

CHAPTER IV

RESULTS

The essential oils and absolutes of four kinds of Thai aromatic flowers; *G. jasminoides*, *M. elengi*, *A. odorata* and *A. siamensis*, were obtained by hydro-distillation and solvent extraction, respectively. The essential oils and absolutes were determined their physical and chemical properties. The results were shown as follows:

4.1 Physical properties

Table 4.1 Physical appearance of essential oils, absolute and lipids

Plant materials	Product	Physical appearance
<i>G. jasminoides</i> (fresh flowers)	Essential oil	Yellow-orange oil
	Absolute	Yellow viscous liquid
	Lipids	Yellow-orange sticky mass
<i>M. elengi</i> (fresh flowers)	Absolute	Colorless viscous liquid
	Lipids	Yellow-brown sticky mass
<i>A. odorata</i> (fresh flowers)	Essential oil	Colorless oil
	Absolute	Yellow viscous liquid
	Lipids	Yellow sticky mass
<i>A. odorata</i> (dried flowers)	Essential oil	Yellow-orange oil
	Absolute	Yellow viscous liquid
	Lipids	Yellow-orange sticky mass
<i>A. siamensis</i> (fresh flowers)	Essential oil	Yellow oil
	Absolute	Yellow-orange viscous liquid
	Lipids	Yellow sticky mass

Table 4.2 Relative density of essential oils of *A. odorata* and *A. siamensis*

Plant materials		Weight of essential oil (g)	Weight of purified water (g)	Relative* density	Average
<i>A. odorata</i> (dried flowers)	No.1	8.5738	9.0892	0.9433	0.9433
	No.2	8.5737	9.0892	0.9433	
<i>A. siamensis</i> (fresh flowers)	No.1	8.1387	9.0892	0.8954	0.8954
	No.2	8.1385	9.0892	0.8954	

* at temperature 25°C

Table 4.3 Refractive index of essential oils of *G. jasminoides*, *A. odorata* and *A. siamensis*

Plant materials	Refractive index			Temperature °C
	No.1	No. 2	Average	
<i>G. jasminoides</i> (fresh flowers)	1.4760	1.4758	1.4759	23.0
<i>A. odorata</i> (fresh flowers)	1.5062	1.5062	1.5062	23.0
<i>A. odorata</i> (dried flowers)	1.5105	1.5104	1.5105	23.0
<i>A. siamensis</i> (fresh flowers)	1.4876	1.4878	1.4877	23.0

Table 4.4 Optical rotation of essential oils of *G. jasminoides*, *A. odorata* and *A. siamensis*

Plant materials	Measurement value	Concentration (g/ml)	Specific rotation	Temperature (°C)
<i>G. jasminoides</i> (fresh flowers)	-0.021	0.01029	-2.04	23.0
<i>A. odorata</i> (dried flowers)	0.054	0.01036	5.21	23.0
<i>A. siamensis</i> (fresh flowers)	-0.306	0.01021	-3.00	23.0

Table 4.5 Solubility of essential oils of *G. jasminoides*, *A. odorata* and *A. siamensis* in ethanol

Plant materials	Volume of 90% ethanol to produced clear solution (ml)	Volume of 90% ethanol to produced cloudy solution (ml)	Volume of 90 % ethanol to become clear solution (ml)	Temperature (°C)
<i>G. jasminoides</i> (fresh flowers)	0.1	-	20.0	20.0
<i>A. odorata</i> (fresh flowers)	0.2	0.5	11.7	20.0
<i>A. odorata</i> (dried flowers)	0.1	0.3	6.8	20.0
<i>A. siamensis</i> (fresh flowers)	0.1	0.6	7.0	20.0

Table 4.6 Water content by azeotropic distillation method of *G. jasminoides*, *M. elengi*, *A. odorata* and *A. siamensis* for essential oils

Plant materials		Weight of sample (g)	Volume of water in the second distillations (ml)	Volume of water in the first distillations (ml)	Volume of water in sample (ml)	%water content (v/w)	average
<i>G. jasminoides</i> (fresh flowers)	No.1	2.9985	4.05	1.80	2.25	75.04	75.02
	No.2	2.9999	4.10	1.85	2.25	75.00	
<i>M. elengi</i> (fresh flowers)	No.1	3.0000	3.00	1.75	1.25	41.67	40.84
	No.2	3.0000	2.95	1.75	1.20	40.00	
<i>A. odorata</i> (fresh flowers)	No.1	1.9980	3.25	1.90	1.35	67.57	67.56
	No.2	1.9985	3.25	1.90	1.35	67.55	
<i>A. odorata</i> (dried flowers)	No.1	9.9995	2.90	1.85	1.05	10.50	10.50
	No.2	9.9984	2.90	1.85	1.05	10.50	
<i>A. siamensis</i> (fresh flowers)	No.1	3.0006	4.30	1.80	2.50	83.32	83.30
	No.2	3.0021	4.35	1.85	2.50	83.28	

Table 4.7 Water content by azeotropic distillation method of *G. jasminoides*, *M. elengi*, *A. odorata* and *A. siamensis* for absolute

Plant materials		Weight of sample (g)	Volume of water in the second distillations (ml)	Volume of water in the first distillations (ml)	Volume of water in sample (ml)	%water content (v/w)	average
<i>G. jasminoides</i> (fresh flowers)	No.1	2.0000	3.55	1.90	1.65	82.50	82.50
	No.2	2.0000	3.55	1.90	1.65	82.50	
<i>M. elengi</i> (fresh flowers)	No.1	3.0266	3.25	1.75	1.50	49.56	48.79
	No.2	3.0200	3.20	1.75	1.45	48.01	
<i>A. odorata</i> (fresh flowers)	No.1	2.0020	3.40	2.00	1.40	69.93	68.71
	No.2	2.0000	3.35	2.00	1.35	67.50	
<i>A. odorata</i> (dried flowers)	No.1	10.0000	2.70	1.85	0.85	8.50	8.50
	No.2	10.0000	2.70	1.85	0.85	8.50	
<i>A. siamensis</i> (fresh flowers)	No.1	2.0017	3.45	1.85	1.60	79.93	79.94
	No.2	2.0015	3.40	1.80	1.60	79.94	

Table 4.8 Essential oil content of Thai aromatic flowers

Plant materials		Weight of sample (g)	Volume of essential oil (ml)	% Essential oil content			
				v/w (wet weight)	Average	v/w (dried weight)	Average
<i>G. jasminoides</i> (fresh flowers)	No.1	2095.0	0.40	0.02	0.02	0.08	0.08
	No.2	600.0	0.10	0.02		0.07	
<i>M. elengi</i> (fresh flowers)	No.1	650.0	trace	-	-	-	-
	No.2	900.0	trace	-		-	
<i>A. odorata</i> (fresh flowers)	No.1	300.0	1.50	0.50	0.50	1.54	1.54
	No.2	-	-	-		-	
<i>A. odorata</i> (dried flowers)	No.1	1500.0	1.50	0.10	0.10	0.11	0.11
	No.2	1500.0	1.50	0.10		0.11	
<i>A. siamensis</i> (fresh flowers)	No.1	1000.0	2.20	0.22	0.24	1.32	1.41
	No.2	560.0	1.40	0.25		1.50	

