Multidisciplinary Approach in Determination of Optimal Conditions for Essential Oil Extraction from Selected Lamiaceae and Apiaceae Species

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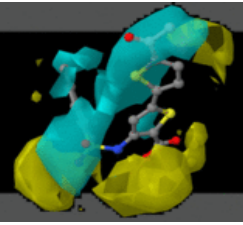

Introduction

- EOs as the naturally occurring volatile compounds mixtures;
- EO is present at low concentrations and it requires high performance extraction techniques in order for high yields to be achieved;
- EOs are produced by different methods: solvent extraction, supercritical fluid extraction, hydro- and steam distillation, ultrasound and microwave-assisted processes;
- The extraction method is important in that the composition of EOs is somewhat dependent on the applied practice;
- Inappropriate extraction procedure can damage or alter the chemical signature, resulting in the loss of bioactivity and natural characteristics.

Steam Distillation

- A separation process for temperature sensitive materials like oils, resins, hydrocarbons, etc. which are insoluble in water and may decompose at their boiling point;
- It enables a compound/mixture of compounds to be distilled at a temperature significantly below the corresponding individual constituent(s) boiling point(s).
- Isolated EOs are different in composition from those naturally occurring in plants, since the process conditions cause chemical reactions to occur, which result in the formation of certain artifacts.
- Different factors determine the composition and quality of EO, such as cultivation, soil and climatic conditions, harvesting time.

24-hour Steam Distillation Method: Background

A comprehensive study on essential oil extraction from wild Mentha suaveolens Ehrh. in terms of different harvesting and extraction time

Molecules **2015**, *20*, 9640-9655; doi:10.3390/molecules20069640

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molecules

ISSN 1420-3049

www.mdpi.com/journal/molecules

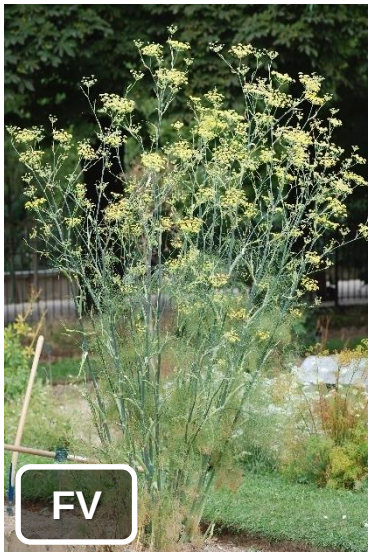
Article

Multidisciplinary Approach to Determine the Optimal Time and Period for Extracting the Essential Oil from *Mentha suaveolens* Ehrh †

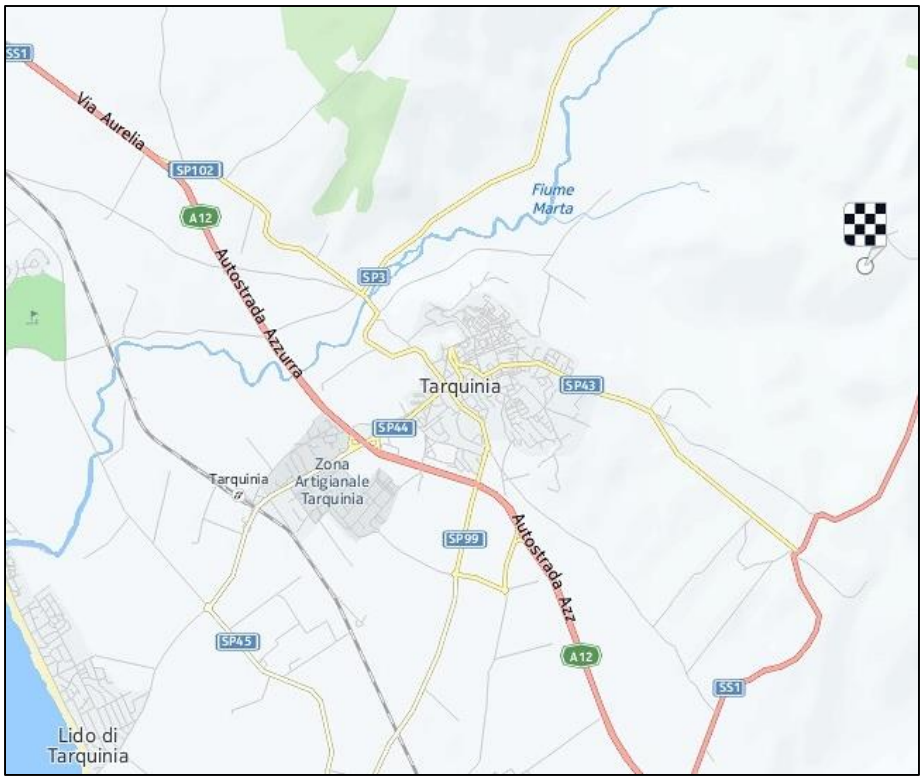
Stefania Garzoli [1], Adele Pirolli [2], Elisabetta Vavala [3], Antonella Di Sotto [4], Gianni Sartorelli [2], Mijat Božović [2], Letizia Angiolella [3], Gabriela Mazzanti [4], Federico Pepi [1] and Rino Ragno [2,*]

Investigated Plant Species

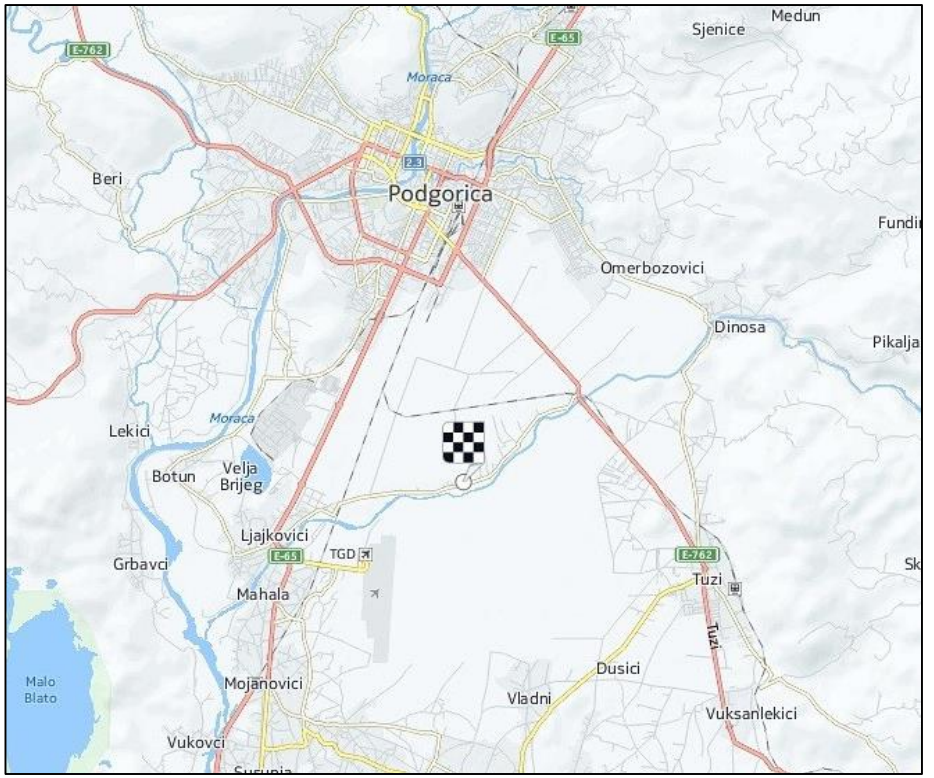
- *Calamintha nepeta* (L.) Savi subsp. *glandulosa* (Req.) Ball (CG),
- *Melissa officinalis* L. subsp. *altissima* (Sibth. & Sm.) Arcangel (MA),
- *Sideritis romana* L. subsp. *purpurea* (Tal. ex Benth.) Heywood (SP),
- *Foeniculum vulgare* Miller (FV) and
- *Ridolfia segetum* Moris (RS).



Plant Material Collecting



Tarquinia city, Province of Viterbo (Italy)

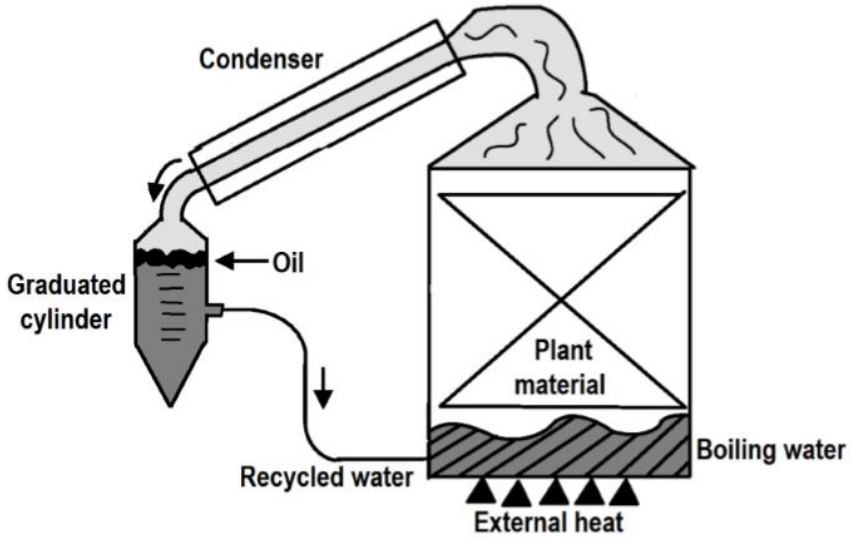


Kuće Rakića, Podgorica city (Montenegro)

EO Extraction: Aims and Objectives

- The aim was to develop a systematic extraction system using steam distillation technique, in terms of different harvesting and extraction times;
- Having in mind that EO is made up of many distinct molecules which come together to form its aroma and therapeutic properties, it should be emphasized that some of these molecules are delicate structures that can be altered or destroyed by adverse environmental conditions;
- Longer distillation may give more complete oil, but on the other hand, it may lead to the accumulation of more artifacts; all of that may have a curious effect on the physical characteristics of EO (odor, density, color), as well as on its biological activities.

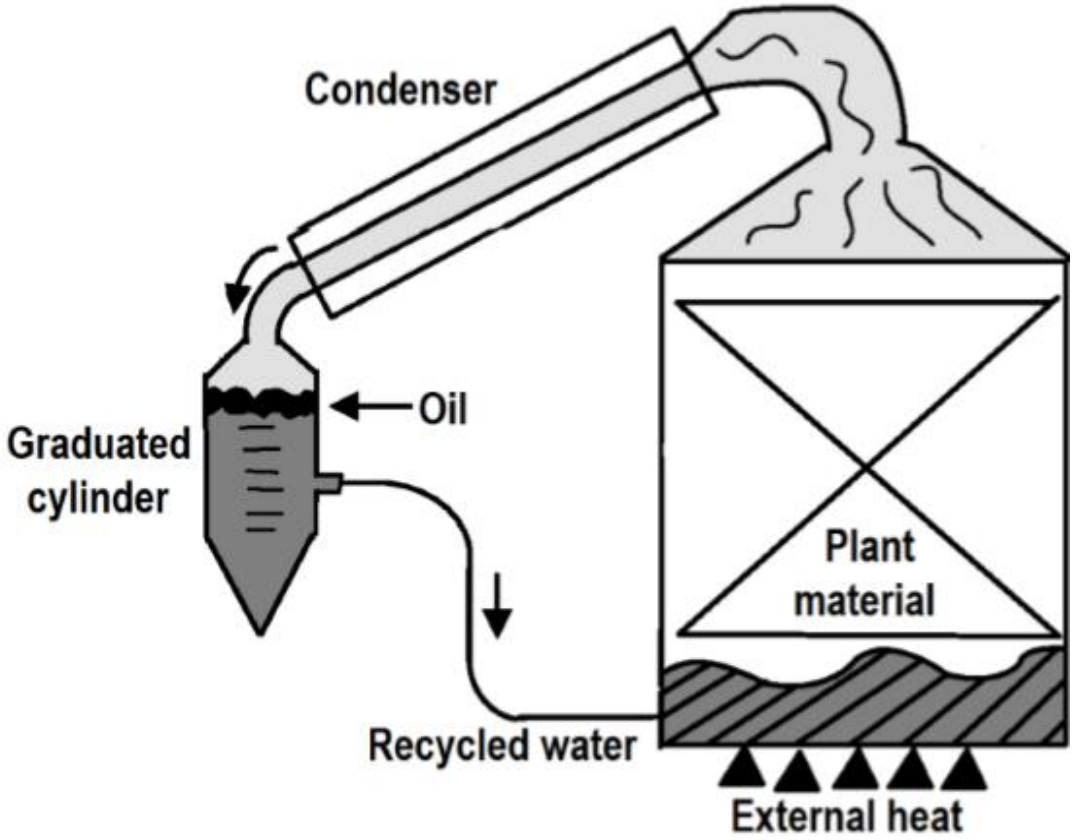
EO Extraction: In General

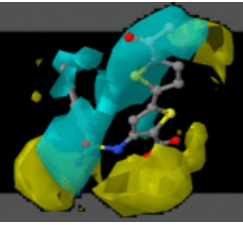


A direct steam distillation process using a 62 L steel distillator apparatus (Albrigi Luigi E0131, Verona, Italy)

EO Extraction: In General

- EO fractions were separated at different time intervals;
- The accumulated EO/water double phase was extracted 3 times with diethyl ether;
- The organic layers were dried on anhydrous Na_2SO_4, filtered and deprived of the solvent *in vacuo* to furnish oils.





