by a high content of piperitone (41.9% and 46%) and piperitenone oxide (50.1% and 49.3%). The most abundant constituents identified in *S. boliviana* oil were isomenthone (33%) and pulegone (25.3%). *Hyptis mutabilis* oil was characterized by β-phellandrene (27.1%) and β-caryophyllene (59.4%). The main constituents of *L. sibiricus* oil were the sesquiterpene hydrocarbons β-caryophyllene (35.2%), α-humulene (22.1%) and α-cubebene (18.4%). The oils of *L. turnerifolia* and *X. ovatifolia* also had a high content of sesquiterpenes. These were α-humulene (40.1%) and β-bisabolene (22.9%) in the oil of *L. turnerifolia* and β-caryophyllene (14.4%), (E)-nerolidol (10.5%), spathulenol (21.6%) and epi-α-cadinol (21.9%) in the oil of *X. ovatifolia*. *Acantholippia salsoloides* oil from Jujuy accumulated high contents of p-cymene (52.8%) and thymol (46.8%), while the oil from the population of Catamarca accumulated α-thujone (98.8%) as the major compound.

Key Word Index

Satureja parvifolia, *Satureja boliviana*, *Hyptis mutabilis*, *Leonorus sibiricus*, *Lippia turnerifolia*, *Xeroaloysia ovatifolia*, *Acantholippia salsoloides*, Verbenaceae, Lamiaceae, essential oil, p-cymene, β-phellandrene, α-thujone, isomenthone, pulegone, piperitone, thymol, piperitenone oxide, β-cubebene, β-caryophyllene, α-humulene, β-bisabolene, (E)-nerolidol, spathulenol, epi-α-cadinol.

Introduction

In some localities of South America the use of medicinal plants is both a valuable resource and a necessity, and furthermore it provides a real alternative for primary health care systems (1–4). Most of the species of Verbenaceae and Lamiaceae are highly aromatic and known as medicinal plants. The composition of the essential oil of species can vary according to geographical distribution and to the different genotypes present (5). In this occasion we study the composition of the oils of the following species: *Hyptis mutabilis*, *Leonorus sibiricus*, *Satureja boliviana*, *Satureja parvifolia*, *Acantholippia salsoloides*, *Lippia turnerifolia* and *Xeroaloysia ovatifolia*. All these species are used in home medicine and prepared as infusions or decoctions for an external or internal way of administration. *Hyptis mutabilis* has been used as a carminative; anti-parasite, anti-malaria, emmenagogue; for fever, to treat larva of *Dermatobia* under the skin, and also to treat pimples, cystitis and gastrointestinal ailments (3,6–8). The oil of this species has been reported to possess anti-ulcerogenic activity (9). An infusion of *L. sibiricus* leaves and flowers has been used to control vomiting and diarrhea. It has also been used in the treatment of colds, cough, bronchitis and rheumatism and to increase blood circulation and as an emmenagogue (6,10,11). *Satureja boliviana* has been used to treat colds, diarrhea and

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stomach pain by Bolivian indigenous groups (12). *Satureja parvifolia* has been used against stomachache, fever, rheumatic pains, bruises, influenza, migraine and nausea caused by non-adjustment to altitudes, against "cold" diseases, diarrhea, dyspepsia and gastrointestinal bloating. These last four uses are also applicable to infusions of *Acantholippia salsoloides* (4).

The oils of *Satureja boliviana*, *S. parvifolia*, *Hyptis mutabilis* and *L. sibiricus* have been studied previously from other regions of Argentina or South America (13–20). The composition of the oils of *L. turnerifolia*, *A. salsoloides* and *X. ovatifolia* are described here for the first time.

Experimental

Plant material: Aerial parts of the species studied were collected randomly in February to April at Yungas, Monte de Sierras y Bolsones and Chaco Seco phytogeographic provinces. Voucher specimens have been deposited in the Herbario of INDELLAR (Instituto de Investigación para el Desarrollo Socioeconómico de Los Llanos de La Rioja) (IZAC) and in Herbario of Jujuy (JUA) (Table I).