Table 4.9 Percentage yield of concrete of Thai aromatic flowers

Plants flowers		Weight of sample (g)	Weight of concrete (g)	Percentage yield of concrete			
				w/w (wet weight)	Average	w/w (dried weight)	Average
<i>G. jasminoides</i> (fresh flowers)	No.1	797.00	0.9500	0.1192	0.1135	0.6811	0.6484
	No.2	1336.60	1.4400	0.1077		0.6156	
<i>M. elengi</i> (fresh flowers)	No.1	436.50	1.6235	0.3719	0.4044	0.7263	0.7897
	No.2	650.00	2.8400	0.4369		0.8532	
<i>A. odorata</i> (fresh flowers)	No.1	666.25	1.5100	0.2266	0.2266	0.7243	0.7243
	No.2	-	-	-		-	
<i>A. odorata</i> (dried flowers)	No.1	500.00	2.0727	0.4145	0.4023	0.4530	0.4397
	No.2	500.00	1.9510	0.3902		0.4265	
<i>A. siamensis</i> (fresh flowers)	No.1	447.80	0.4500	0.1005	0.0978	0.5010	0.4876
	No.2	410.00	0.3900	0.0951		0.4742	

4.2 Chemical analysis

Four kinds of Thai aromatic flowers were analyzed for their volatile constituents by Gas Chromatography and Mass Spectrometry technique (GC-MS). The results of their chromatograms and volatile compositions with KI were shown in Figure 4.1-4.14 and Table 4.10-4.14.

4.2.1 Chemical identification of *G. jasminoides*

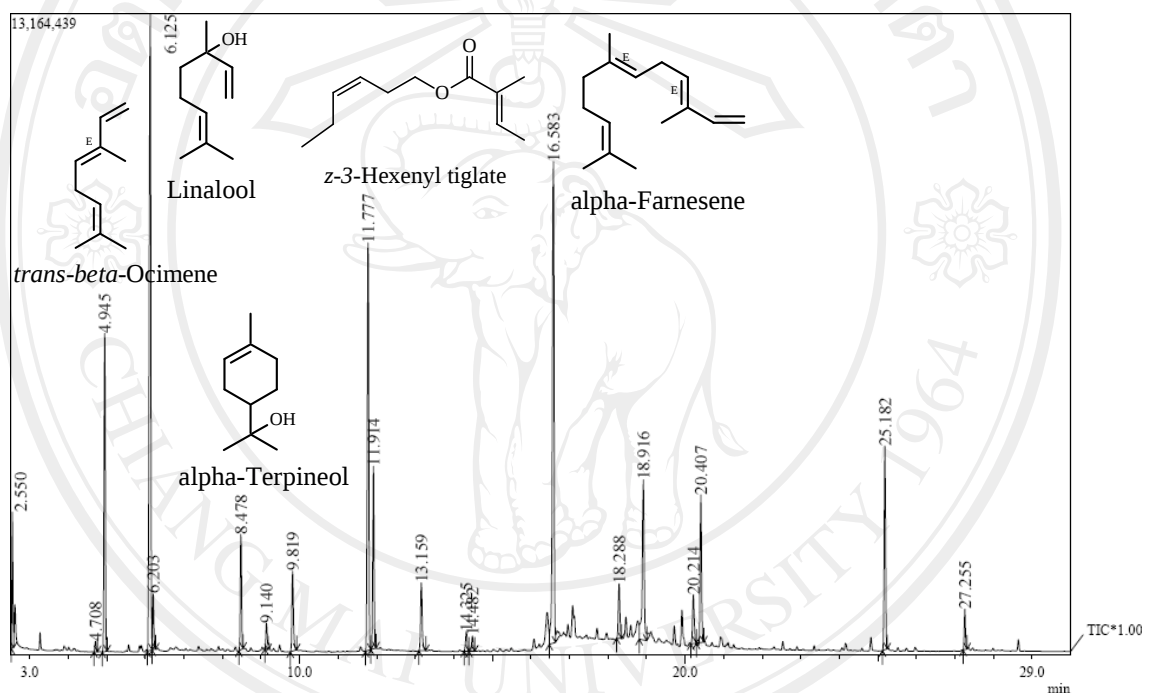


Figure 4.1 Chromatogram of Gardenia oil (fresh flowers)

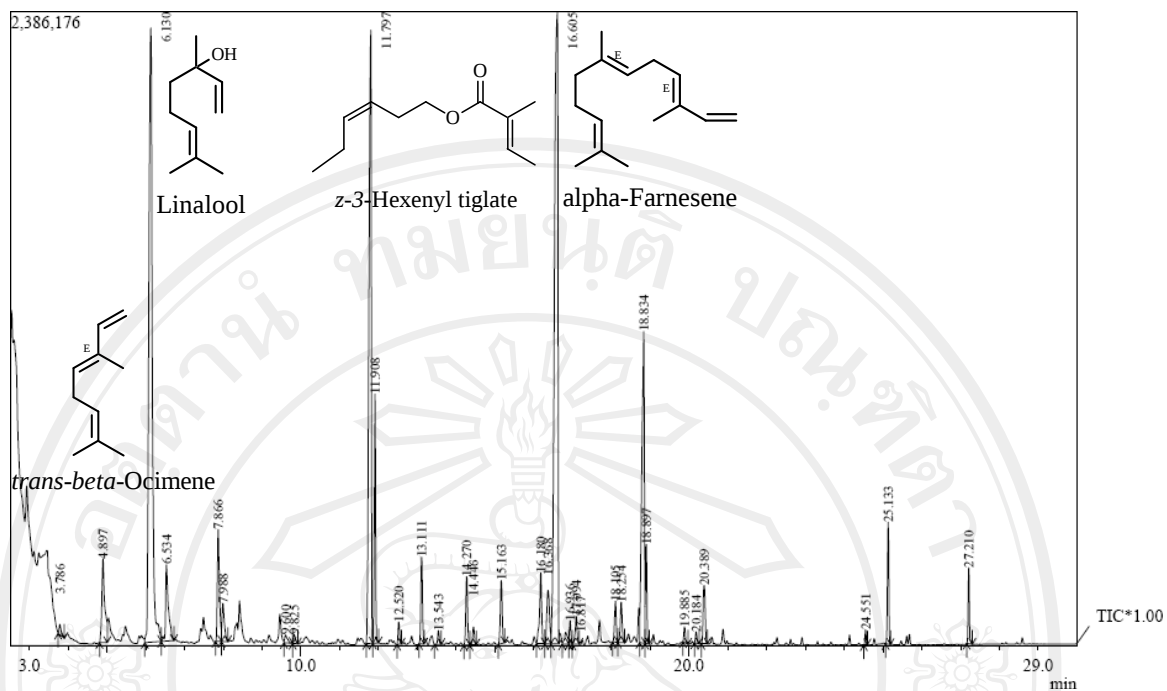


Figure 4.2 Chromatogram of absolute of Gardenia (fresh flowers)