Materials and Methods

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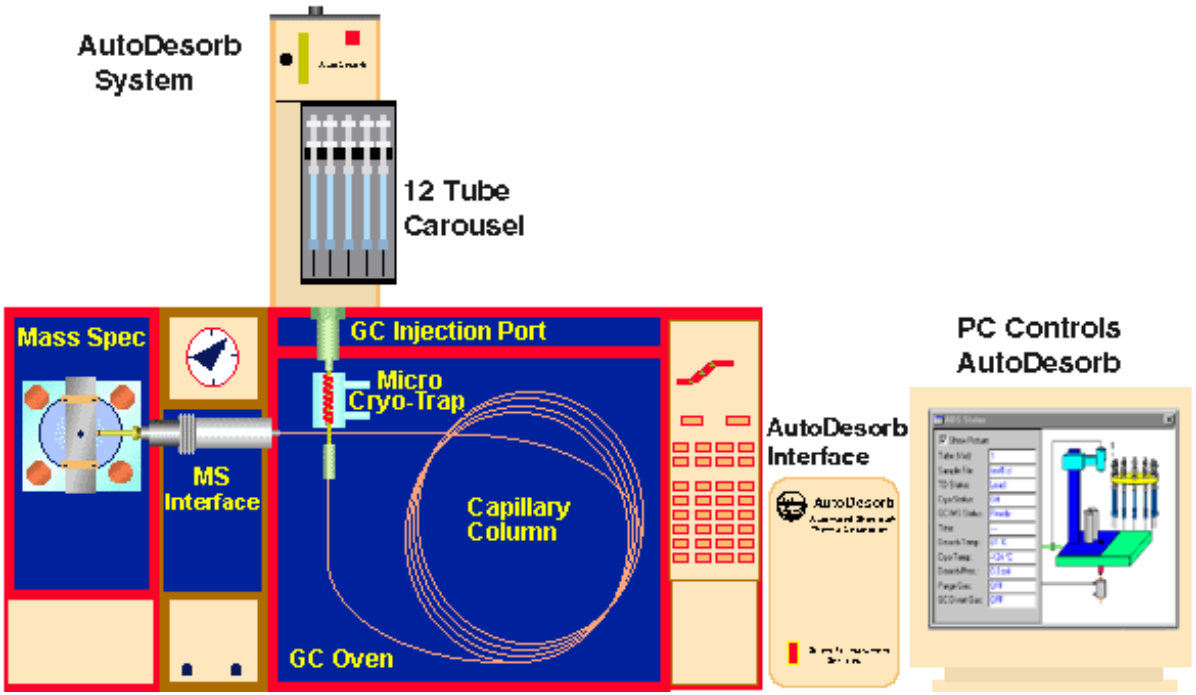
EO Extraction: The Method Validation and Application

- *Rosmarinus officinalis* L. *
- *Thymus serphyllum* L. *
- *Origanum vulgare* L. *
- *Origanum dictamnus* L. *
- *Mentha spicata* L. *
- *Melissa officinalis* L. *
- *Salvia officinalis* L. *
- *Salvia sclarea* L. *
- *Hyssopus officinalis* L. *
- *Stachys officinalis* L. *
- *Aloysia citridora* Paláu *
- *Matricaria chamomilla* L. *
- *Calendula officinalis* L. *
- *Heterotheca inuloides* Cass. *
- *Helichrysum italicum* (Roth.) Don fil. *
- *Eucalyptus globulus* Labill. *
- *Jasminum officinale* L. *
- *Citrus x aurantium* L. *
- *Rosa gallica* L. *
- *Agrimonia eupatoria* L. *
- *Alchemilla vulgaris* L. *
- *Ocimum basilicum* L. **
- *Mentha x villosa* Hunds. **
- *Origanum vulgare* L.
- *Mentha longifolia* Huds.
- *Mentha suaveolens* Ehrh. ***

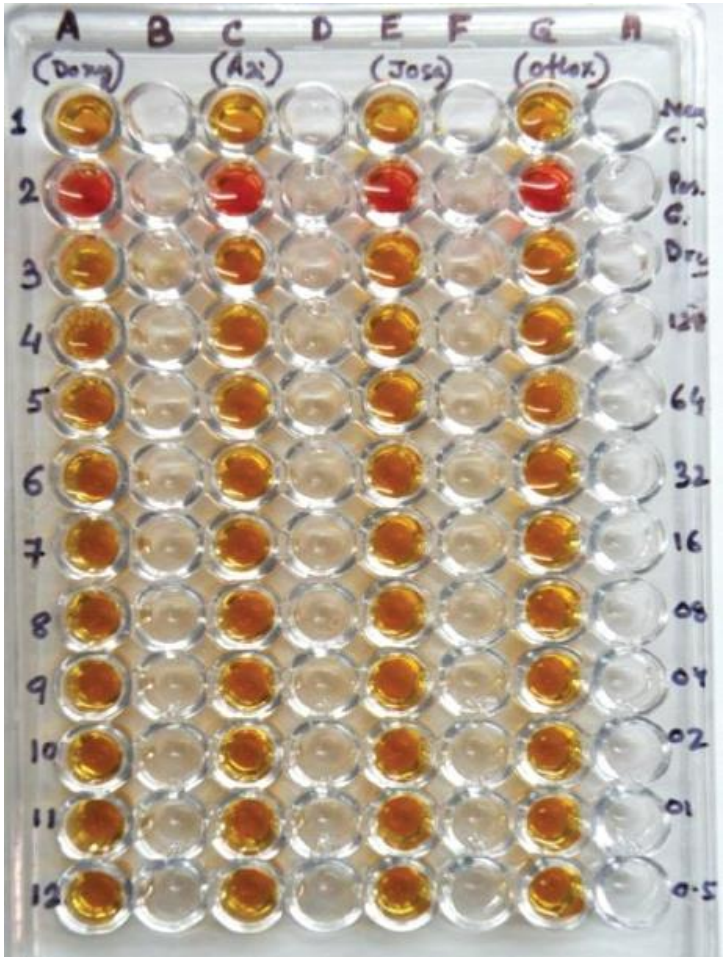
* *Minardi & Figli srl* **Orto La Rocca ***Vivaio 98.3 Piante Mediterranee

Chemical Analysis of EOs



GC-MS analysis using a Perkin Elmer GS-MS equipped with a Stabilwax fused silica capillary column

Microbiology: Antifungal and Anti-biofilm Activities



- The *in vitro* antifungal activity of EOs was evaluated against the reference strain *Candida albicans* ATCC 10231;
- The MIC was determined by *microbroth dilution method* described in the CLSI M27-A3 Standard following the international recommendations given by the National Committee for Clinical Laboratory Standards;
- The anti-biofilm activity was tested on bacterial cultures of 5 different strains belonging to genera *Pseudomonas* and *Staphylococcus*;
- Biofilm formation was assessed in static conditions;
- To measure the formation of biofilm, crystal violet staining was used;
- The biofilm-forming inhibition of less than 35% has been considered as not effective.

EO Extraction: Yields Numbers

Relative yield % of essential oils over time

Plant species	h [1] / m [2]	1	2	3	6	12	24
SP	*Jun.*	0.011	0.014	0.016	0.020	0.027	0.038
MA	*Jul.*	0.010	0.014	0.016	0.019	0.024	0.030
	Aug.	0.020	0.026	0.029	0.033	0.036	0.039
	Sep.	0.020	0.026	0.028	0.031	0.034	0.037
MS	*Jul.*	0.030	0.040	0.050	0.050	0.060	0.070
	Aug.	0.070	0.090	0.100	0.120	0.150	0.190
	Sep.	0.050	0.090	0.090	0.100	0.110	0.180
CG	*Jul.*	0.300	0.350	0.360	0.366	0.370	0.373
	Aug.	0.300	0.360	0.400	0.420	0.426	0.432
	Sep.	0.190	0.250	0.300	0.360	0.376	0.381
	Oct.	0.180	0.260	0.290	0.320	0.328	0.328
FV	*Aug.*	0.070	0.110	0.140	0.180	0.196	0.213
	Sep.	0.090	0.140	0.170	0.200	0.218	0.240
	Oct.	0.360	0.640	0.830	1.090	1.210	1.250
RS	*Jul.*	0.200	0.300	0.440	0.640	0.740	0.800

[1] Extraction hour, [2] Month of harvesting.

EO Extraction: Yields Numbers

Relative yield % of essential oils over time

Plant species	h [1] / m [2]	1	2	3	6	12	24
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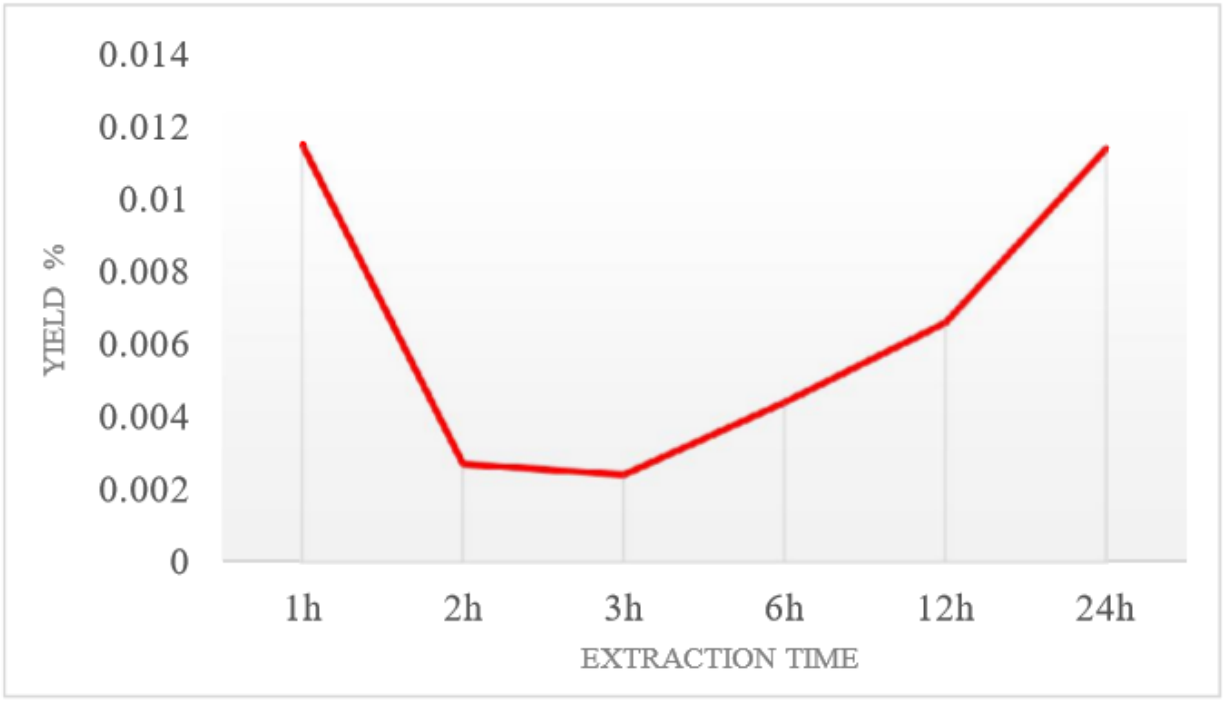
MA	*Jul.*	0.010	0.014	0.016	0.019	0.024	0.030
	Aug.	0.020	0.026	0.029	0.033	0.036	0.039
	Sep.	0.020	0.026	0.028	0.031	0.034	0.037
MS	*Jul.*	0.030	0.040	0.050	0.050	0.060	0.070
	Aug.	0.070	0.090	0.100	0.120	0.150	0.190
	Sep.	0.050	0.090	0.090	0.100	0.110	0.180
CG	*Jul.*	0.300	0.350	0.360	0.366	0.370	0.373
	Aug.	0.300	0.360	0.400	0.420	0.426	0.432
	Sep.	0.190	0.250	0.300	0.360	0.376	0.381
	Oct.	0.180	0.260	0.290	0.320	0.328	0.328
FV	*Aug.*	0.070	0.110	0.140	0.180	0.196	0.213
	Sep.	0.090	0.140	0.170	0.200	0.218	0.240
	Oct.	0.360	0.640	0.830	1.090	1.210	1.250
RS	*Jul.*	0.200	0.300	0.440	0.640	0.740	0.800

[1] Extraction hour, [2] Month of harvesting.