Isolation of the essential oils and analysis: The oils were separately obtained by hydrodistillation according to Zygadlo et al. (21). Analyses were performed in a Shimadzu GC-R1A (FID) gas-chromatograph, fitted with a 30 m × 0.25 mm (0.25 μm film thickness) fused silica capillary column coated with a phase 5% phenyl 95% dimethylpolysiloxane, non-polar DB-5 column and then a polar Supelcowax 10 coated with a phase polyethylene glycol. The GC operating conditions were as follows: oven temperature programmed from 40–230°C at 2°C/min, injector and detector temperatures were 240°C. The carrier gas was N_2 at a constant flow of 0.9 mL/min. GC/MS analyses were performed with a Perkin Elmer Q-700 equipped with a SE-30 capillary column (30 m × 0.25 mm; coating thickness 0.25 μm film). The analytical conditions were: oven temperature from 40–230°C at 2°C/min, the carrier gas was He at a constant flow of 0.9 mL/min, and the source was at 70 eV.

The constituents of the oils were identified on the basis of their GC retention index (RI) with reference to an homologous series of n-alkanes (C_{12}-C_{25}), by comparison of their retention times with those of pure authentic samples from Sigma and Fluka Companies, peak enrichment on co-injection with authentic standards wherever possible, by GC/MS library search (NIST) and using visual inspection of the mass spectra from literature (22), for confirmation.

Results and Discussion

Seventy-five compounds, representing more than 90% of the oils, were identified (Table II). The monoterpene fraction was relatively high in the oil of *Satureja* sp. and *Acantholippia salsoloides* species, while the sesquiterpene fraction was high in the oils of *H. mutabilis*, *L. sibiricus*, *L. turnerifolia* and *X. ovatifolia.* Among the monoterpenes, *S. parvifolia* (Sp1 and Sp2) oils were characterized by a high content of the oxygenated monoterpenes, piperitone (41.9% and 46%, respectively) and piperitenone oxide (50.1% and 49.3%, respectively) (Table II). These compositions differ from an earlier study where the oil of this species contained piperitenone oxide as the main compound (14). There were no differences practically between the two population of *S. parvifolia* studied here (Table I). *Satureja parvifolia* is used against stomachache, diarrhea, dyspepsia and gastrointestinal bloating (4). Piperitenone oxide has been reported to be a relaxant of the intestinal smooth muscle (23)

Table I. Vouchers of species analyzed

Species	Locality	Altitude (m)	Collector
Lamiaceae			
1) *Satureja parvifolia* (Phil.) Epling, "muña"	La Rioja. Dpto. Famatina. Sierra de Famatina. Paraje Los Berros Phytogeographic area: Monte de Sierras y Bolsones.	2450	Biurrum- 7138 (IZAC)
2) *Satureja parvifolia* (Phil.) Epling, "salvia muña"	La Rioja. Dpto. Cnel. Felipe Varela. Parque Nacional Talampaya. Sierra de Los Tarjados, cañón de Talampaya: sector "Los Cajones" Phytogeographic area: Monte de Sierras y Bolsones.	1730	Biurrum- 7916 (IZAC)
3) *Satureja boliviana* (Benth.) Briq., "K'hoa"	Jujuy.Dpto. Dr. Manuel Belgrano. Tiraxi. Phytogeographic area: Yungas.	1800	Rotman- 1353 (JUA)
4) *Hyptis mutabilis* (Rich.) Briq.	Jujuy. Dpto. Dr. Manuel Belgrano. Tiraxi. Phytogeographic area: Yungas.	1800	Rotman- 1371 (JUA)
5) *Leonurus sibiricus* L., "cuatro cantos"	Jujuy. Dpto. Dr. Manuel Belgrano. Chijra. Phytogeographic area: Yungas.	1270	Rotman- 1338 (JUA)
Verbenaceae			
6) *Acantholippia salsoloides* Griseb., "rica rica"	Jujuy. Dpto. Humahuaca. Chucalezna. Phytogeographic area: Yungas.	2770	Rotman- 1383 (JUA)
7) *Acantholippia salsoloides* Griseb., "rica rica"	Catamarca. Dpto. Belén. Laguna Blanca. Phytogeographic area: Monte de Sierras y Bolsones.	3290	Biurrum- 8325 (IZAC)
8) *Lippia turnerifolia* Cham.	Jujuy. Dpto. Dr. Manuel Belgrano. Tiraxi. Phytogeographic area: Yungas.	1600	Rotman- 1370 (JUA)
9) *Xeroaloysia ovatifolia* (Moldenke) Tronc.	La Rioja. Dpto. Gral. Belgrano. Ruta Nac. Nº 79 a 18km de Chamical. Sierra Los Llanos. Phytogeographic area: Chaco Seco.	453	Biurrum- 7933 (IZAC)

Table II. Percentage composition of the essential oils of *Satureja parvifolia* (Sp1,Sp2), *Satureja boliviana* (Sb), *Hyptis mutabilis* (Hm), *Leonorus sibiricus* (Ls) and *Acantholippia salsoloides* (As6, As7), *Lippia turnerifolia* (Lt) and *Xeroaloysia ovatifolia* (Xo).