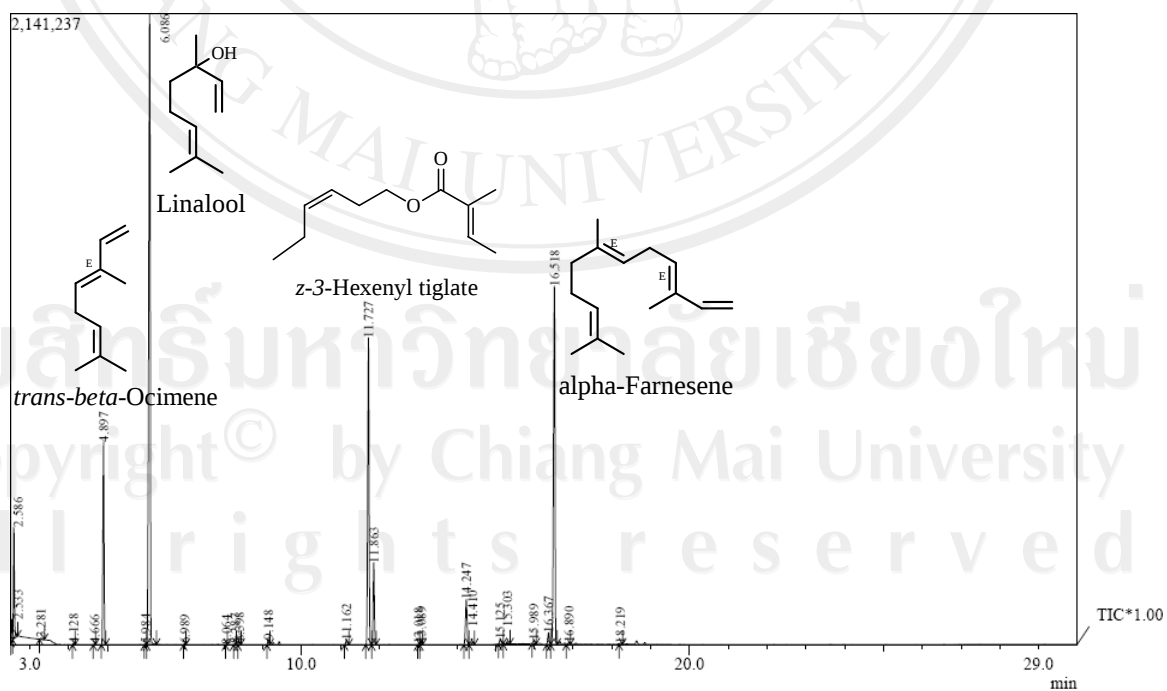


Figure 4.3 Chromatogram of fresh flowers of Gardenia

4.2.2 Chemical identification of *M. elengi*

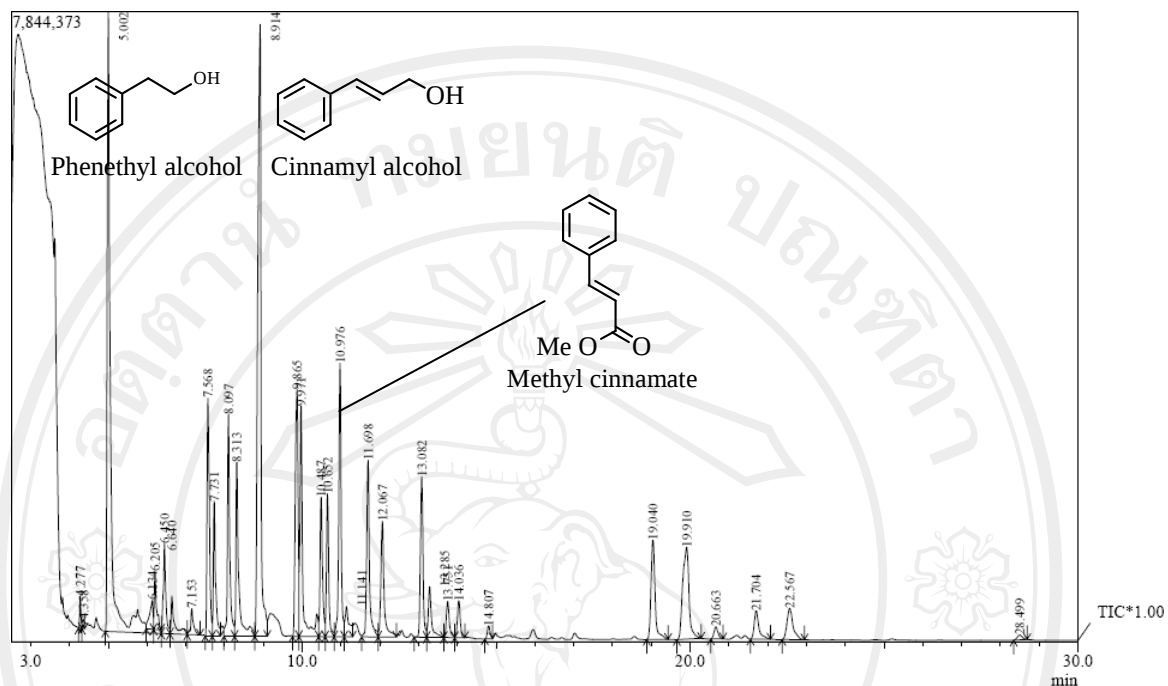


Figure 4.4 Chromatogram of absolute of Pikul (fresh flowers)