EO Extraction: Yields Plots

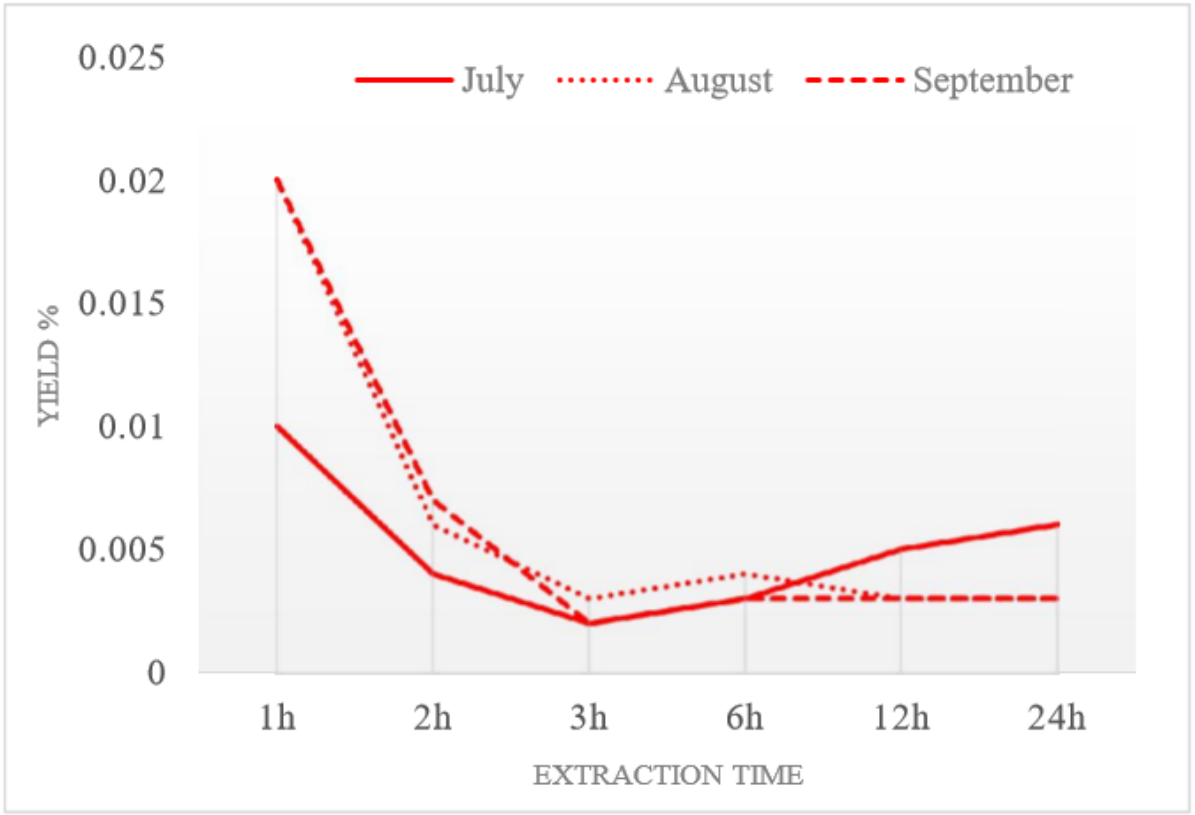


24-hour (total) yield

0.04 %

Yield curve for Sideritis purpurea harvested in June

EO Extraction: Yields Plots

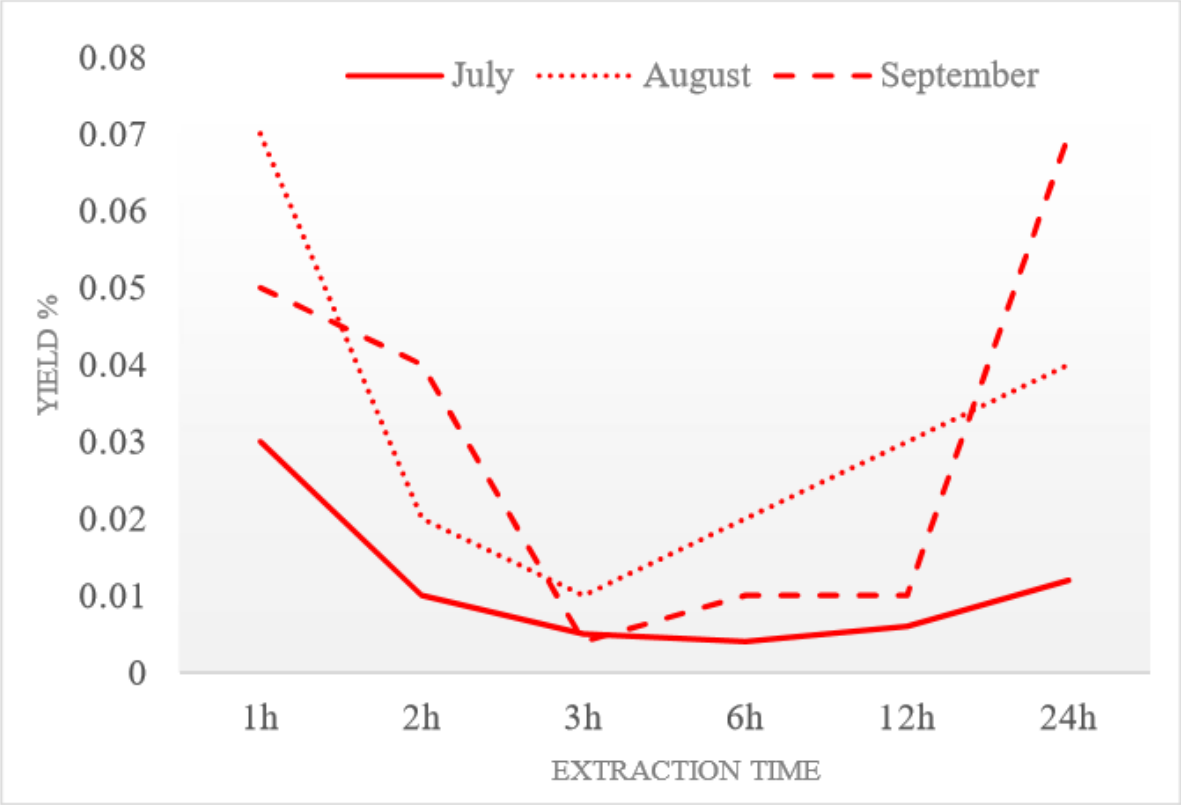


24-hour (total) yield

July: 0.03 %
August: 0.04 %
September: 0.07 %

Yields curves for Melissa altissima monitored for 3 months

EO Extraction: Yields Plots

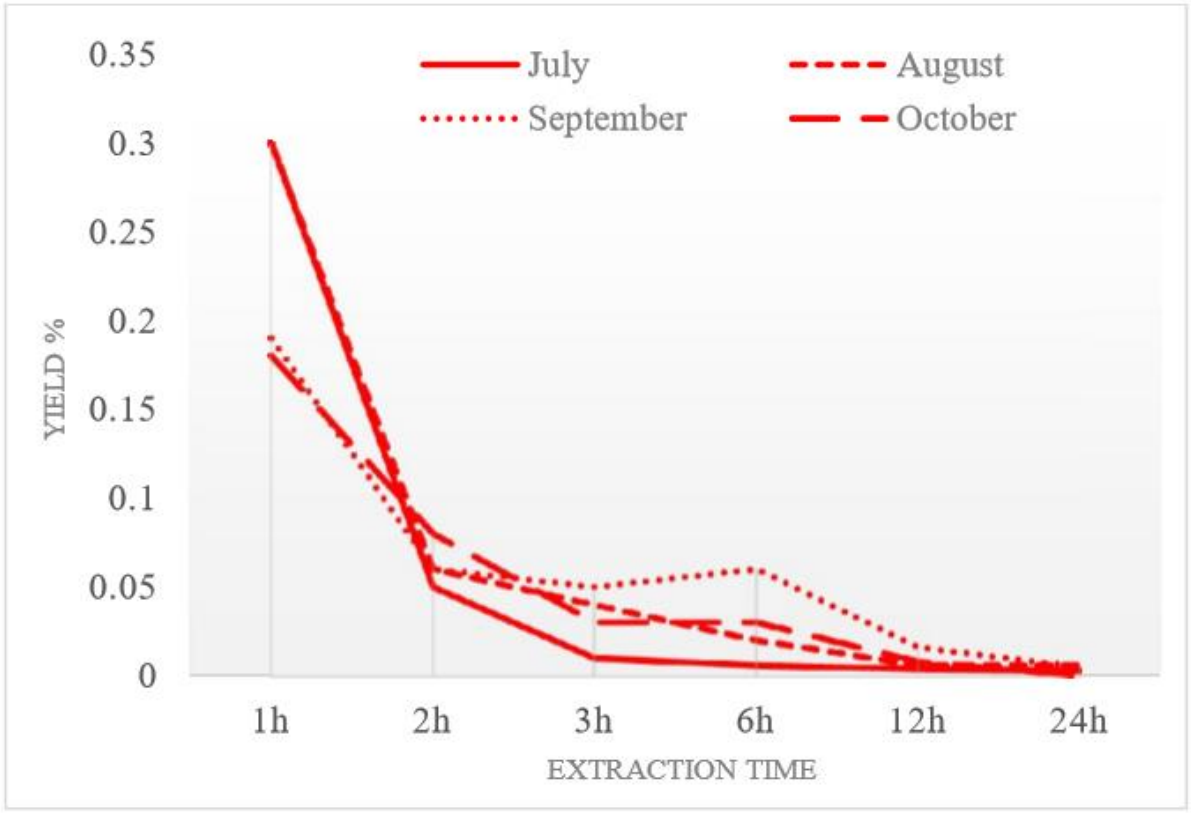


24-hour (total) yield

July: 0.07 %
August: 0.19 %
September: 0.18 %

Yields curves for Mentha suaveolens monitored for 3 months

EO Extraction: Yields Plots

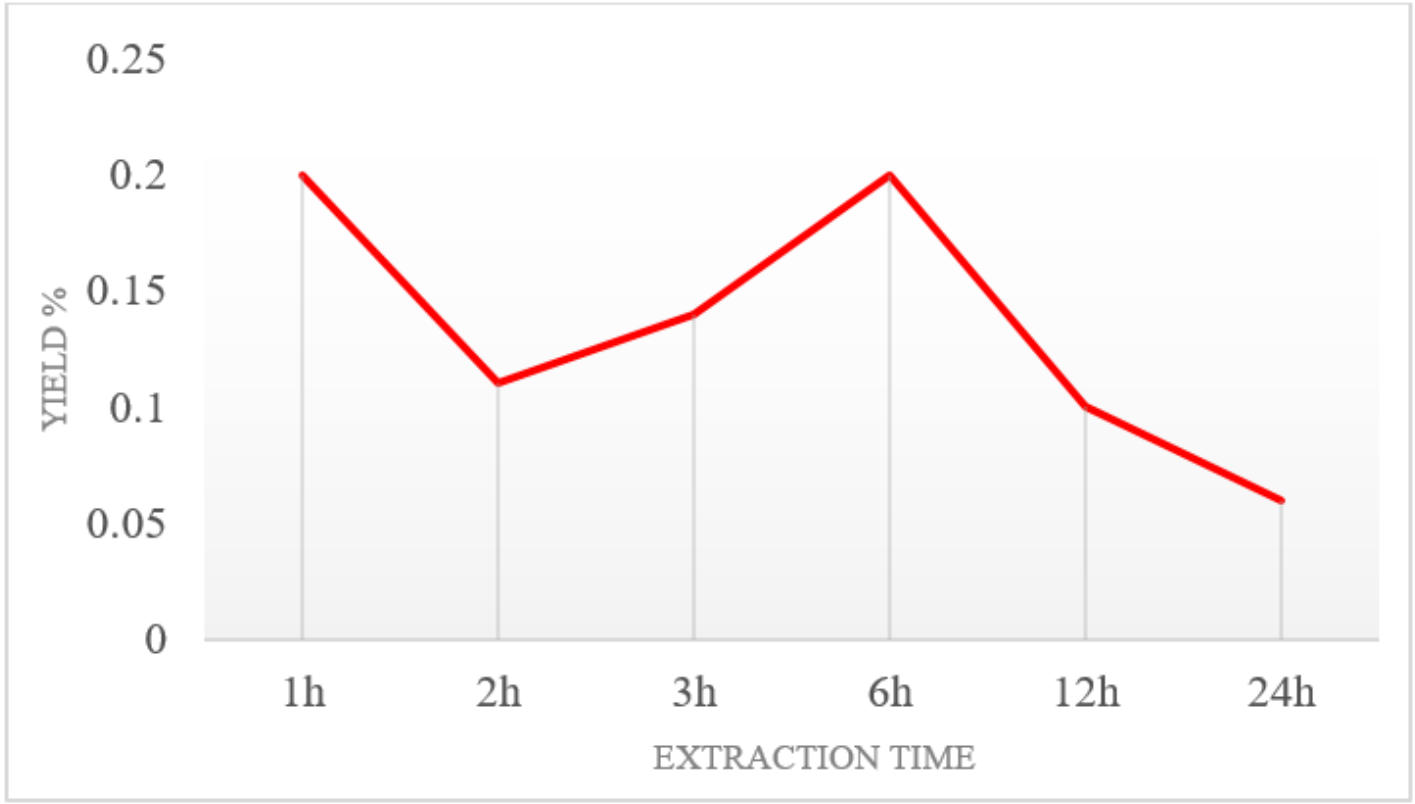


24-hour (total) yield

July: 0.37 %
August: 0.43 %
September: 0.38 %
October: 0.33 %

Yields curves for Calamintha glandulosa monitored for 4 months

EO Extraction: Yields Plots

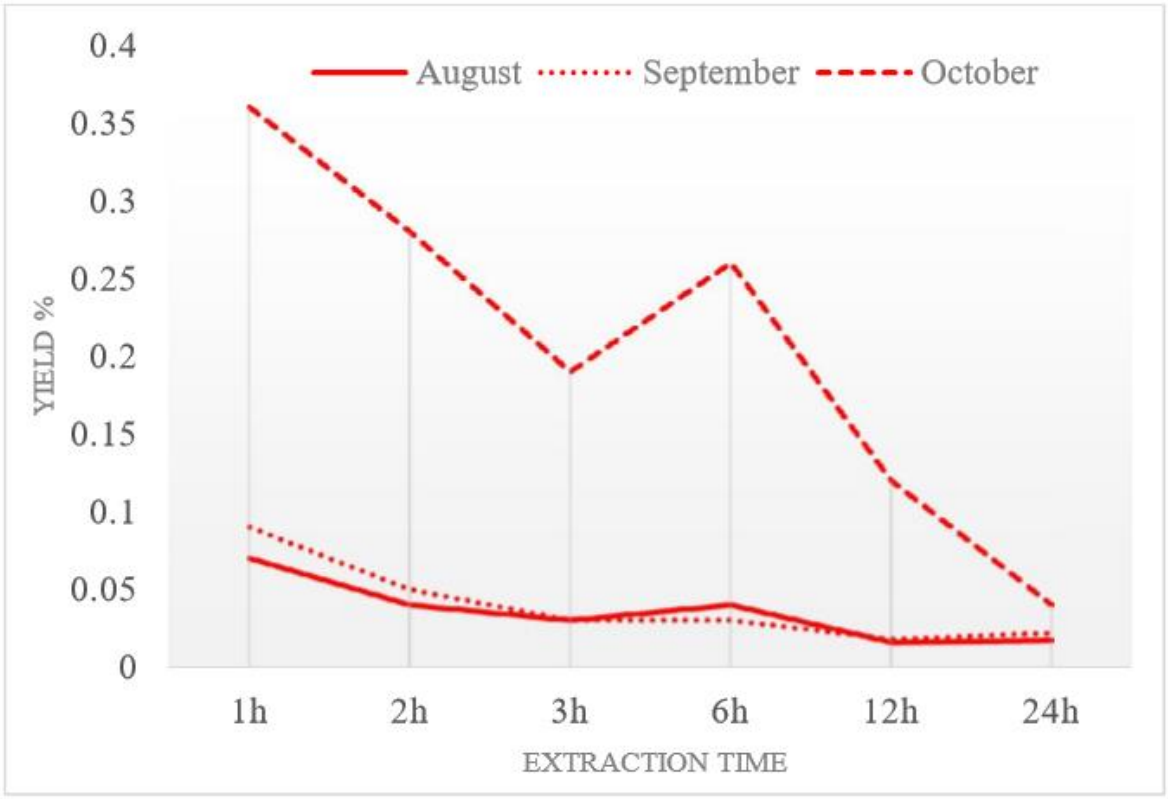


24-hour (total) yield

0.8 %

Yield curve for Ridolfia segetum harvested in July

EO Extraction: Yields Plots



24-hour (total) yield

August: 0.21 %
September: 0.24 %
October: 1.25 %

Yields curves for Foeniculum vulgare monitored for 3 months

Chemical Analyses of EOs

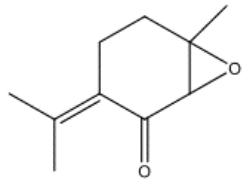
h [1]	July [2]			August			September		
	PO	*PHA*	*CIN*	*PO*	*PHA*	*CIN*	*PO*	*PHA*	*CIN*
1	87.2	-	0.2	65.0	5.1	-	38.7	1.6	18.8
2	70.6	-	0.1	77.5	8.0	-	35.6	10.1	-
3	65.6	-	-	50.0	16.5	-	69.5	0.1	-
6	26.0	-	-	16.9	9.1	23.1	13.2	12.1	2.7
12	14.0	-	-	2.4	2.6	34.5	5.5	6.4	13.0
24	-	-	7.7	-	0.4	38.8	5.6	6.3	19.0

[1] Extraction hours, [2] Month of harvesting.

PO: *piperitenone oxide*; PHA: *α-pharnesene*; CIN: *cinerolone*

Chemical composition of Mentha suaveolens EOs

Chemical Analyses of EOs



piperitenone oxide

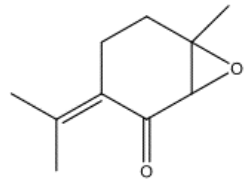
h [1]	July [2]			August			September		
	PO	*PHA*	*CIN*	*PO*	*PHA*	*CIN*	*PO*	*PHA*	*CIN*
1	87.2	-	0.2	65.0	5.1	-	38.7	1.6	18.8
2	70.6	-	0.1	77.5	8.0	-	35.6	10.1	-
3	65.6	-	-	50.0	16.5	-	69.5	0.1	-
6	26.0	-	-	16.9	9.1	23.1	13.2	12.1	2.7
12	14.0	-	-	2.4	2.6	34.5	5.5	6.4	13.0
24	-	-	7.7	-	0.4	38.8	5.6	6.3	19.0

[1] Extraction hours, [2] Month of harvesting.

PO: *piperitenone oxide*; PHA: *α-pharnesene*; CIN: *cinerolone*

Chemical composition of Mentha suaveolens EOs

Chemical Analyses of EOs



piperitenone oxide

h [1]	July [2]			August			September		
	PO	*PHA*	*CIN*	*PO*	*PHA*	*CIN*	*PO*	*PHA*	*CIN*
1	87.2	-	0.2	65.0	5.1	-	38.7	1.6	18.8
2	70.6	-	0.1	77.5	8.0	-	35.6	10.1	-
3	65.6	-	-	50.0	16.5	-	69.5	0.1	-
6	26.0	-	-	16.9	9.1	23.1	13.2	12.1	2.7
12	14.0	-	-	2.4	2.6	34.5	5.5	6.4	13.0
24	-	-	7.7	-	0.4	38.8	5.6	6.3	19.0

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Chemical composition of Mentha suaveolens EOs

Chemical Analyses of EOs

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2	70.6	-	0.1	77.5	8.0	-	35.6	10.1	-
3	65.6	-	-	50.0	16.5	-	69.5	0.1	-
6	26.0	-	-	16.9	9.1	23.1	13.2	12.1	2.7
12	14.0	-	-	2.4	2.6	34.5	5.5	6.4	13.0
24	-	-	7.7	-	0.4	38.8	5.6	6.3	19.0

[1] Extraction hours, [2] Month of harvesting.

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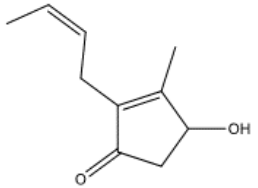
Chemical composition of Mentha suaveolens EOs

Chemical Analyses of EOs



cinerolone

h [1]	July [2]			August			September		
	PO	*PHA*	*CIN*	*PO*	*PHA*	*CIN*	*PO*	*PHA*	*CIN*
1	87.2	-	0.2	65.0	5.1	-	38.7	1.6	18.8
2	70.6	-	0.1	77.5	8.0	-	35.6	10.1	-
3	65.6	-	-	50.0	16.5	-	69.5	0.1	-
6	26.0	-	-	16.9	9.1	23.1	13.2	12.1	2.7
12	14.0	-	-	2.4	2.6	34.5	5.5	6.4	13.0
24	-	-	7.7	-	0.4	38.8	5.6	6.3	19.0

[1] Extraction hours, [2] Month of harvesting.

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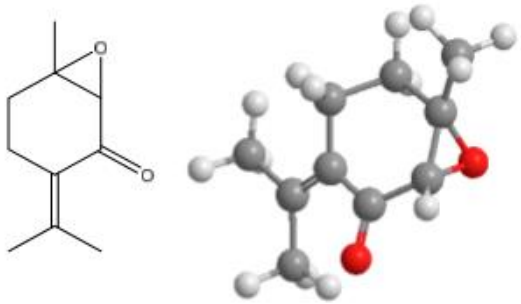
Chemical composition of Mentha suaveolens EOs

Chemical Analyses of EOs



Molecules **2015**, *20*, 8605-8633; doi:10.3390/molecules20058605

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ISSN 1420-3049