RI Supelcowax 10	RI DB-5	Compounds[a,c]	Sp 1	Sp 2	Sb	Hm	Ls	As 6	As 7	Lt	Xo
	930	α-thujene	t	t	0.4					3.1	0.1
	939	α-pinene [b]	t	t	0.5		2.8		0.2		0.1
	954	camphene			0.3						t
	975	sabinene [b]			2	t			0.1		
	979	β-pinene [b]			0.8		0.6		t		
	991	myrcene [b]	t	t	0.1	t	0.8	t	0.1		
	1003	α-phellandrene	t	0.1	0.1	t				0.3	
	1017	α-terpinene			0.4						0.2
	1025	p-cymene [b]	t	0.2	6.6	t		**52.8**	0.1		0.2
	1028	limonene	t	t	1.1	t	0.9		0.1	0.3	0.3
	1030	β-phellandrene				27.1					
1208	1031	1,8-cineole * [b]	t	t	7.3	t			0.1	0.5	0.2
1149	1031	δ-3-carene*			0.1		1.8				
	1050	(E)-β-ocimene	t	0.1	0.1	t					t
	1060	γ-terpinene	t	0.2	1.9	t		0.1			
	1087	fenchone				t					
	1097	linalool	t	t	0.9	t				3.1	
	1102	α-thujone [b]							**98.8**		
	1114	β-thujone							0.1	2.2	
	1116	neomenthol								0.1	
	1144	*cis*-β-terpineol			0.1						
	1146	camphor	t	0.1				t		0.5	
	1153	menthone			0.2						
	1162	isoborneol									1.2
	1163	isomenthone			**33.0**						
	1165	pinocarvone	0.1	0.1							
	1169	borneol			1.2					0.6	
	1177	terpinen-4-ol			0.5	t		0.1			
	1183	p-cymen-8-ol								0.4	
	1184	*cis*-pinocarveol								0.9	
	1189	α-terpineol			1.1	t					
	1235	methyl thymol						t			
	1237	pulegone [b]			**25.3**						
	1243	carvone									0.1
	1253	piperitone	**41.9**	**46.0**							
	1257	linalyl acetate			0.3						
	1290	thymol [b]	0.1	0.1	5.4	t		**46.8**	0.1		0.8
	1299	carvacrol	0.2	t	t			t	0.1		
	1351	α-cubebene				0.1				0.1	0.1
	1352	thymyl acetate	0.1	0.3	0.2				t		
	1359	eugenol				t					
	1369	piperitenone oxide	**50.1**	**49.3**							
	1373	carvacryl acetate	0.1	0.2	0.2				t		
	1377	α-copaene				t				5.9	2.5
1503	1388	β-bourbonene *	0.1	0.4	0.4	0.4	0.9			0.4	
1539	1388	β-cubebene *					**18.4**			0.2	0.2
	1408	longifolene									0.1
	1419	β-caryophyllene	0.2	0.3	2.7	**59.4**	**35.2**	t			**14.4**
	1434	gurjunene β									0.1
	1437	γ-elemene				t				1.5	
	1455	α-humulene			0.2	0.1	**22.1**			**40.1**	2.5
	1480	γ-muurolene					0.7			4.6	0.6
	1483	germacrene D			0.4	0.1	0.4				
1719	1500	α-muurolene *									**0.2**
1751	1500	bicyclogermacrene *			t	0.1					**5.2**
	1506	β-bisabolene								**22.9**	
	1514	γ-cadinene			0.1		0.2			0.4	0.6
	1515	cubebol									0.3
	1523	δ-cadinene			0.1					1.1	5.7
	1539	α-cadinene					2.6				0.5
	1540	*cis*-calamenene								0.4	0.3
	1546	α-calacorene									0.1
	1563	(E)-nerolidol								1.2	**10.5**
	1566	β-calacorene									0.1