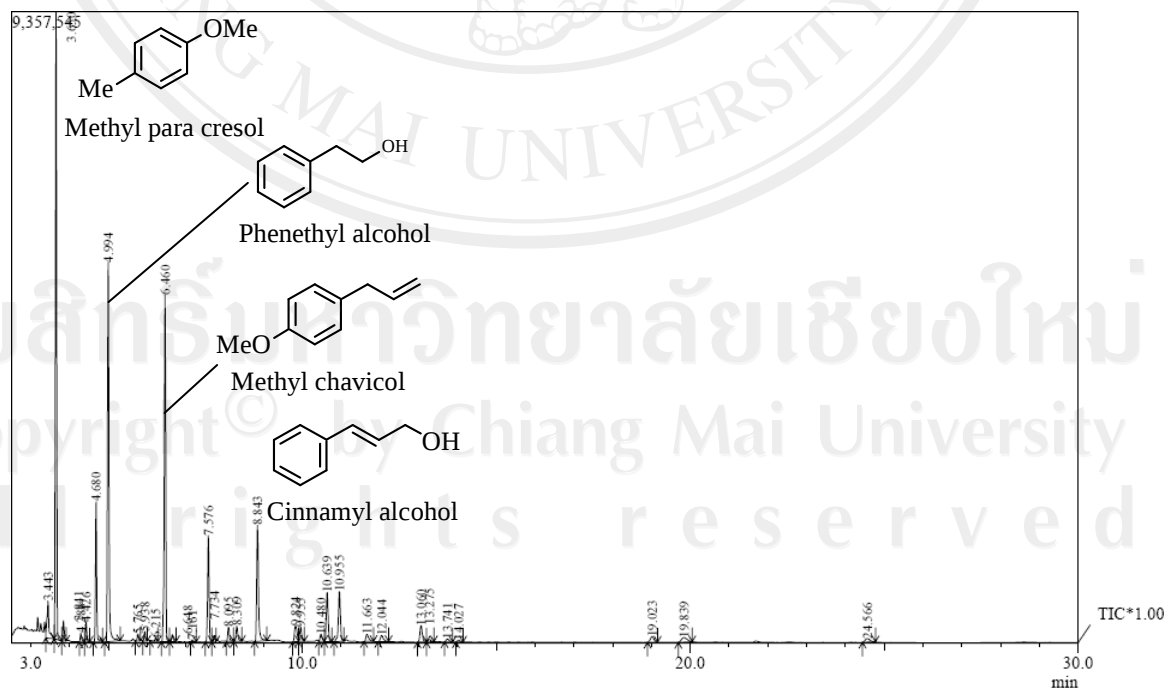


Figure 4.5 Chromatogram of fresh flowers of Pikul

4.2.3 Chemical identification of *A. odorata*

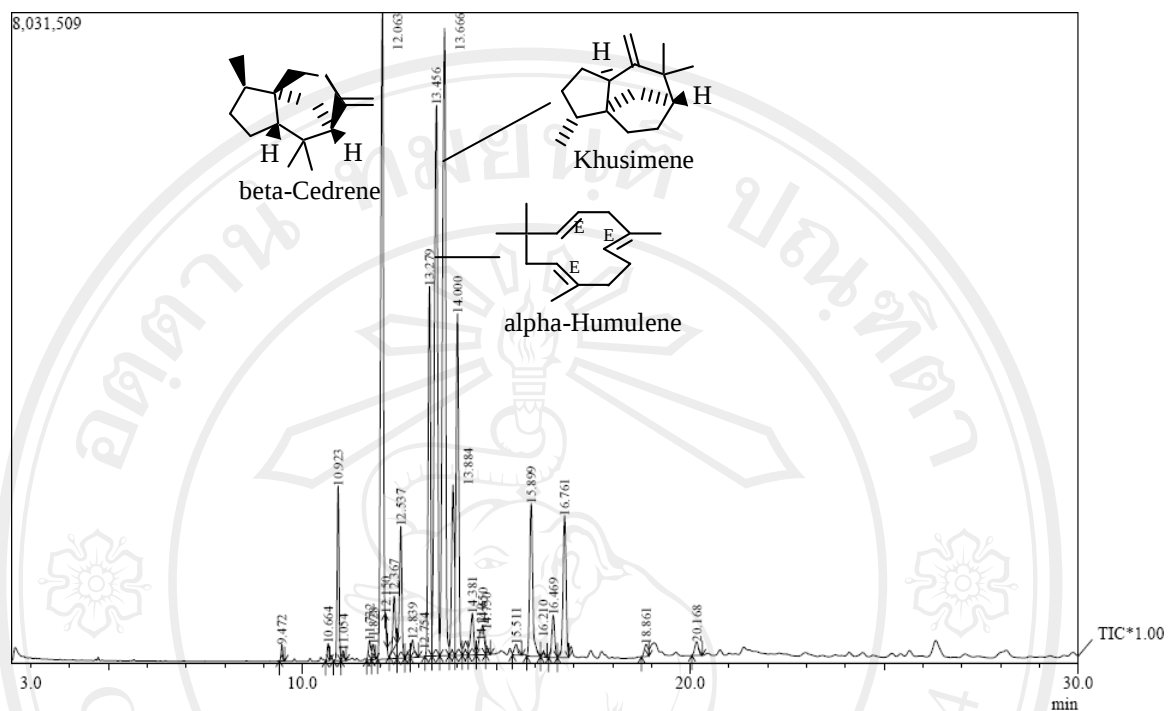


Figure 4.6 Chromatogram of Prayong oil (fresh flowers)

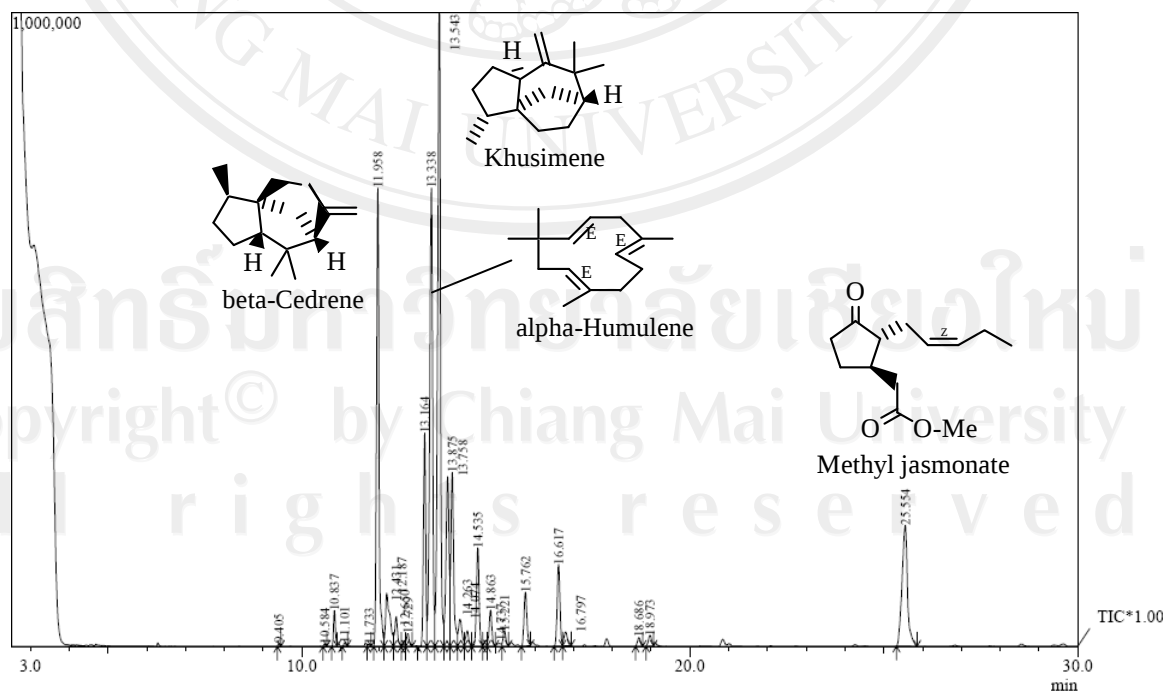


Figure 4.7 Chromatogram of absolute of Prayong (fresh flowers)