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Review

Mentha suaveolens Ehrh. (Lamiaceae) Essential Oil and Its Main Constituent Piperitenone Oxide: Biological Activities and Chemistry †

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Chemical Analyses of EOs

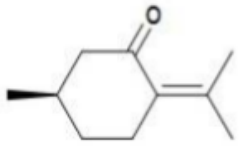
h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

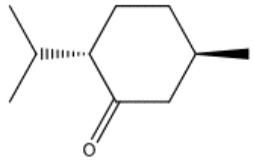
PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs



pulegone



menthone

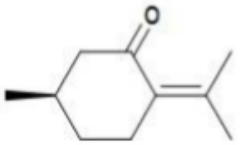
h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs



pulegone

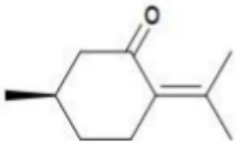
h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs



pulegone

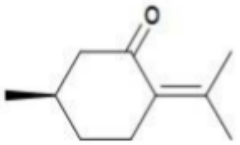
h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs



pulegone

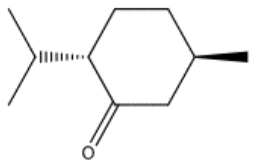
h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs



menthone

h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs

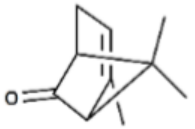
h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs



chrysanthenone

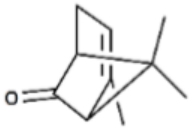
h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs



chrysanthenone

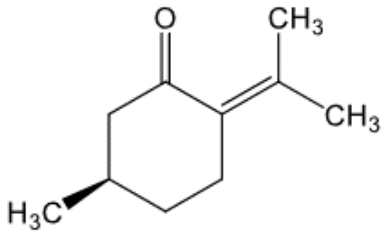
h [1]	July [2]			August			September			October		
	PUL	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*	*PUL*	*MEN*	*CRY*
1	76.8	3.1	4.4	80.8	3.9	2.6	48.8	20.3	1.3	42.5	35.4	1.3
2	77.7	0.8	10.5	84.7	2.1	5.2	62.5	20.0	2.0	57.5	27.8	2.3
3	64.3	0.6	20.3	80.0	1.0	9.0	72.9	11.2	3.4	53.3	23.6	3.3
6	53.2	0.6	22.7	66.0	0.8	18.4	74.9	5.9	6.8	68.2	10.9	5.3
12	41.1	0.6	33.9	55.4	0.7	24.0	64.8	4.1	13.6	68.8	7.0	5.4
24	37.7	-	27.3	49.9	0.7	29.5	43.2	3.7	18.6	51.8	6.8	13.4

[1] Extraction hours, [2] Month of harvesting.

PUL: *pulegone*; MEN: *menthone*; CRY: *chrysanthenone*

Chemical composition of Calamintha glandulosa EOs

Chemical Analyses of EOs



molecules

MDPI

Review

Calamintha nepeta (L.) Savi and Its Main Essential Oil Constituent Pulegone: Biological Activities and Chemistry

Mijat Božović[§] and Rino Ragno[§,ς,*]

[§]Rome Center for Molecular Design, Department of Drug Chemistry and Technology, Sapienza University, P.le Aldo Moro 5, 00185 Rome, Italy; E-mail: mijat.bozovic@uniroma1.it (M.B.)
[ς]Alchemical Dynamics s.r.l., 00125 Rome, Italy
* Corresponding author: rino.ragno@uniroma1.it (R.R.); Tel.: +39-06-4991-3937; Fax: +39-06-4991-3627

Chemical Analyses of EOs

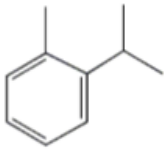
h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs



o-cymene

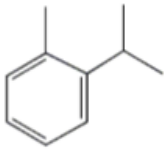
h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

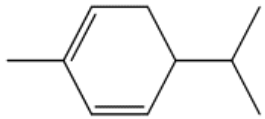
OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs



o-cymene



α-phellandrene

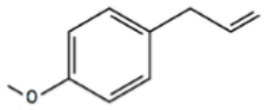
h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs



estragole

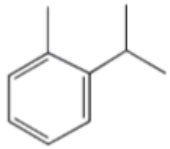
h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs



o-cymene

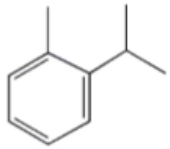
h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs



o-cymene

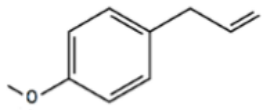
h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs



estragole

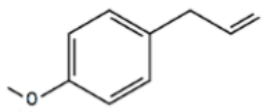
h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs



estragole

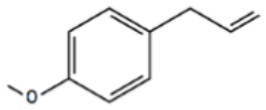
h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs



estragole

h [1]	August [2]			September			October		
	OCI	*EST*	*APH*	*OCI*	*EST*	*APH*	*OCI*	*EST*	*APH*
1	22.9	12.0	11.8	52.2	-	12.9	3.9	57.6	5.7
2	21.5	12.5	12.3	35.9	-	15.7	2.7	54.8	6.6
3	24.4	14.0	5.9	25.7	-	1.3	3.5	39.1	8.0
6	18.7	5.9	20.0	18.8	-	6.0	1.6	30.1	8.6
12	13.6	1.7	3.8	12.7	-	0.9	0.6	9.4	3.4
24	2.4	0.9	-	18.1	-	0.4	6.0	8.6	2.8

[1] Extraction hours, [2] Month of harvesting.