Table II. Continued

1576	germacrene D-4-ol	0.1	t			1.2			4.8	
1578	spathulenol			**2.0**						**21.6**
1583	caryophyllene oxide	0.1	0.1	0.3						0.7
1585	globulol									0.2
1608	humulene epoxide II					2.7				
1640	epi-α-cadinol (= tau- cadinol)									**21.9**
1642	epi-α-muurolol								0.6	
1646	α-muurolol				6.0					
1654	α-eudesmol			0.2	6.0					
1701	(Z,E)-farnesyl acetate					**8.4**				
Identified components		**98.1**	**99.6**	**96.5**	**99.3**	**99.7**	**99.8**	**99.8**	**96.2**	**91.6**
Monoterpene hydrocarbons		**t**	**0.6**	**14.4**	**27.1**	**6.9**	**52.9**	**0.6**	**3.7**	**0.9**
Oxygen-containing monoterpenes		**92.4**	**95.6**	**75.3**	**t**	**t**	**46.9**	**99.2**	**8.3**	**2.3**
Sesquiterpene hydrocarbons		**0.3**	**0.7**	**3.9**	**60.2**	**80.5**	**t**	**t**	**77.6**	**33.5**
Oxygen-containing sesquiterpenes		**5.4**	**2.7**	**2.9**	**12.0**	**12.6**	**t**	**t**	**6.6**	**54.9**

a) Retention index, b) peak enrichment, c) mass spectra, e) compounds listed in order of elution from a DB-5 column. *) the compounds identified by Supelcowax 10.

while piperitone has been reported to possess strong enterobactericidal activity (24); these properties of major constituents of oil of *S. parvifolia* seem to support its traditional use.

The most abundant constituents identified in *S. boliviana* oil were isomenthone (33%) and pulegone (25.3%). Senatore et al. (14) showed that the essential oil of the same species in Perú contained isomenthone and menthone as the main components.

Hyptis mutabilis oil was characterized by high content of hydrocarbons compounds—β-phellandrene (27.1%) and β-caryophyllene (59.4%) were the main compounds. The rural medical uses of *H. mutabilis* such as carminative, emmenagogic and treatment of gastrointestinal ailments, could be supported by its major oil constituents. β-Phellandrene showed anti-microbial activity (25), while β-caryophyllene manifested cytoprotective and anti-inflammatory effects (26), and anti-microbial activity (27). However, previous studies of the oil of this species reported a different composition. β-Caryophyllene (14.7%), spathulenol (14.2%) and germacrene D (11.1%) were the major components of one oil (27), while p-cymene (15.1%) and β-caryophyllene (12.35%) were major components in the oil of the species of Amazonian origin (29), and thymol, γ-terpinene, δ-3-carene, terpinolene, globulol, 1,8-cineole and bicyclogermacrene were the main components of the same species from a different region of Brazil (30).

The main constituents of *L. sibiricus* oil were the sesquiterpene hydrocarbons β-caryophyllene (35.2%), α-humulene (22.1%) and β-cubebene (18.4%). An earlier study on the analysis of the oil from *L. sibiricus* showed that, although the main component may vary, the sesquiterpene fraction was the dominant one (19,20). The species *L. turnerifolia* and *X. ovatifolia* were also rich in sesquiterpenes (Table II). *Lippia turnerifolia* oil contained α-humulene (40.1%) and β-bisabolene (22.9%), while *X. ovatifolia* contained β-caryophyllene (14.4%), (E)-nerolidol (10.5%), spathulenol (21.6%) and epi-α-cadinol (21.9%) as the main components. There are reports showing the anti-microbial activity of sesquiterpene hydrocarbons such as β-caryophyllene, α-humulene and germacrene D (19,31). Sesquiterpene compounds were absent in the oil of both populations of *A. salsoloides* (As6, As7 in Table II), although the monoterpene fractions were different. The oil of *A. salsoloides* from Jujuy (As6) accumulated a high content of p-cymene (52.8%) and thymol (46.8%) while the population of Catamarca (As7) accumulated α-thujone (98.8%) as the major compound in the oil. p-Cymene and thymol have been reported to possess analgesic and anti-pyretic activities (32,33), while thujone was described as a cause for the mental disorder "absinthism" (34). These results show that the chemical composition of the oils studied here provides some support for the folkloric medicinal use.