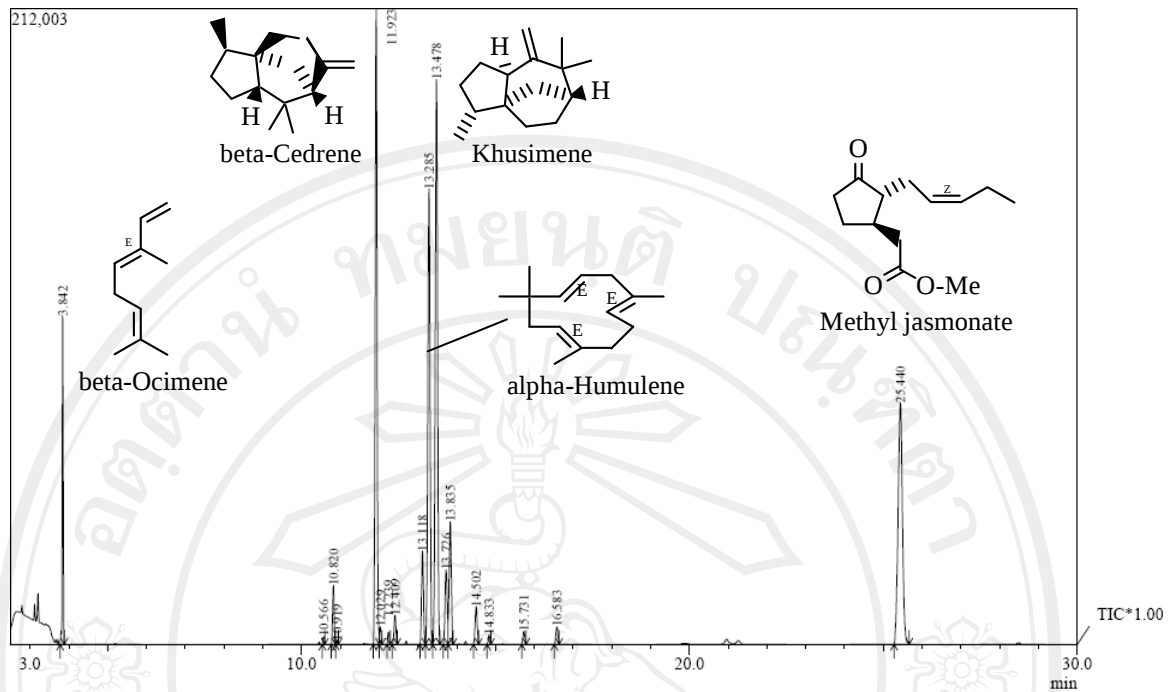


Figure 4.8 Chromatogram of fresh flowers of Prayong

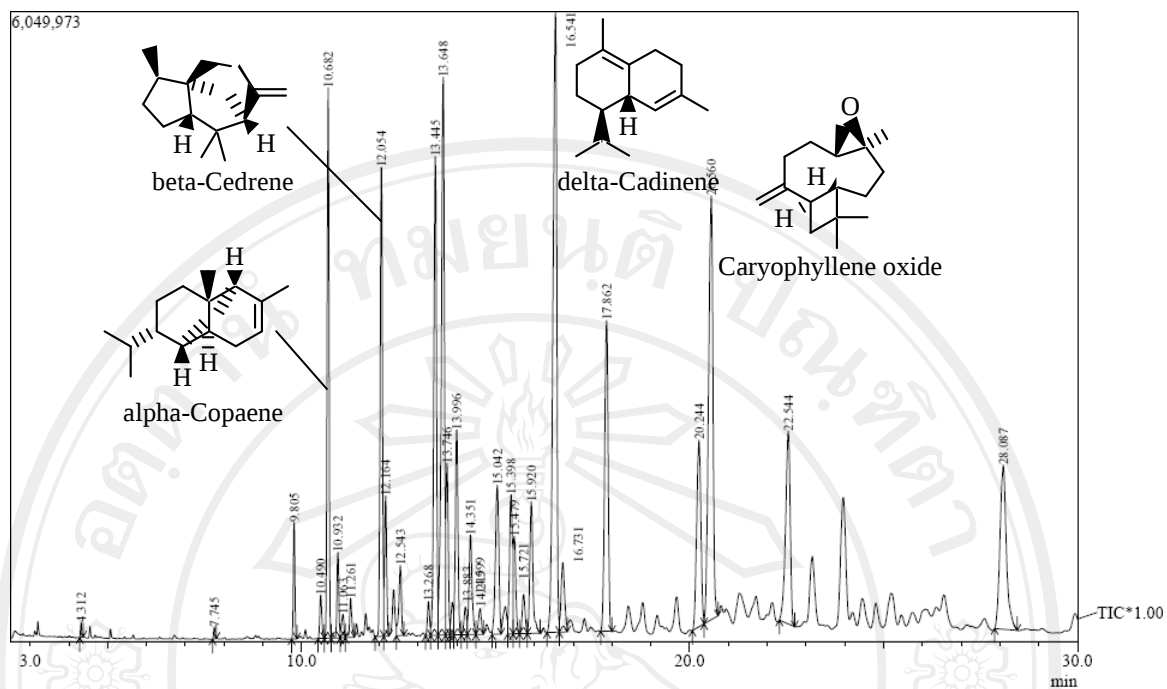


Figure 4.9 Chromatogram of Prayong oil (dried flowers)

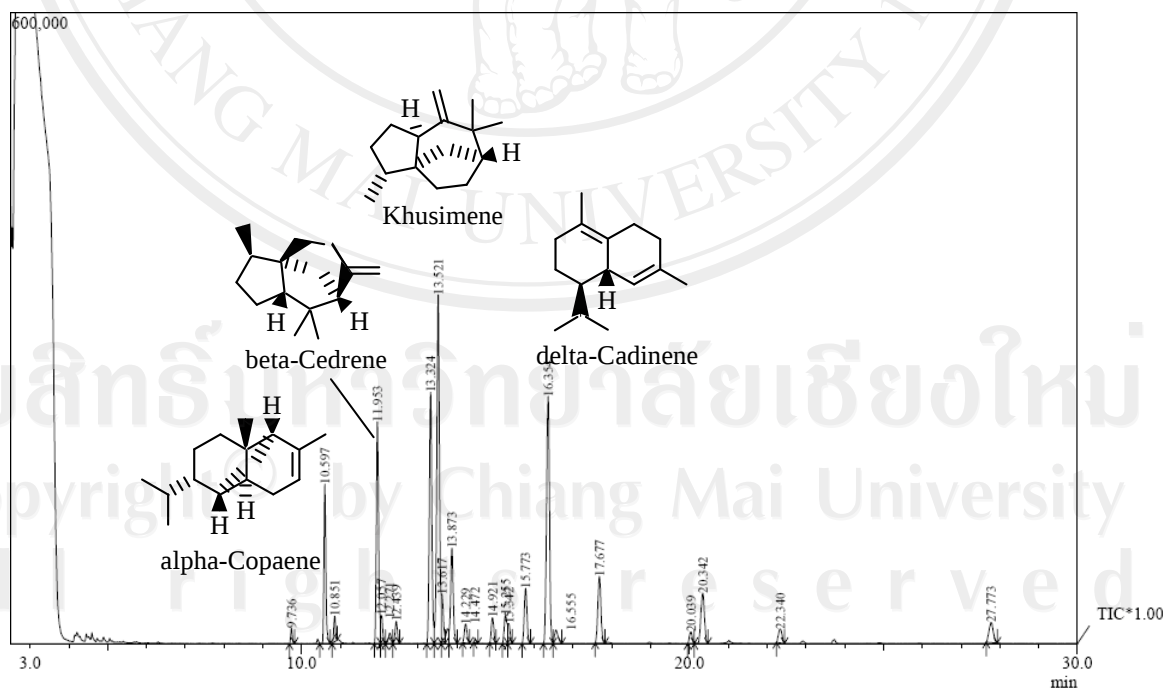


Figure 4.10 Chromatogram of absolute of Prayong (dried flowers)