OCI: *o-cymene*; EST: *estragole*; APH: *α-phellandrene*

Chemical composition of Foeniculum vulgare EOs

Chemical Analyses of EOs

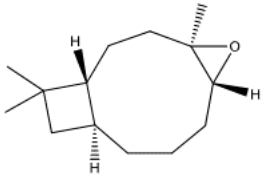
	July [2]			August			September		
h [1]	*CAR*	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*
1	22.4	0.5	10.7	-	18.8	2.4	6.2	61.1	1.5
2	24.0	16.6	14.1	-	23.7	-	25.6	19.3	8.6
3	17.6	18.0	17.7	-	18.6	3.1	21.4	20.8	10.8
6	10.9	12.2	9.0	9.3	20.4	11.7	17.1	7.5	11.0
12	18.9	5.8	-	-	16.1	18.6	4.3	8.5	63.1
24	5.0	-	29.6	6.9	17.3	22.9	6.6	14.0	19.2

[1] Extraction hours, [2] Month of harvesting.

CAR: *caryophyllene*; CAO: *caryophyllene oxide*; PUL: *pulegone*

Chemical composition of Melissa altissima EOs

Chemical Analyses of EOs



caryophyllene oxide

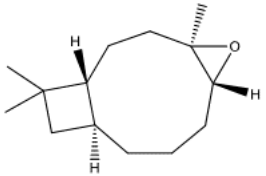
h [1]	July [2]			August			September		
	CAR	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*
1	22.4	0.5	10.7	-	18.8	2.4	6.2	61.1	1.5
2	24.0	16.6	14.1	-	23.7	-	25.6	19.3	8.6
3	17.6	18.0	17.7	-	18.6	3.1	21.4	20.8	10.8
6	10.9	12.2	9.0	9.3	20.4	11.7	17.1	7.5	11.0
12	18.9	5.8	-	-	16.1	18.6	4.3	8.5	63.1
24	5.0	-	29.6	6.9	17.3	22.9	6.6	14.0	19.2

[1] Extraction hours, [2] Month of harvesting.

CAR: *caryophyllene*; CAO: *caryophyllene oxide*; PUL: *pulegone*

Chemical composition of Melissa altissima EOs

Chemical Analyses of EOs



caryophyllene oxide

h [1]	July [2]			August			September		
	CAR	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*
1	22.4	0.5	10.7	-	18.8	2.4	6.2	61.1	1.5
2	24.0	16.6	14.1	-	23.7	-	25.6	19.3	8.6
3	17.6	18.0	17.7	-	18.6	3.1	21.4	20.8	10.8
6	10.9	12.2	9.0	9.3	20.4	11.7	17.1	7.5	11.0
12	18.9	5.8	-	-	16.1	18.6	4.3	8.5	63.1
24	5.0	-	29.6	6.9	17.3	22.9	6.6	14.0	19.2

[1] Extraction hours, [2] Month of harvesting.

CAR: *caryophyllene*; CAO: *caryophyllene oxide*; PUL: *pulegone*

Chemical composition of Melissa altissima EOs

Chemical Analyses of EOs

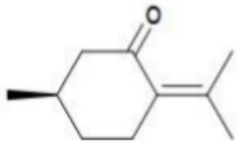
h [1]	July [2]			August			September		
	CAR	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*
1	22.4	0.5	10.7	-	18.8	2.4	6.2	61.1	1.5
2	24.0	16.6	14.1	-	23.7	-	25.6	19.3	8.6
3	17.6	18.0	17.7	-	18.6	3.1	21.4	20.8	10.8
6	10.9	12.2	9.0	9.3	20.4	11.7	17.1	7.5	11.0
12	18.9	5.8	-	-	16.1	18.6	4.3	8.5	63.1
24	5.0	-	29.6	6.9	17.3	22.9	6.6	14.0	19.2

[1] Extraction hours, [2] Month of harvesting.

CAR: *caryophyllene*; CAO: *caryophyllene oxide*; PUL: *pulegone*

Chemical composition of Melissa altissima EOs

Chemical Analyses of EOs



pulegone

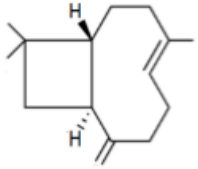
h [1]	July [2]			August			September		
	CAR	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*
1	22.4	0.5	10.7	-	18.8	2.4	6.2	61.1	1.5
2	24.0	16.6	14.1	-	23.7	-	25.6	19.3	8.6
3	17.6	18.0	17.7	-	18.6	3.1	21.4	20.8	10.8
6	10.9	12.2	9.0	9.3	20.4	11.7	17.1	7.5	11.0
12	18.9	5.8	-	-	16.1	18.6	4.3	8.5	63.1
24	5.0	-	29.6	6.9	17.3	22.9	6.6	14.0	19.2

[1] Extraction hours, [2] Month of harvesting.

CAR: *caryophyllene*; CAO: *caryophyllene oxide*; PUL: *pulegone*

Chemical composition of Melissa altissima EOs

Chemical Analyses of EOs



caryophyllene

h [1]	July [2]			August			September		
	CAR	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*	*CAR*	*CAO*	*PUL*
1	22.4	0.5	10.7	-	18.8	2.4	6.2	61.1	1.5
2	24.0	16.6	14.1	-	23.7	-	25.6	19.3	8.6
3	17.6	18.0	17.7	-	18.6	3.1	21.4	20.8	10.8
6	10.9	12.2	9.0	9.3	20.4	11.7	17.1	7.5	11.0
12	18.9	5.8	-	-	16.1	18.6	4.3	8.5	63.1
24	5.0	-	29.6	6.9	17.3	22.9	6.6	14.0	19.2

[1] Extraction hours, [2] Month of harvesting.

CAR: *caryophyllene*; CAO: *caryophyllene oxide*; PUL: *pulegone*

Chemical composition of Melissa altissima EOs

Chemical Analyses of EOs

h [1]	July		
	OCI	*API*	*LIM*
1	40.1	6.5	7.4
2	23.6	11.7	4.5
3	3.3	18.2	5.8
6	12.1	22.3	3.3
12	6.5	52.2	1.1
24	3.5	60.3	0.2

[1] Extraction hours.

h [1]	June		
	GEL	*SPA*	*VER*
1	22.2	18.1	-
2	25.2	27.7	-
3	14.4	26.7	6.4
6	9.2	15.4	8.5
12	6.3	10.4	11.5
24	6.7	8.9	13.9

[1] Extraction hours.

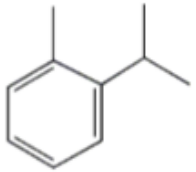
OCI: *o-cymene*; API: *apiol*; LIM: *limonene*; GEL: *γ-elemene*; SPA: *spathulenol*; VER: *verbenone*

Chemical composition of Ridolfia sefetum and Sideritis purpurea EOs

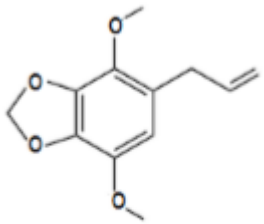
Chemical Analyses of EOs

h [1]	July		
	OCI	*API*	*LIM*
1	40.1	6.5	7.4
2	23.6	11.7	4.5
3	3.3	18.2	5.8
6	12.1	22.3	3.3
12	6.5	52.2	1.1
24	3.5	60.3	0.2

[1] Extraction hours.



o-cymene



apiol

h [1]	June		
	GEL	*SPA*	*VER*
1	22.2	18.1	-
2	25.2	27.7	-
3	14.4	26.7	6.4
6	9.2	15.4	8.5
12	6.3	10.4	11.5
24	6.7	8.9	13.9

[1] Extraction hours.

OCI: *o-cymene*; API: *apiol*; LIM: *limonene*; GEL: *γ-elemene*; SPA: *spathulenol*; VER: *verbenone*

Chemical composition of Ridolfia sefetum and Sideritis purpurea EOs

Chemical Analyses of EOs

h [1]	July		
	OCI	*API*	*LIM*
1	40.1	6.5	7.4
2	23.6	11.7	4.5
3	3.3	18.2	5.8
6	12.1	22.3	3.3
12	6.5	52.2	1.1
24	3.5	60.3	0.2

[1] Extraction hours.

h [1]	June		
	GEL	*SPA*	*VER*
1	22.2	18.1	-
2	25.2	27.7	-
3	14.4	26.7	6.4
6	9.2	15.4	8.5
12	6.3	10.4	11.5
24	6.7	8.9	13.9

[1] Extraction hours.

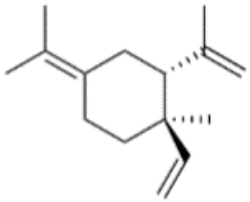
OCI: *o-cymene*; API: *apiol*; LIM: *limonene*; GEL: *γ-elemene*; SPA: *spathulenol*; VER: *verbenone*

Chemical composition of Ridolfia sefetum and Sideritis purpurea EOs

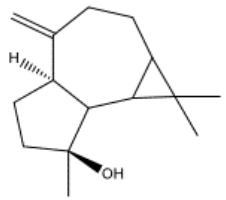
Chemical Analyses of EOs

h [1]	July		
	OCI	*API*	*LIM*
1	40.1	6.5	7.4
2	23.6	11.7	4.5
3	3.3	18.2	5.8
6	12.1	22.3	3.3
12	6.5	52.2	1.1
24	3.5	60.3	0.2

[1] Extraction hours.



γ-elemene



spathulenol

h [1]	June		
	GEL	*SPA*	*VER*
1	22.2	18.1	-
2	25.2	27.7	-
3	14.4	26.7	6.4
6	9.2	15.4	8.5
12	6.3	10.4	11.5
24	6.7	8.9	13.9

[1] Extraction hours.

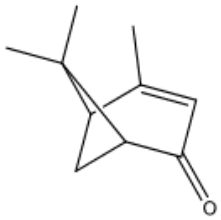
OCI: *o-cymene*; API: *apiol*; LIM: *limonene*; GEL: *γ-elemene*; SPA: *spathulenol*; VER: *verbenone*

Chemical composition of Ridolfia sefetum and Sideritis purpurea EOs

Chemical Analyses of EOs

h [1]	July		
	OCI	*API*	*LIM*
1	40.1	6.5	7.4
2	23.6	11.7	4.5
3	3.3	18.2	5.8
6	12.1	22.3	3.3
12	6.5	52.2	1.1
24	3.5	60.3	0.2

[1] Extraction hours.



verbenone

h [1]	June		
	GEL	*SPA*	*VER*
1	22.2	18.1	-
2	25.2	27.7	-
3	14.4	26.7	6.4
6	9.2	15.4	8.5
12	6.3	10.4	11.5
24	6.7	8.9	13.9

[1] Extraction hours.

OCI: *o-cymene*; API: *apiol*; LIM: *limonene*; GEL: *γ-elemene*; SPA: *spathulenol*; VER: *verbenone*

Chemical composition of Ridolfia segetum and Sideritis purpurea EOs

Antifungal Activity of EOs

Sample [1]	MIC mg/mL	PO %
J1h	0.10	87.2
J2h	0.10	70.6
J3h	0.10	65.6
J6h	6.25	26.0
J12h	6.25	14.8
J24h	12.50	-
A1h	0.10	65.0
A2h	0.02	77.5
A3h	0.10	50.0
A6h	0.78	16.9
A12h	3.12	2.4
A24h	6.25	-
S1h	0.20	38.7
S2h	0.20	35.6
S3h	0.10	69.5
S6h	6.25	13.2
S12h	6.25	5.5
S24h	0.20	5.6
Miconazole [#]	0.016	-

Anti-Candida albicans activities of Mentha suaveolens EOs

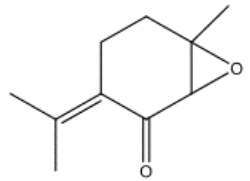
Antifungal Activity of EOs

Sample [1]	MIC mg/mL	PO %
J1h	0.10	87.2
J2h	0.10	70.6
J3h	0.10	65.6
J6h	6.25	26.0
J12h	6.25	14.8
J24h	12.50	-
A1h	0.10	65.0
A2h	0.02	77.5
A3h	0.10	50.0
A6h	0.78	16.9
A12h	3.12	2.4
A24h	6.25	-
S1h	0.20	38.7
S2h	0.20	35.6
S3h	0.10	69.5
S6h	6.25	13.2
S12h	6.25	5.5
S24h	0.20	5.6
Miconazole [#]	0.016	-

Anti-Candida albicans activities of Mentha suaveolens EOs

Antifungal Activity of EOs

Sample [1]	MIC mg/mL	PO %
J1h	0.10	87.2
J2h	0.10	70.6
J3h	0.10	65.6
J6h	6.25	26.0
J12h	6.25	14.8
J24h	12.50	-
A1h	0.10	65.0
A2h	0.02	77.5
A3h	0.10	50.0
A6h	0.78	16.9
A12h	3.12	2.4
A24h	6.25	-
S1h	0.20	38.7
S2h	0.20	35.6
S3h	0.10	69.5
S6h	6.25	13.2
S12h	6.25	5.5
S24h	0.20	5.6
Miconazole [#]	0.016	-



piperitenone oxide

Anti-Candida albicans activities of Mentha suaveolens EOs

Antifungal Activity of EOs

Sample [1]	MIC mg/mL	PO %
J1h	0.10	87.2
J2h	0.10	70.6
J3h	0.10	65.6
J6h	6.25	26.0
J12h	6.25	14.8
J24h	12.50	-
A1h	0.10	65.0
A2h	0.02	77.5
A3h	0.10	50.0
A6h	0.78	16.9
A12h	3.12	2.4
A24h	6.25	-
S1h	0.20	38.7
S2h	0.20	35.6
S3h	0.10	69.5
S6h	6.25	13.2
S12h	6.25	5.5
S24h	0.20	5.6
Miconazole [#]	0.016	-