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References

1. M.N. Alexiades and D. Lacaze, *FENAMADs program in traditional medicine: an integrated approach to health care in the Peruvian Amazon*. In: *Medicinal Resources of the Tropical Forest*. Edits., M.J. Balick, E. Elisabetsky and S.A. Laird, pp. 341–365, Columbia University Press, New York, NY (1996).
2. X. Lozoya, *Medicinal plants of Mexico: a program for their scientific validation*. In: *Medicinal Resources of the Tropical Forest*. Edits., M.J. Balick, E. Elisabetsky and S. A. Laird, pp. 311–316, Columbia University Press, New York, NY (1996).
3. G. Bourdy, S.J. DeWalt, L.R. Chávez de Michel, A. Roca, E. Deharo, V. Nuñoz, L. Balderrama, C. Quenevo and A. Gimenez, *Medicinal plants uses of the Tacana, an Amazonian Bolivian ethnic group*. J. Ethnopharmacol., **70**, 87–109 (2000).
4. N.I. Hilgert, *Plants used in home medicine in the Zenta River basin, Northwest Argentina*. J. Ethnopharmacol., **76**, 11–34 (2001).
5. A.M. Viljoen, S. Subramoney, S.F. van Vuuren, K.H.C. Baser and B. Demirci, *The composition, geographical variation and antimicrobial activity of* Lippia javanica *(Verbenaceae) leaf essential oils*. J. Ethnopharmacol., **96**, 271–277 (2005).
6. E. del V. Carrizo, M.O. Palacio and L.D. Roic, *Plantas de uso medicinal en la flora de los alrededores de la ciudad de Santiago del Estero (Argentina)*. Dominguezia, **18**, 3–12 (2002).
7. A. Fournet, A.A. Barrios and V. Muñoz, *Leishmanicidal and trypanocidal activities of Bolivian medicinal plants*. J. Ethnopharmacol., **41**, 19–37 (1994).
8. D.Q. Falcão and F.S. Menezes, *Revisão etnofarmacológica, farmacológica e química do gênero* Hyptis. Rev. Bras. Farm., **84**, 69–74 (2003).