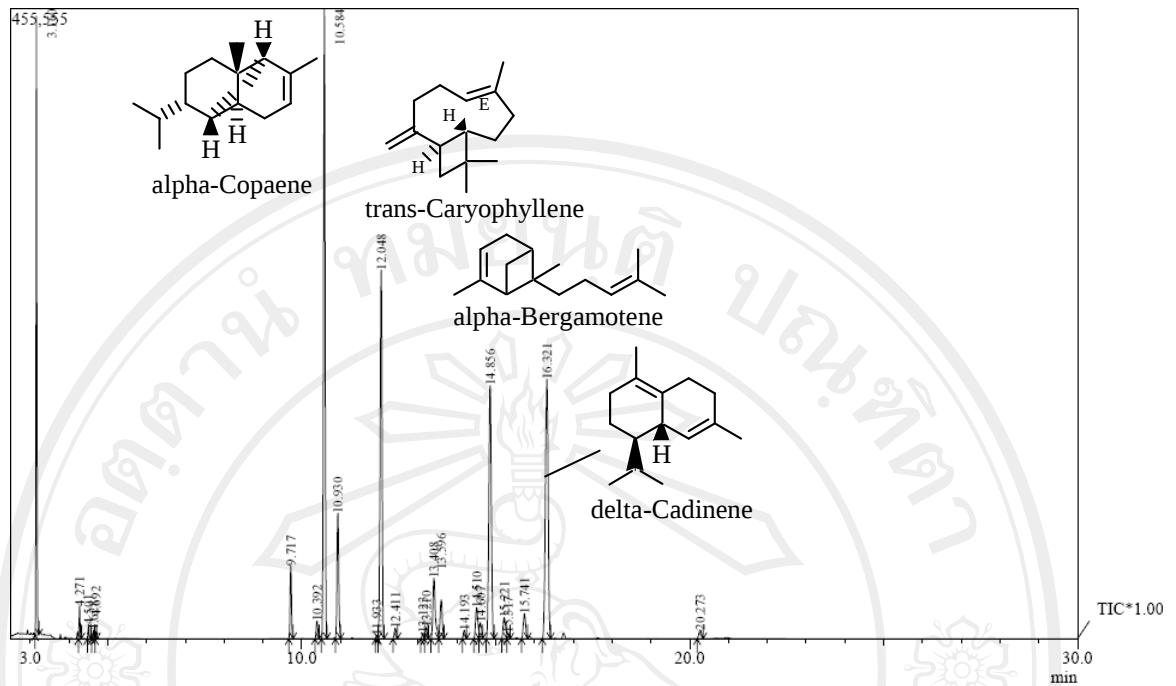


Figure 4.11 Chromatogram of dried flowers of Prayong

4.2.4 Chemical identification of *A. siamensis*

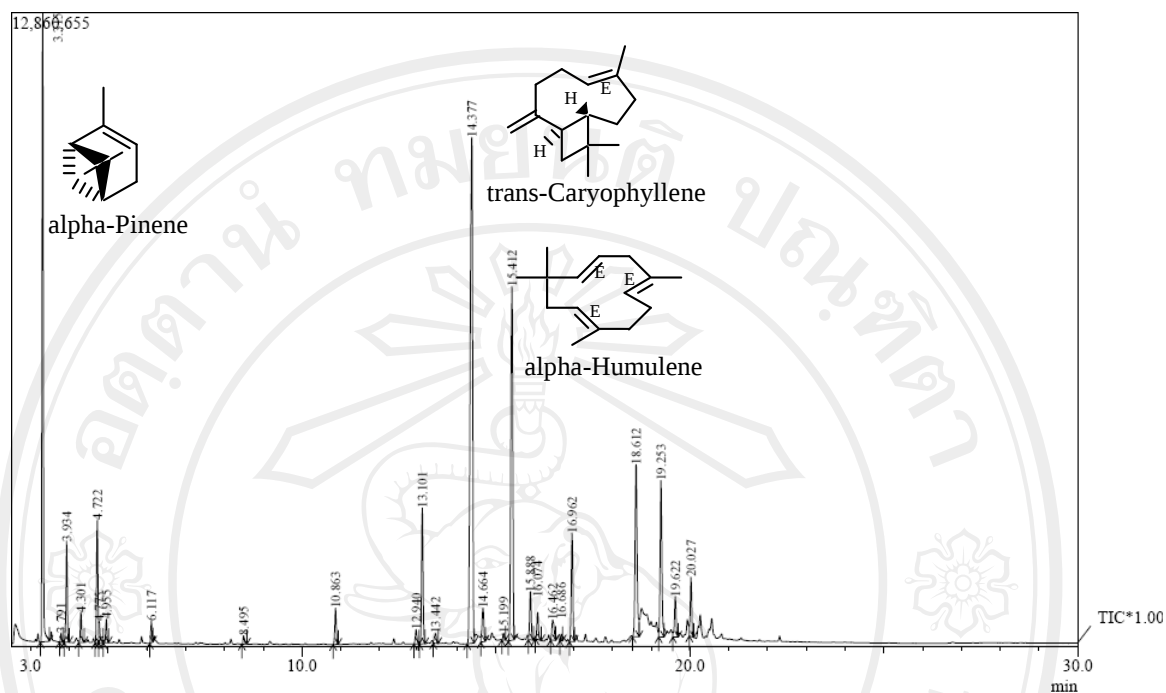


Figure 4.12 Chromatogram of Karawek oil (fresh flowers)

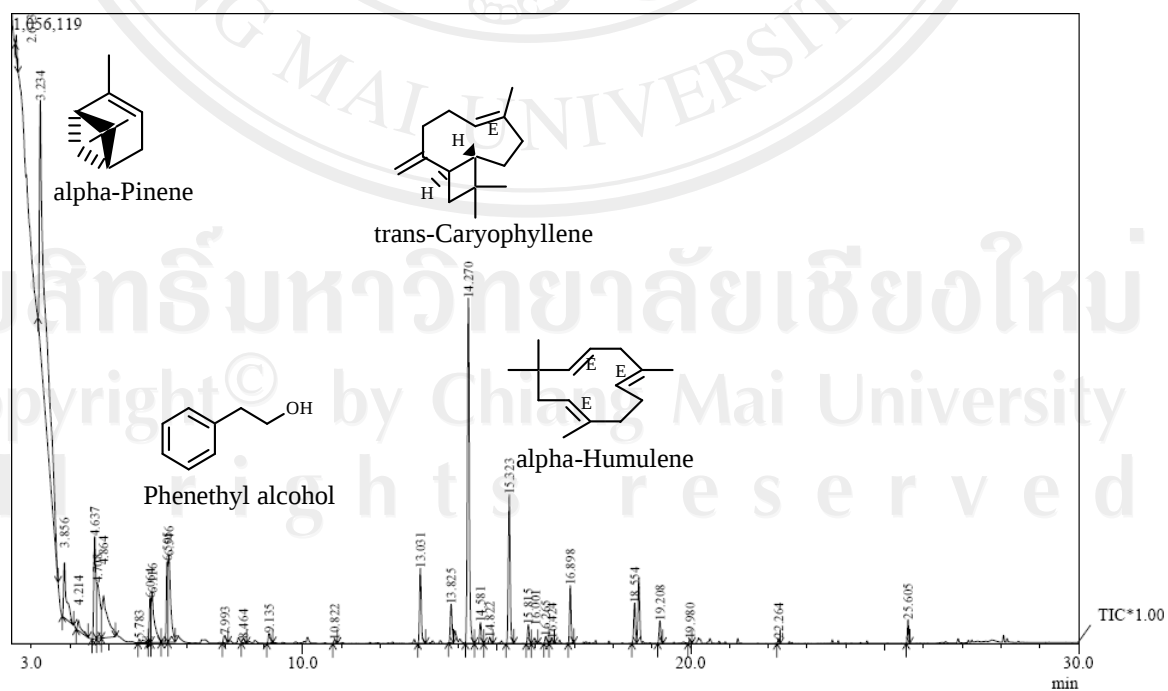


Figure 4.13 Chromatogram of absolute of Karawek (fresh flowers)