Anti-Candida albicans activities of Mentha suaveolens EOs

Antifungal Activity of EOs

Sample [1]	MIC mg/mL	PO %
J1h	0.10	87.2
J2h	0.10	70.6
J3h	0.10	65.6
J6h	6.25	26.0
J12h	6.25	14.8
J24h	12.50	-
A1h	0.10	65.0
A2h	0.02	77.5
A3h	0.10	50.0
A6h	0.78	16.9
A12h	3.12	2.4
A24h	6.25	-
S1h	0.20	38.7
S2h	0.20	35.6
S3h	0.10	69.5
S6h	6.25	13.2
S12h	6.25	5.5
S24h	0.20	5.6
Miconazole [#]	0.016	-

Anti-Candida albicans activities of Mentha suaveolens EOs

Antifungal Activity of EOs

Sample [1]	MIC mg/mL	PO %
J1h	0.10	87.2
J2h	0.10	70.6
J3h	0.10	65.6
J6h	6.25	26.0
J12h	6.25	14.8
J24h	12.50	-
A1h	0.10	65.0
A2h	0.02	77.5
A3h	0.10	50.0
A6h	0.78	16.9
A12h	3.12	2.4
A24h	6.25	-
S1h	0.20	38.7
S2h	0.20	35.6
S3h	0.10	69.5
S6h	6.25	13.2
S12h	6.25	5.5
S24h	0.20	5.6
Miconazole [#]	0.016	-

Anti-Candida albicans activities of Mentha suaveolens EOs

Antifungal Activity of EOs

Sample [1]	MIC mg/mL		PUL %	Sample [1]	MIC mg/mL		PUL %
	24h	48h			24h	48h	
J1h	6.24	6.24	76.8	**S1h**	6.24	12.48	48.8
J2h	6.24	12.48	77.7	**S2h**	6.24	12.48	62.5
J3h	0.78	6.24	64.3	**S3h**	3.12	12.48	72.9
J6h	na	na	53.2	**S6h**	1.56	6.24	74.9
J12h	12.48	12.48	41.1	**S12h**	3.12	12.48	64.8
J24h	na	na	37.7	**S24h**	12.48	na	43.2
A1h	3.12	12.48	80.8	**O1h**	6.24	12.48	42.5
A2h	3.12	6.24	84.7	**O2h**	6.24	12.48	57.5
A3h	1.56	3.12	80.0	**O3h**	6.24	12.48	53.3
A6h	3.12	6.24	66.0	**O6h**	12.48	12.48	68.2
A12h	6.24	na	55.4	**O12h**	12.48	12.48	68.8
A24h	6.24	12.48	49.9	**O24h**	na	na	51.8

Anti-Candida albicans activities of Calamintha glandulosa EOs

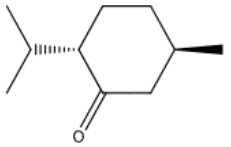
Antifungal Activity of EOs

Sample [1]	MIC mg/mL		PUL %	Sample [1]	MIC mg/mL		PUL %
	24h	48h			24h	48h	
J1h	6.24	6.24	76.8	**S1h**	6.24	12.48	48.8
J2h	6.24	12.48	77.7	**S2h**	6.24	12.48	62.5
J3h	0.78	6.24	64.3	**S3h**	3.12	12.48	72.9
J6h	na	na	53.2	**S6h**	1.56	6.24	74.9
J12h	12.48	12.48	41.1	**S12h**	3.12	12.48	64.8
J24h	na	na	37.7	**S24h**	12.48	na	43.2
A1h	3.12	12.48	80.8	**O1h**	6.24	12.48	42.5
A2h	3.12	6.24	84.7	**O2h**	6.24	12.48	57.5
A3h	1.56	3.12	80.0	**O3h**	6.24	12.48	53.3
A6h	3.12	6.24	66.0	**O6h**	12.48	12.48	68.2
A12h	6.24	na	55.4	**O12h**	12.48	12.48	68.8
A24h	6.24	12.48	49.9	**O24h**	na	na	51.8

Anti-Candida albicans activities of Calamintha glandulosa EOs

Antifungal Activity of EOs

Sample [1]	MIC mg/mL		PUL %	Sample [1]	MIC mg/mL		PUL %
	24h	48h			24h	48h	
J1h	6.24	6.24	76.8	**S1h**	6.24	12.48	48.8
J2h	6.24	12.48	77.7	**S2h**	6.24	12.48	62.5
J3h	0.78	6.24	64.3	**S3h**	3.12	12.48	72.9
J6h	na	na	53.2	**S6h**	1.56	6.24	74.9
J12h	12.48	12.48	41.1	**S12h**	3.12	12.48	64.8
J24h	na	na	37.7	**S24h**	12.48	na	43.2
A1h	3.12	12.48	80.8	**O1h**	6.24	12.48	42.5
A2h	3.12	6.24	84.7	**O2h**	6.24	12.48	57.5
A3h	1.56	3.12	80.0	**O3h**	6.24	12.48	53.3
A6h	3.12	6.24	66.0	**O6h**	12.48	12.48	68.2
A12h	6.24	na	55.4	**O12h**	12.48	12.48	68.8
A24h	6.24	12.48	49.9	**O24h**	na	na	51.8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Anti-Candida albicans activities of Calamintha glandulosa EOs

Antifungal Activity of EOs

molecules
MDPI

Article

Essential Oil Extraction, Chemical Analysis and Anti-*Candida* Activity of *Calamintha nepeta* (L.) Savi subsp. *glandulosa* (Req.) Ball—New Approaches

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Antifungal Activity of EOs

Sample [1]	MIC mg/mL		Sample [1]	MIC mg/mL		Sample [1]	MIC mg/mL	
	24h	48h		24h	48h		24h	48h
A1h	na	na	**S1h**	na	na	**O1h**	1.56	6.24
A2h	12.48	na	**S2h**	6.24	12.48	**O2h**	3.12	12.48
A3h	na	na	**S3h**	6.24	12.48	**O3h**	1.56	12.48
A6h	na	na	**S6h**	6.24	na	**O6h**	3.12	6.24
A12h	na	na	**S12h**	6.24	na	**O12h**	6.24	12.48
A24h	na	na	**S24h**	12.48	12.48	**O24h**	na	na

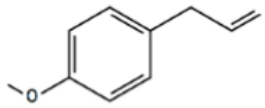
Anti-Candida albicans activities of Foeniculum vulgare EOs

Antifungal Activity of EOs

Sample [1]	MIC mg/mL		Sample [1]	MIC mg/mL		Sample [1]	MIC mg/mL	
	24h	48h		24h	48h		24h	48h
A1h	na	na	**S1h**	na	na	**O1h**	1.56	6.24
A2h	12.48	na	**S2h**	6.24	12.48	**O2h**	3.12	12.48
A3h	na	na	**S3h**	6.24	12.48	**O3h**	1.56	12.48
A6h	na	na	**S6h**	6.24	na	**O6h**	3.12	6.24
A12h	na	na	**S12h**	6.24	na	**O12h**	6.24	12.48
A24h	na	na	**S24h**	12.48	12.48	**O24h**	na	na

Anti-Candida albicans activities of Foeniculum vulgare EOs

Antifungal Activity of EOs



estragole

Sample [1]	MIC mg/mL		Sample [1]	MIC mg/mL		Sample [1]	MIC mg/mL	
	24h	48h		24h	48h		24h	48h
A1h	na	na	**S1h**	na	na	**O1h**	1.56	6.24
A2h	12.48	na	**S2h**	6.24	12.48	**O2h**	3.12	12.48
A3h	na	na	**S3h**	6.24	12.48	**O3h**	1.56	12.48
A6h	na	na	**S6h**	6.24	na	**O6h**	3.12	6.24
A12h	na	na	**S12h**	6.24	na	**O12h**	6.24	12.48
A24h	na	na	**S24h**	12.48	12.48	**O24h**	na	na

Anti-Candida albicans activities of Foeniculum vulgare EOs

Anti-biofilm Activity of EOs

- The activity was evaluated against 5 bacterial pathogens: 2 strains belonging to *Staphylococcus epidermidis*, 2 belonging to *S. aureus* species and *Pseudomonas aeruginosa* PaO1;
- The effect is reported as % of residual biofilm after treatment in comparison to untreated bacteria;
- In general, both strains of *S. aureus* were found to be the most resistant, whereas the strains of *S. epidermidis* species showed highest susceptibility.
- However, none of the concentrations caused the complete inhibition of biofilm;

Anti-biofilm Activity of EOs

Calamintha glandulosa

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
J1h	0.0003814	0.0003814	na	na	na
J2h	0.0003814	0.0003814	na	na	na
J3h	12.5	12.5	na	na	na
J6h	12.5	25	1.55	na	na
J12h	25	25	na	na	na
J24h	25	25	3.125	na	na
A1h	0.0003814	3.125	na	na	25
A2h	0.0003814	0.18	na	na	na
A3h	0.0003814	0.18	na	na	25
A6h	0.0003814	0.39	na	na	25
A12h	25	na	25	na	na
A24	12.5	na	6.25	12.5	na
S1h	0.0003814	na	25	na	na
S2h	0.0003814	0.18	25	na	na
S3h	0.0003814	0.18	na	na	na
S6h	0.0003814	0.18	na	na	na
S12h	na	na	12.5	na	na
S24h	na	na	0.39	na	na
O1h	0.0003814	0.39	na	6.25	na
O2h	0.0003814	0.39	na	na	na
O3h	12.5	12.5	25	na	na
O6h	0.0003814	0.39	na	na	na
O12h	na	na	na	na	na
O24h	25	na	na	na	na

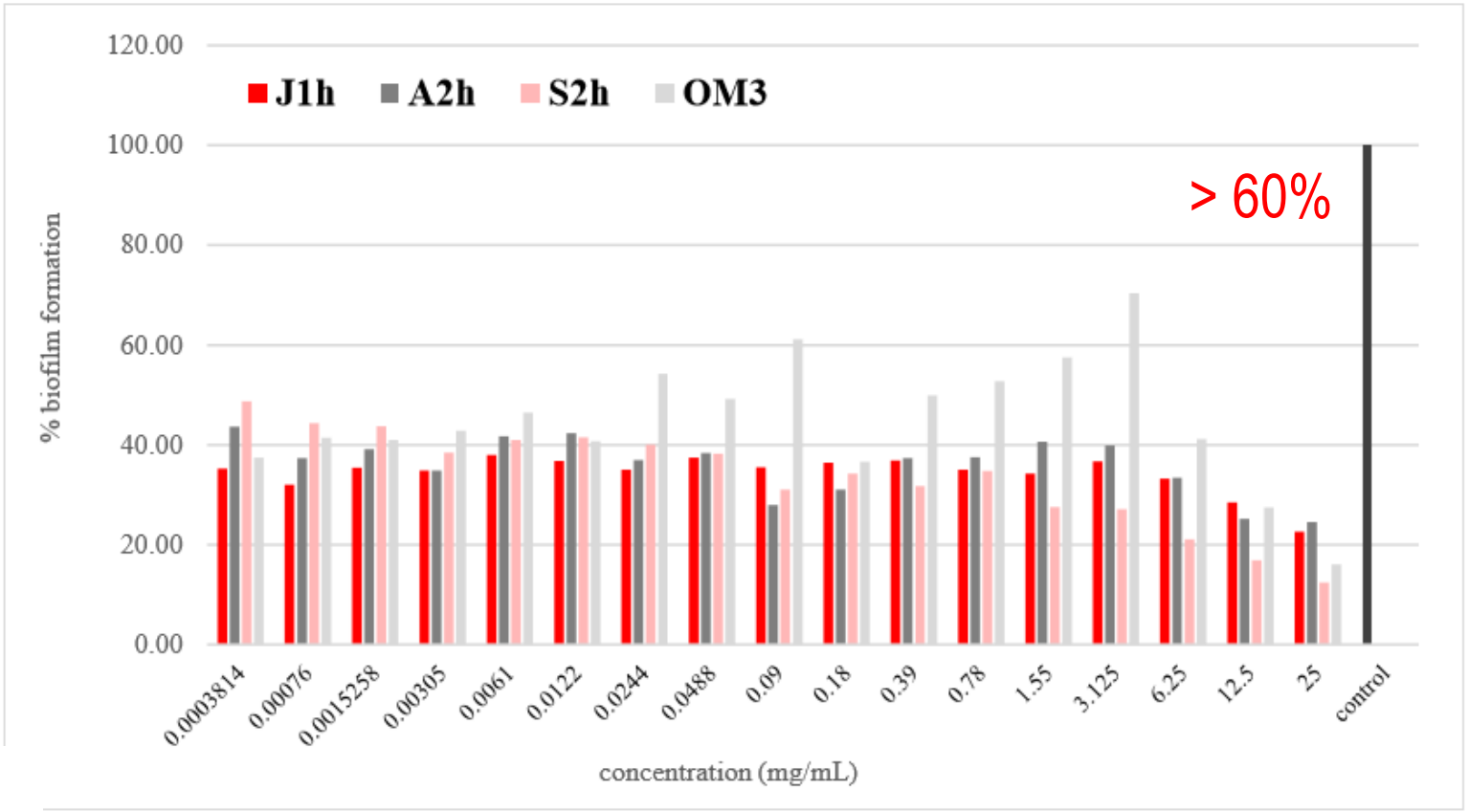
Anti-biofilm Activity of EOs

Calamintha glandulosa

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
J1h	0.0003814	0.0003814	na	na	na
J2h	0.0003814	0.0003814	na	na	na
J3h	12.5	12.5	na	na	na
J6h	12.5	25	1.55	na	na
J12h	25	25	na	na	na
J24h	25	25	3.125	na	na
A1h	0.0003814	3.125	na	na	25
A2h	0.0003814	0.18	na	na	na
A3h	0.0003814	0.18	na	na	25
A6h	0.0003814	0.39	na	na	25
A12h	25	na	25	na	na
A24	12.5	na	6.25	12.5	na
S1h	0.0003814	na	25	na	na
S2h	0.0003814	0.18	25	na	na
S3h	0.0003814	0.18	na	na	na
S6h	0.0003814	0.18	na	na	na
S12h	na	na	12.5	na	na
S24h	na	na	0.39	na	na
O1h	0.0003814	0.39	na	6.25	na
O2h	0.0003814	0.39	na	na	na
O3h	12.5	12.5	25	na	na
O6h	0.0003814	0.39	na	na	na
O12h	na	na	na	na	na
O24h	25	na	na	na	na