9. P.P.P. Barbosa and C.P. Ramos, *Studies on the antiulcerogenic activity of the essential oil of* Hyptis mutabilis *Briq. in rats*. Phytoter. Res., **6**, 114–115 (1992).
10. F.C. Hoehne, *Plantas e substãncias vegetais tóxicas e medicinais, 2nd edition*. Graphicars, São Paulo, Brazil (1939).
11. S. Castellucci, M.I.S. Lima, N. Nordi and J.G.W. Marques, *Plantas medicinais relatadas pela comunidade residente na estação ecológica de Jataí, municipio de Luis Antonio/SP: uma abordagem etnobotânica*. Rev. Bras. Pl. Med., **3**, 51–60 (2000).
12. M J. Macía, E. García and P.J. Vidaurre, *An ethnobotanical survey of medicinal plants commercialized in the markets of La Paz and El Alto, Bolivia*. J. Ethnopharmacol., **97**, 337–350 (2005).
13. C. Viturro, A. Molina, I. Guy, B. Charles, H. Guinaudeau and A. Fournet, *Essential oils of* Satureja boliviana *and* S. parvifolia *growing in the region of Jujuy, Argentina*. Flav. Fragr. J., **15**, 377–382 (2000).
14. F. Senatore, E. Soria Urrunaga, R. Soria Urrunaga, G. Della Porta and V. De Feo, *Essential oils from two Peruvian* Satureja *species*. Flav. Fragr. J., **13**, 1–4 (1998).
15. R. Vila, B. Milo, C. Labbé, O. Muñoz, E. Soria and U. Soria, *Chemical Composition of Two Samples of Essential Oil of* Satureja boliviana *(Benth.) Briq. From Perú and Bolivia*. J. Essent. Oil Res., **8**, 307–309 (1996).
16. A. Velasco-Negueruela, G.E. Abarca, M.J. Perez-Alonso and J.L. Esteban, *Essential Oil of* Satureja boliviana *Briq. From Peru*. J. Essent. Oil Res., **6**, 641–642 (1994).
17. A. Velasco-Negueruela, M.J. Perez-Alonso, J.L. Esteban, C.A. Guzman, J.A. Zygadlo and L.A. Espinar, *Volatile Constituents of* Hyptis mutabilis *(Rich.) Briq*. J. Essent Oil Res., **7**, 81–82 (1995).
18. P. Ballac, C. Duschatzky, M. Ponzi and N. Firpo, *Essential Oil of* Hyptis mutabilis *(Rich.) Briq. Grown in San Luis, Argentina*. J. Essent. Oil Res., **11**, 217–219 (1999).
19. L.F.R. Almeida, M.E.A. Delachiave and M.O.M. Marques, *Composição do óleo essencial de rubim (*Leonurus sibiricus *L.- Lamiaceae)*. Rev. Bras. Pl. Med., Botucatu, **8**, 35–38 (2005).
20. B.M. Lawrence, *Labiatae Oils-Mother Nature´s Chemical Factory*. 11th International Congress of Essential Oils, Fragrances and Flavors, New Delhi, India (1989).
21. J.A. Zygadlo, D.M. Maestri, A.L. Lamarque, C.A. Guzmán, A. Velasco-Negueruela, M.J. Pérez-Alonso, M.C. García-Vallejos and N.R. Grosso, *Essential oil variability of* Minthostachys verticillata. Biochem. Syst. Ecol., **24**, 319–323 (1996).
22. R.P. Adams, *Identification of Essential Oils Components by Gas Chromatography/Quadrupole Mass Spectroscopy*. Allured Publ. Corp., Carol Stream, IL (2001).
23. P.J. Sousa, P.J. Magalhaes, C.C. Lima, V.S. Oliveira and J.H. Leal-Cardoso, *Effect piperitenone oxide on the intestinal smooth muscle of the guinea pig*. Braz. J. Med. Biol. Res., **30**, 787–789 (1997).
24. F. Rafii and A.R. Shahuerdi, *Comparison of essential oils from three plants for enhancement of antimicrobial activity of nitrofurantoin against enterobacteria*. Chemotherapy, **53**, 21–25 (2003).
25. M.P. Tampieri, R. Galuppi, F. Macchioni., M.S. Carelle, L. Falcioni, P.L. Cioni and I. Morelli, *The inhibition of* Candida albicans *by selected essential oils and their major components*. Mycopathologia, **159**, 339–345 (2005).
26. Y. Tambe, H. Tsujiuchi, G. Honda, Y. Ikeshiro and S. Tanaka, *Gastric cytoprotection of the non-steroidal anti-inflammatory sesquiterpene:* β *caryophyllene*. Planta Med., **62**, 469–470 (1996).
27. B. Sabulal, M. Dan, J.J. Anil, R. Kurup, N.S. Pradeep, R.K. Valsamma and G. Varughese, *Caryophyllene rich rhizome oil of* Zingiber nimmonii *from South India: chemical characterization and antimicrobial activity*. Phytochemistry, **67**, 2469–2473 (2006).
28. M.M. Oliva, M.S. Demo, A.G. Lopez, M.L. Lopez and J.A. Zygadlo, *Antimicrobial activity and composition of* Hyptis mutabilis *essential oil*. J. Herbs, Spices Med. Plants, **11**, 57–63 (2005).
29. A.I.R. Luz, M.B. Zoghbi, L.S. Ramos, J.G.S. Maia and M.L.Da Silva, *Essential oils of some Amazonian Labiatae*. J. Nat. Prod., **47**, 745–747 (1984).
30. E.H.A. Aguiar, M.G.B. Zoghbi, M.H.L. Silva, J.G.S. Maia, J.M.R. Amasifén and U.M. Rojas, *Chemical Variation in the Essential Oil of* Hyptis mutabilis *(Rich) Briq*. J. Essent. Oil Res., **15**, 130–132 (2003).
31. A. Koroch, H.R. Juliani and J.A. Zygadlo, *Flavours and Fragrances Chemistry, Bioprocessing and Sustainability*. In: *Bioactivity of essential oils and their components*. Edits., G. Ralph and Berger, pp. 87–115, Springer-Verlag, Berlin, Germany (2007).
32. A.A. Abena, M. Diatewa, G. Gakosso, M. Gbeassor, Th. Hondi-Assah and J.M. Ouamba, *Analgesic, antipyretic and antiinflammatory effects of essential oil of* Lippia multiflora. Fitoterapia, **74**, 231–236 (2003).
33. M.V.B. Monteiro, A.K.R. Melo Leite, L.M. Bertini, S.M. de Morais and D.C.S. Nunes-Pinheiro, *Topical anti inflammatory, gastroprotective and antioxidant effects of the essential oils of* Lippia sidoides *Cham. leaves*. J. Ethnopharmacol., **111**, 378–382 (2007).
34. D.W. Lachenmeier, J. Emmert, T. Kuballa and G. Sartor, *Thujone—cause of absinthism?* Forensic Sci. Int., **158**, 1–8 (2006).