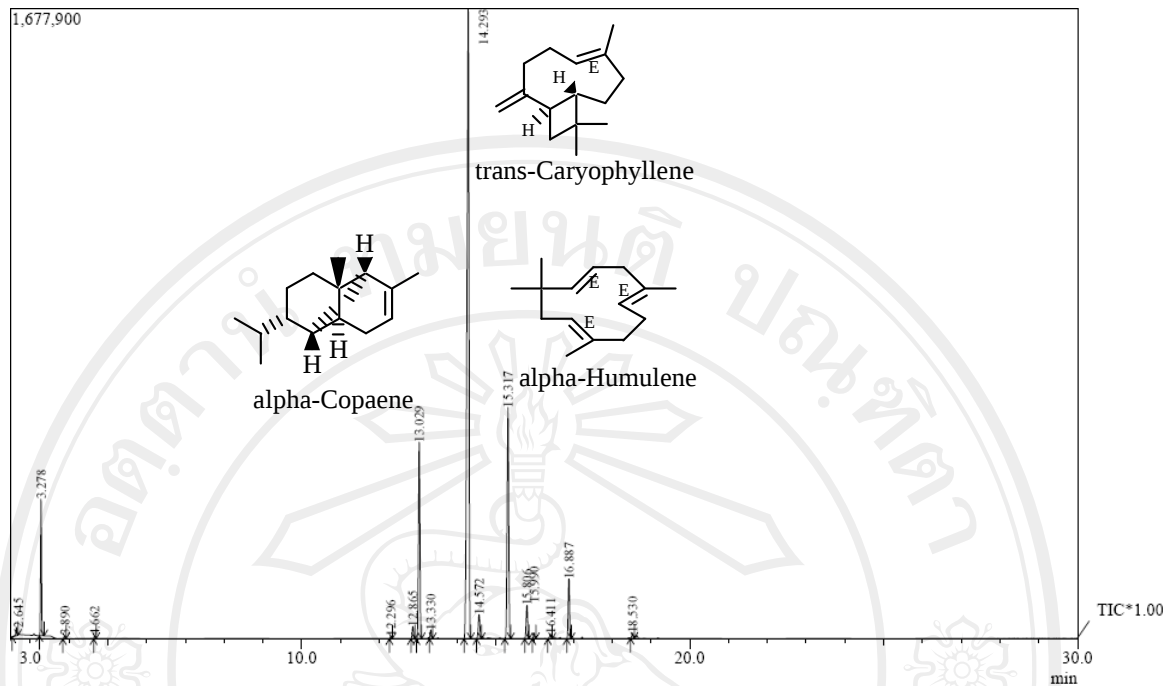


Figure 4.14 Chromatogram of fresh flowers of Karawek

Table 4.10 Identification of volatile constituents of *G. jasminoides* flowers

No.	Rt (min)	Compounds	KI ^a	Chemical groups	Formula	MW	Relative content (%)		
							Essential oil	Absolute	Fresh flowers
1	2.550	<i>cis</i> -3-Hexenol	- ^b	alcohols	C ₆ H ₁₂ O	100	2.63	-	0.76
2	2.586	Methyl tiglate	- ^b	esters	C ₆ H ₁₀ O ₂	114	-	-	4.30
3	3.281	<i>alpha</i> -Thujene	935	monoterpenes	C ₁₀ H ₁₆	136	-	-	0.06
4	3.786	1-Octen-3-ol	979	alcohols	C ₈ H ₁₆ O	128	-	0.22	-
5	4.125	<i>z</i> -3-Hexenyl acetate	1005	esters	C ₈ H ₁₄ O ₂	142	-	-	0.06
6	4.708	<i>cis</i> -Ocimene	1037	monoterpenes	C ₁₀ H ₁₆	136	0.24	-	0.03
7	4.945	<i>trans-beta</i> -Ocimene	1050	monoterpenes	C ₁₀ H ₁₆	136	8.64	2.61	9.50
8	5.984	<i>z</i> -3-Hexenyl propionate	1098	esters	C ₉ H ₁₆ O ₂	156	-	-	0.05
9	6.125	Linalool	1104	monoterpene alcohols	C ₁₀ H ₁₈ O	154	21.49	22.46	38.23
10	6.203	Ho-trienol	1109	monoterpene alcohols	C ₁₀ H ₁₆ O	152	1.33	-	-
11	6.534	Phenethyl alcohol	1121	benzyl alcohols	C ₈ H ₁₀ O	122	-	2.31	-
12	7.866	Ethyl benzoate	1173	benzyl esters	C ₉ H ₁₀ O ₂	150	-	2.46	-
13	7.988	Borneol	1182	monoterpene alcohols	C ₁₀ H ₁₈ O	154	-	0.94	-
14	8.067	<i>z</i> -3-Hexenyl butyrate	1186	monoterpene esters	C ₁₀ H ₁₈ O ₂	170	-	-	0.02
15	8.416	Methyl salicylate	1199	phenolic esters	C ₉ H ₈ O ₃	152	-	1.04	0.15
16	8.478	<i>alpha</i> -Terpineol	1202	monoterpene alcohols	C ₁₀ H ₁₈ O	154	3.05	-	-
17	9.140	Nerol	1230	monoterpene alcohols	C ₁₀ H ₁₈ O	154	0.75	-	-
18	9.148	<i>z</i> -3-Hexenyl 2-methylbutanoate	1227	esters	C ₁₁ H ₂₀ O ₂	184	-	-	0.25
19	9.600	Ethyl phenylacetate		phenyl esters	C ₁₀ H ₁₂ O ₂	164	-	0.24	-
20	9.819	Geraniol	1253	monoterpene alcohols	C ₁₀ H ₁₈ O	154	2.49	0.21	-
21	11.162	Indole	1301	miscellaneous	C ₈ H ₇ N	117	-	-	0.29
22	11.777	<i>z</i> -3-Hexenyl tiglate	1324	esters	C ₁₁ H ₁₈ O ₂	182	12.67	15.21	16.27
23	11.914	Hexyl tiglate	1333	esters	C ₁₁ H ₂₀ O ₂	184	4.84	3.48	3.94
24	12.520	Eugenol	1359	phenols	C ₁₀ H ₁₂ O ₂	164	-	0.36	-
25	13.018	<i>alpha</i> -Copaene	1377	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	0.03
26	13.159	Calarene	1384	sesquiterpenes	C ₁₅ H ₂₄	204	2.22	1.51	-
27	13.543	<i>n</i> -Tetradecane	1397	miscellaneous	C ₁₄ H ₃₀	198	-	0.23	-
28	14.325	<i>trans</i> -Caryophyllene	1422	sesquiterpenes	C ₁₅ H ₂₄	204	0.66	1.28	2.84
29	14.482	Unknown	1428				0.48	0.35	0.16
30	15.163	Isoeugenol	1454	phenols	C ₁₀ H ₁₂ O ₂	164	-	1.28	0.31
31	15.989	Germacrene D	1485	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	0.20
32	16.180	<i>alpha</i> -Berganotene	1490	sesquiterpenes	C ₁₅ H ₂₄	204	-	1.62	-
33	16.368	Bicyclogermacrene	1499	sesquiterpenes	C ₁₅ H ₂₄	204	-	1.53	0.65
34	16.583	<i>alpha</i> -Farnesene	1506	sesquiterpenes	C ₁₅ H ₂₄	204	17.54	23.35	21.40
35	16.817	<i>beta</i> -Guaiene	1515	sesquiterpenes	C ₁₅ H ₂₄	204	-	0.38	-
36	16.936	<i>delta</i> -Cadinene	1521	sesquiterpenes	C ₁₅ H ₂₄	204	-	0.38	0.10
37	18.288	<i>cis</i> -3-Hexenyl benzoate	1574	benzyl esters	C ₁₃ H ₁₆ O ₂	204	1.75	0.80	0.08
38	18.833	Cyclopenta[c]pyran-4-carboxylic acid, 7-methyl-, methyl ester	1600	esters	C ₁₁ H ₁₀ O ₃	190	-	8.38	-
39	18.916	Guaiol	1601	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	6.36	1.42	-
40	19.885	<i>delta</i> -Cadinol	1649	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	-	0.24	-
41	20.214	Unknown	1666				1.68	-	-
42	20.407	Bulnesol	1673	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	4.26	1.28	-
43	24.551	Methyl palmitate	1923	esters	C ₁₇ H ₃₄ O ₂	270	-	0.17	-
44	25.182	Unknown	1961				5.86	1.77	-
45	27.210	<i>n</i> -Tricosane	- ^b	miscellaneous	C ₂₃ H ₄₈	324	-	0.97	-
46	27.255	Tetracosane	- ^b	miscellaneous	C ₂₄ H ₅₀	338	1.01	-	-