Anti-biofilm Activity of EOs



Effects of selected Calamintha glandulosa samples treatment on biofilm formation for S. epidermidis O47

Anti-biofilm Activity of EOs

Calamintha glandulosa

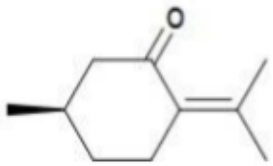
The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
J1h	0.0003814	0.0003814	na	na	na
J2h	0.0003814	0.0003814	na	na	na
J3h	12.5	12.5	na	na	na
J6h	12.5	25	1.55	na	na
J12h	25	25	na	na	na
J24h	25	25	3.125	na	na
A1h	0.0003814	3.125	na	na	25
A2h	0.0003814	0.18	na	na	na
A3h	0.0003814	0.18	na	na	25
A6h	0.0003814	0.39	na	na	25
A12h	25	na	25	na	na
A24	12.5	na	6.25	12.5	na
S1h	0.0003814	na	25	na	na
S2h	0.0003814	0.18	25	na	na
S3h	0.0003814	0.18	na	na	na
S6h	0.0003814	0.18	na	na	na
S12h	na	na	12.5	na	na
S24h	na	na	0.39	na	na
O1h	0.0003814	0.39	na	6.25	na
O2h	0.0003814	0.39	na	na	na
O3h	12.5	12.5	25	na	na
O6h	0.0003814	0.39	na	na	na
O12h	na	na	na	na	na
O24h	25	na	na	na	na

Anti-biofilm Activity of EOs

Calamintha glandulosa

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.



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Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
J1h	0.0003814	0.0003814	na	na	na
J2h	0.0003814	0.0003814	na	na	na
J3h	12.5	12.5	na	na	na
J6h	12.5	25	1.55	na	na
J12h	25	25	na	na	na
J24h	25	25	3.125	na	na
A1h	0.0003814	3.125	na	na	25
A2h	0.0003814	0.18	na	na	na
A3h	0.0003814	0.18	na	na	25
A6h	0.0003814	0.39	na	na	25
A12h	25	na	25	na	na
A24	12.5	na	6.25	12.5	na
S1h	0.0003814	na	25	na	na
S2h	0.0003814	0.18	25	na	na
S3h	0.0003814	0.18	na	na	na
S6h	0.0003814	0.18	na	na	na
S12h	na	na	12.5	na	na
S24h	na	na	0.39	na	na
O1h	0.0003814	0.39	na	6.25	na
O2h	0.0003814	0.39	na	na	na
O3h	12.5	12.5	25	na	na
O6h	0.0003814	0.39	na	na	na
O12h	na	na	na	na	na
O24h	25	na	na	na	na

Anti-biofilm Activity of EOs

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
1h	25	25	0.0003814	25	na
2h	25	25	0.0488	na	na
3h	na	25	3.125	12.5	na
6h	0.0003814	0.0003814	na	na	na
12h	25	25	12.5	na	na
24h	0.0003814	0.0003814	na	na	na

Ridolfia segetum

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

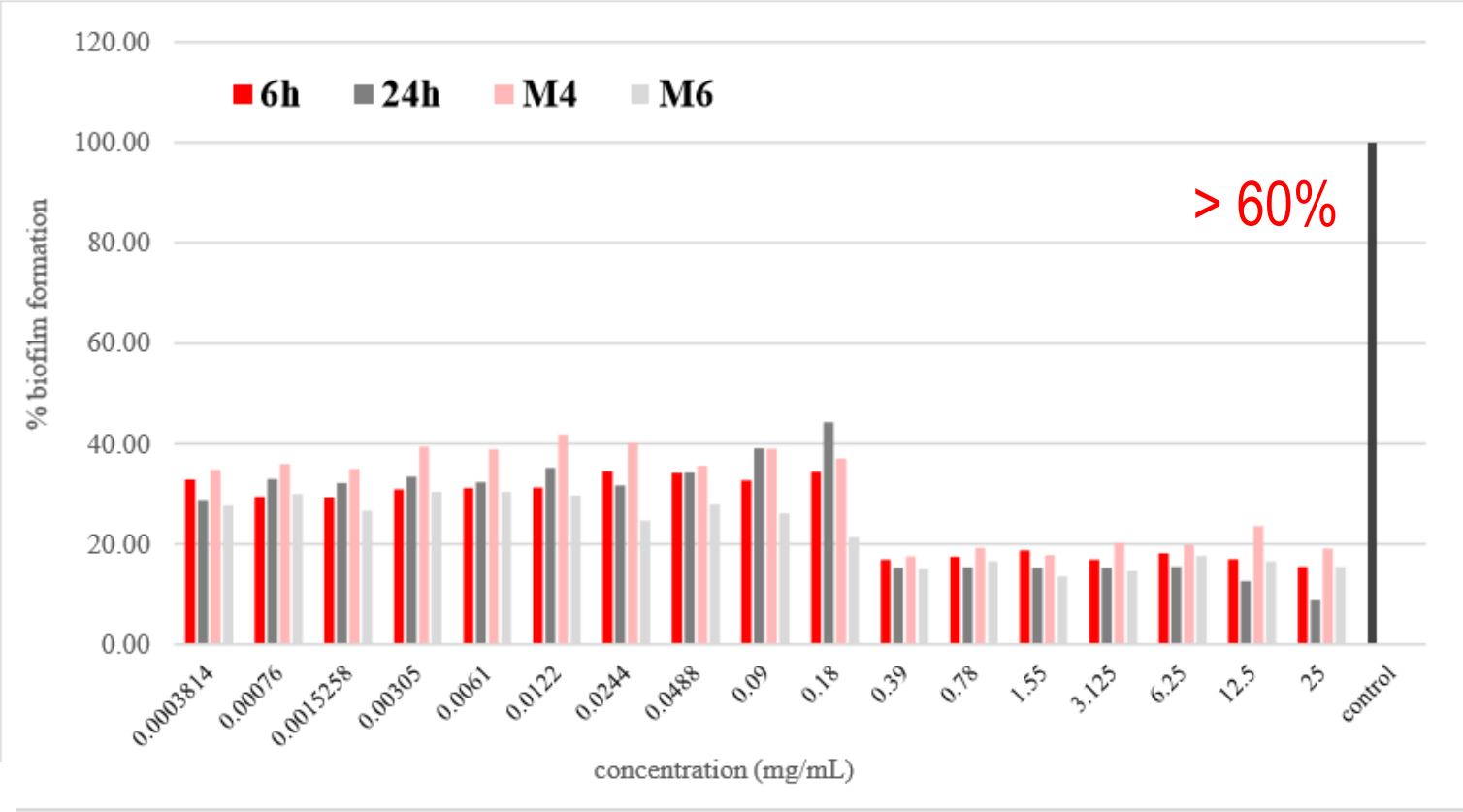
Anti-biofilm Activity of EOs

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
1h	25	25	0.0003814	25	na
2h	25	25	0.0488	na	na
3h	na	25	3.125	12.5	na
6h	0.0003814	0.0003814	na	na	na
12h	25	25	12.5	na	na
24h	0.0003814	0.0003814	na	na	na

Ridolfia segetum

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Anti-biofilm Activity of EOs



Effects of selected Ridolfia segetum samples treatment on biofilm formation for S. epidermidis RP62A

Anti-biofilm Activity of EOs

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
1h	25	25	0.0003814	25	na
2h	25	25	0.0488	na	na
3h	na	25	3.125	12.5	na
6h	0.0003814	0.0003814	na	na	na
12h	25	25	12.5	na	na
24h	0.0003814	0.0003814	na	na	na

Ridolfia segetum

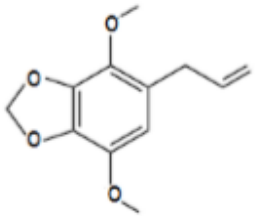
The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Anti-biofilm Activity of EOs

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
1h	25	25	0.0003814	25	na
2h	25	25	0.0488	na	na
3h	na	25	3.125	12.5	na
6h	0.0003814	0.0003814	na	na	na
12h	25	25	12.5	na	na
24h	0.0003814	0.0003814	na	na	na

Ridolfia segetum

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.



apiol

Anti-biofilm Activity of EOs

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
1h	25	25	0.0003814	25	na
2h	25	25	0.0488	na	na
3h	na	25	3.125	12.5	na
6h	0.0003814	0.0003814	na	na	na
12h	25	25	12.5	na	na
24h	0.0003814	0.0003814	na	na	na

Ridolfia segetum

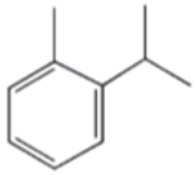
The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Anti-biofilm Activity of EOs

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
1h	25	25	0.0003814	25	na
2h	25	25	0.0488	na	na
3h	na	25	3.125	12.5	na
6h	0.0003814	0.0003814	na	na	na
12h	25	25	12.5	na	na
24h	0.0003814	0.0003814	na	na	na

Ridolfia segetum

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.



o-cymene

Anti-biofilm Activity of EOs

Foeniculum vulgare

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
A1h	na	3.125	0.0003814	25	na
A2h	na	na	0.0003814	na	na
A3h	25	25	0.0003814	na	na
A6h	25	25	0.0003814	25	na
A12h	25	12.5	0.0003814	25	na
A24h	12.5	12.5	0.0003814	na	na
S1h	na	na	0.0003814	12.5	na
S2h	na	na	6.25	12.5	0.78
S3h	25	25	na	12.5	na
S6h	25	25	12.5	12.5	25
S12h	25	25	na	12.5	na
S24h	25	25	na	na	na
O1h	0.0003814	0.0003814	na	na	na
O2h	na	na	na	na	na
O3h	0.0003814	0.0003814	na	na	na
O6h	0.0003814	0.0003814	na	na	na
O12h	na	na	25	na	na
O24h	0.0003814	0.0003814	na	na	na

Anti-biofilm Activity of EOs

Foeniculum vulgare

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
A1h	na	3.125	0.0003814	25	na
A2h	na	na	0.0003814	na	na
A3h	25	25	0.0003814	na	na
A6h	25	25	0.0003814	25	na
A12h	25	12.5	0.0003814	25	na
A24h	12.5	12.5	0.0003814	na	na
S1h	na	na	0.0003814	12.5	na
S2h	na	na	6.25	12.5	0.78
S3h	25	25	na	12.5	na
S6h	25	25	12.5	12.5	25
S12h	25	25	na	12.5	na
S24h	25	25	na	na	na
O1h	0.0003814	0.0003814	na	na	na
O2h	na	na	na	na	na
O3h	0.0003814	0.0003814	na	na	na
O6h	0.0003814	0.0003814	na	na	na
O12h	na	na	25	na	na
O24h	0.0003814	0.0003814	na	na	na

Anti-biofilm Activity of EOs

Foeniculum vulgare

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
A1h	na	3.125	0.0003814	25	na
A2h	na	na	0.0003814	na	na
A3h	25	25	0.0003814	na	na
A6h	25	25	0.0003814	25	na
A12h	25	12.5	0.0003814	25	na
A24h	12.5	12.5	0.0003814	na	na
S1h	na	na	0.0003814	12.5	na
S2h	na	na	6.25	12.5	0.78
S3h	25	25	na	12.5	na
S6h	25	25	12.5	12.5	25
S12h	25	25	na	12.5	na
S24h	25	25	na	na	na
O1h	0.0003814	0.0003814	na	na	na
O2h	na	na	na	na	na
O3h	0.0003814	0.0003814	na	na	na
O6h	0.0003814	0.0003814	na	na	na
O12h	na	na	25	na	na
O24h	0.0003814	0.0003814	na	na	na

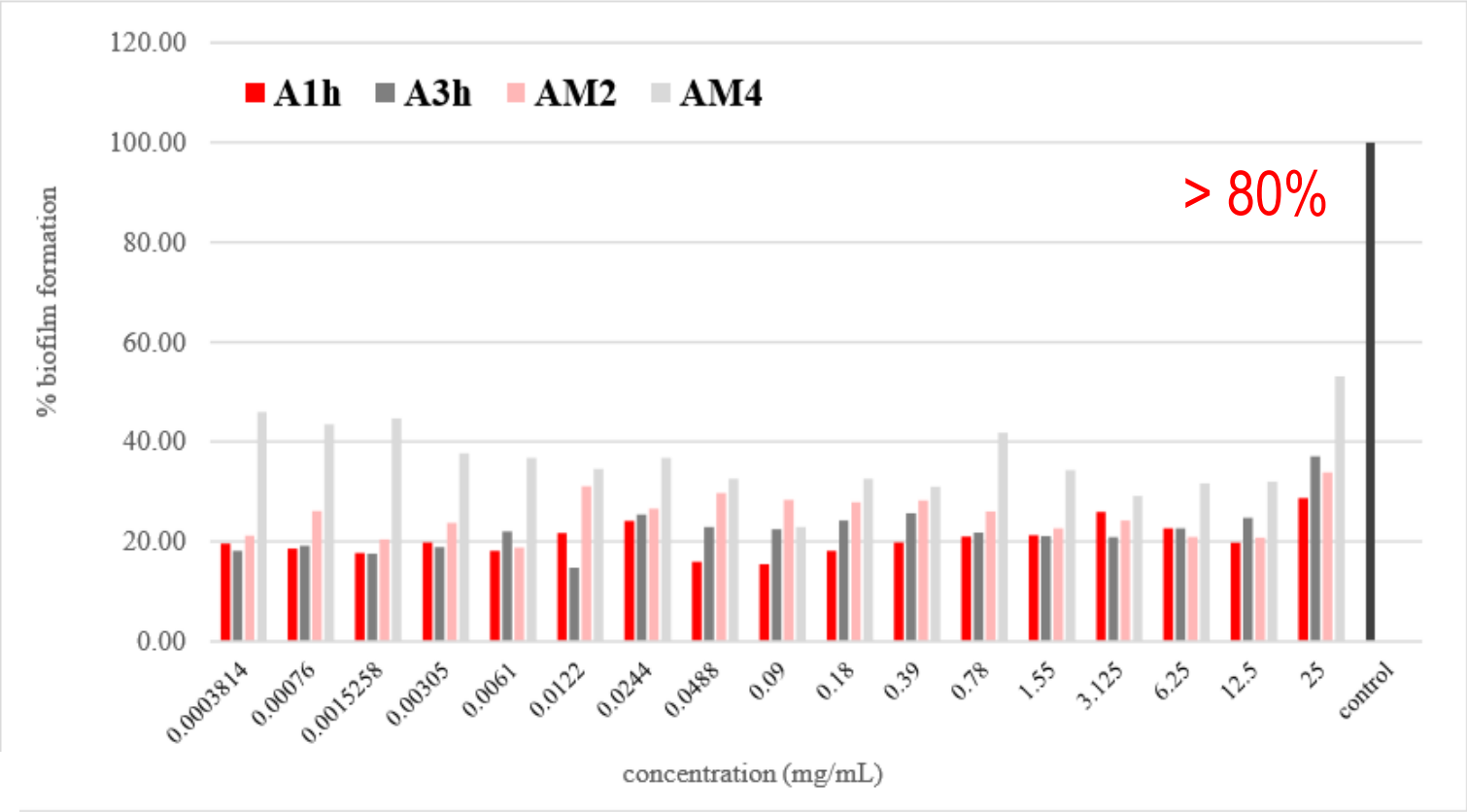
Anti-biofilm Activity of EOs

Foeniculum vulgare

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
A1h	na	3.125	0.0003814	25	na
A2h	na	na	0.0003814	na	na
A3h	25	25	0.0003814	na	na
A6h	25	25	0.0003814	25	na
A12h	25	12.5	0.0003814	25	na
A24h	12.5	12.5	0.0003814	na	na
S1h	na	na	0.0003814	12.5	na
S2h	na	na	6.25	12.5	0.78
S3h	25	25	na	12.5	na
S6h	25	25	12.5	12.5	25
S12h	25	25	na	12.5	na
S24h	25	25	na	na	na
O1h	0.0003814	0.0003814	na	na	na
O2h	na	na	na	na	na
O3h	0.0003814	0.0003814	na	na	na
O6h	0.0003814	0.0003814	na	na	na
O12h	na	na	25	na	na
O24h	0.0003814	0.0003814	na	na	na

Anti-biofilm Activity of EOs



Effects of selected Foeniculum vulgare samples treatment on biofilm formation for P. aeruginosa PaO1

Anti-biofilm Activity of EOs

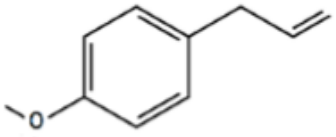
Foeniculum vulgare

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
A1h	na	3.125	0.0003814	25	na
A2h	na	na	0.0003814	na	na
A3h	25	25	0.0003814	na	na
A6h	25	25	0.0003814	25	na
A12h	25	12.5	0.0003814	25	na
A24h	12.5	12.5	0.0003814	na	na
S1h	na	na	0.0003814	12.5	na
S2h	na	na	6.25	12.5	0.78
S3h	25	25	na	12.5	na
S6h	25	25	12.5	12.5	25
S12h	25	25	na	12.5	na
S24h	25	25	na	na	na
O1h	0.0003814	0.0003814	na	na	na
O2h	na	na	na	na	na
O3h	0.0003814	0.0003814	na	na	na
O6h	0.0003814	0.0003814	na	na	na
O12h	na	na	25	na	na
O24h	0.0003814	0.0003814	na	na	na

Anti-biofilm Activity of EOs

Foeniculum vulgare



estragole

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
A1h	na	3.125	0.0003814	25	na
A2h	na	na	0.0003814	na	na
A3h	25	25	0.0003814	na	na
A6h	25	25	0.0003814	25	na
A12h	25	12.5	0.0003814	25	na
A24h	12.5	12.5	0.0003814	na	na
S1h	na	na	0.0003814	12.5	na
S2h	na	na	6.25	12.5	0.78
S3h	25	25	na	12.5	na
S6h	25	25	12.5	12.5	25
S12h	25	25	na	12.5	na
S24h	25	25	na	na	na
O1h	0.0003814	0.0003814	na	na	na
O2h	na	na	na	na	na
O3h	0.0003814	0.0003814	na	na	na
O6h	0.0003814	0.0003814	na	na	na
O12h	na	na	25	na	na
O24h	0.0003814	0.0003814	na	na	na

Anti-biofilm Activity of EOs

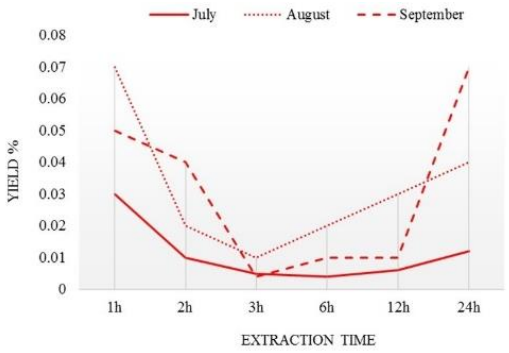
Foeniculum vulgare

The lowest concentration (mg/mL) of samples causing at least 35% biofilm inhibition.

Sample [1]	*S. epidermidis* O47	*S. epidermidis* RP62A	*P. aeruginosa* PaO1	*S. aureus* 6538P	*S. aureus* 25923
A1h	na	3.125	0.0003814	25	na
A2h	na	na	0.0003814	na	na
A3h	25	25	0.0003814	na	na
A6h	25	25	0.0003814	25	na
A12h	25	12.5	0.0003814	25	na
A24h	12.5	12.5	0.0003814	na	na
S1h	na	na	0.0003814	12.5	na
S2h	na	na	6.25	12.5	0.78
S3h	25	25	na	12.5	na
S6h	25	25	12.5	12.5	25
S12h	25	25	na	12.5	na
S24h	25	25	na	na	na
O1h	0.0003814	0.0003814	na	na	na
O2h	na	na	na	na	na
O3h	0.0003814	0.0003814	na	na	na
O6h	0.0003814	0.0003814	na	na	na
O12h	na	na	25	na	na
O24h	0.0003814	0.0003814	na	na	na

Results Overview

Name	Sample					
	J1h	J2h	J3h	J6h	J12h	J24h
3-octanol	2.2	0.4	0.3	0.4	0.5	-
4-terpineol	0.6	0.5	0.4	0.4	0.4	-
caryophyllene	0.3	-	1.3	2.9	2.3	-
cinerolone	-	-	-	2.9	5.8	-
crysanthenone	4.4	10.5	20.3	22.7	33.9	27.3
δ-cadinene	-	-	-	0.6	0.8	2.4
d-limonene	5.9	0.6	0.2	0.1	0.1	-
germacrene D	-	-	1.5	2.7	0.8	-
isocaryophyllene	-	-	-	-	-	3.8
isopiperitenone						2.2
isopulegone	0.6	0.5	0.5	0.5	0.4	-
linalool	0.3	-	0.2	0.4	0.5	-
menthone	3.1	0.8	0.6	0.6	0.5	-
methylisopulegone	-	-	-	-	-	12.6
myrcene	0.4	-	-	-	-	-
p-cymen-8-ol	-	-	-	0.7	1.5	2.2
p-mentha-1,8-dien-3-one	-	0.6	0.7	1.2	2.0	-
p-menthene	-	-	-	0.2	-	-
pulegone	76.8	77.7	64.3	53.2	41.1	37.7
sabinene	0.6	-	-	-	-	-
terpineol	0.3	0.5	0.7	0.8	1.2	-
trans-*p*-mentha-2,8-dienol	-	-	-	0.2	0.1	-
Unidentified compounds	**4.5**	**7.9**	**9.0**	**9.5**	**8.1**	**11.8**



Sample [1]	MIC mg/mL		Sample [1]	MIC mg/mL	
	24h	48h		24h	48h
A1h	*na*	*na*	**S1h**	*na*	*na*
A2h	12.48	*na*	**S2h**	6.24	12.48
A3h	*na*	*na*	**S3h**	6.24	12.48
A6h	*na*	*na*	**S6h**	6.24	*na*
A12h	*na*	*na*	**S12h**	6.24	*na*
A24h	*na*	*na*	**S24h**	12.48	12.48
AM1	12.48	*na*	**SM1**	3.12	12.48
AM2	12.48	12.48	**SM2**	3.12	12.48
AM3	12.48	*na*	**SM3**	6.24	6.24
AM4	12.48	*na*	**SM4**	6.24	12.48
AM5	*na*	*na*	**SM5**	6.24	*na*

different yield

different chemical composition

different related biological activity

6 different EO fractions

Conclusions

- A selection of 6 Lamiaceae and Apiaceae plant species has been analyzed leading to a conclusion that no rule can be given about the appropriate duration of steam distillation process;
- Different plant species have different EO yields, and the dynamic of oil extraction from plant material could be considered a species specific;
- Harvesting period is also very important, directly affecting these parameters: it could be more related to the plant family than to the species;

Conclusions

- The extraction method applied resulted in EO fractions that differ greatly in their chemical compositions;
- Although the main characterizing compounds are usually present in every fraction, variations in their amount are particularly evident between the first 3 fractions and the last ones;
- Furthermore, some compounds appear only with the development of the extraction process, and gradually increase in amount, being significantly present only in the last few fractions;
- Concerning the period of harvest, the chemical profile of an EO has been found to be heavily influenced by this factor.

Conclusions

- In order to monitor the biological variability, EOs of selected plant species were assayed by means of antimicrobial activity;
- Having in mind the processes of synergism and antagonism between EO compounds, overall potential of the isolated oil fractions was evaluated;
- Analyses of antifungal activity have shown the significant efficacy of some samples, particularly in the case of *Mentha suaveolens*;
- Analyses of anti-biofilm activity against 5 bacterial pathogens showed *S. aureus* as the most resistant one, whereas 2 strains of *S. epidermidis* have demonstrated the highest susceptibility.

Conclusions

- The process duration is always dependent on what the study is conducted for;
- Prolonged and/or fractionated distillation may surely give more complete and chemically more diverse EO;
- As a delicate structure, its chemical profile can be easily altered or destroyed by adverse distillation conditions (e.g. thermal, hydrolytic), leading to the possible accumulation of artifactual formations;
- However, all of that may have a very curious effect on its biological activities: this concept has been clearly proved by our results.

Acknowledgments

RCMD Lab

Rino Ragno
Antonello Mai
Manuela Sabatino
Francesca Borzacchi
Alberto Navarra

External Collaborations

Rome

Stefania Garzoli (GC-MS)
Federico Pepi (GC-MS)
Laura Selan (Microbiology)
Rosanna Papa (Microbiology)

Ferrara

Stefano Manfredini (Microbiology)

Herbal companies:

Minardi & Figli srl (Modena)
Orto La Rocca (Sperlonga)
Vivaio 98.3 (Tarquinia)

Acknowledgments

Thank you!
Grazie!
Hvala!

Natural habitat of the investigated species, Tarquinia countryside (Viterbo, Italy)