- not identified

^a Kovats Retention indices relative to C₈-C₂₀ *n*-alkanes on DB-5MS column.^b Retention times is outside of retention times of homologous series of C₈-C₂₀ *n*-alkanes

Table 4.11 Identification of volatile constituents of *M. elengi* flowers

No.	Rt (min)	Compounds	KI ^a	Chemical groups	Formula	MW	Relative content (%)	
							Absolute	Fresh flowers
1	3.442	2-Hexenyl acetate	1009	esters	C ₈ H ₁₄ O ₂	142	-	2.34
2	3.639	Methyl <i>para</i> cresol	1026	benzyl ethers	C ₈ H ₁₀ O	122	-	25.45
3	3.829	Benzyl alcohol	1042	benzyl alcohols	C ₇ H ₈ O	108	-	0.87
4	4.277	<i>p</i> -Cresol	1076	phenols	C ₇ H ₈ O	108	0.32	0.39
5	4.358	Styralyl alcohol	1082	benzyl alcohols	C ₈ H ₁₀ O	122	0.14	
6	4.408	Methyl phenethyl ether	1087	benzyl ethers	C ₉ H ₁₂ O	136	-	0.74
7	4.675	Methyl benzoate	1105	aromatic ester	C ₈ H ₈ O ₂	136	-	5.62
8	4.983	Phenethyl alcohol	1123	benzyl alcohol	C ₈ H ₁₀ O	122	16.19	18.28
9	5.765	Benzyl acetate	1166	benzyl esters	C ₉ H ₁₀ O ₂	150	-	0.38
10	5.942	Ethyl benzoate	1176	benzyl esters	C ₉ H ₁₀ O ₂	150	-	0.49
11	6.134	Benzoic acid	1188	benzyl acid	C ₇ H ₆ O ₂	122	0.81	
12	6.205	<i>p</i> -Cresol, 2-methoxy-	1193	Phenol	C ₈ H ₁₀ O ₂	138	1.02	0.20
13	6.450	Methyl chavicol	1205	benzyl ethers	C ₁₀ H ₁₂ O	148	1.80	16.61
14	6.640	3-Phenylhexane	1214	benzyl	C ₁₂ H ₁₈	162	0.97	0.36
15	7.161	Benzenepropanol	1239	benzyl alcohols	C ₉ H ₁₂ O	136	0.58	0.10
16	7.577	Phenethyl acetate	1259	benzyl esters	C ₁₀ H ₁₂ O ₂	164	4.54	5.10
17	7.730	<i>p</i> -Anisaldehyde	1266	benzyl aldehydes	C ₈ H ₈ O ₂	136	2.43	0.33
18	8.091	Cinnamaldehyde	1283	benzyl aldehydes	C ₉ H ₈ O	132	4.10	0.78
19	8.311	<i>p</i> -Anisyl alcohol	1294	benzyl alcohols	C ₈ H ₁₀ O ₂	138	3.83	0.89
20	8.914	Cinnamyl alcohol	1314	benzyl alcohols	C ₉ H ₁₀ O	134	16.10	6.78
21	9.865	3-hydroxy-4-phenyl-2-butanone	1348	ketones	C ₁₀ H ₁₂ O ₂	164	5.61	1.33
22	9.971	Eugenol	1356	phenols	C ₁₀ H ₁₂ O ₂	164	4.94	0.87
23	10.485	Ethanol, 2-(<i>p</i> -methoxyphenyl)	1374	benzyl alcohols	C ₉ H ₁₂ O ₂	152	2.78	0.52
24	10.658	Methyl <i>p</i> -anisate	1379	benzyl esters	C ₉ H ₁₀ O ₃	166	2.62	2.98
25	10.976	Methyl cinnamate	1390	benzyl esters	C ₁₀ H ₁₀ O ₂	162	5.27	3.37
26	11.141	Phenethyl isobutyrate	1396	benzyl esters	C ₁₂ H ₁₆ O ₂	192	0.98	-
27	11.698	2-Propanol, 1, 3-diphenyl	1412	benzyl alcohols	C ₁₅ H ₁₆ O	212	4.03	0.66
28	12.067	Unknown	1420				3.06	0.59
29	13.082	Cinnamyl acetate	1445	benzyl esters	C ₁₁ H ₁₂ O ₂	176	3.41	1.31
30	13.285	Ethyl <i>p</i> -anisate	1449	benzyl esters	C ₁₀ H ₁₂ O ₃	180	1.33	0.20
31	13.751	Methyl <i>p</i> -hydroxybenzoate	1461	phenolic esters	C ₈ H ₈ O ₃	152	0.89	0.27
32	14.036	Ethyl cinnamate	1467	benzyl ester	C ₁₁ H ₁₂ O ₂	176	0.83	0.15
33	14.807	<i>beta</i> -Phenylethyl isovalerate	1486	benzyl ester	C ₁₃ H ₁₈ O ₂	206	0.30	
34	19.040	Nerolidol	1556	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	3.27	0.66
35	19.910	3-Methoxycinnamaldehyde	1569	benzyl aldehydes	C ₁₀ H ₁₀ O ₂	162	4.65	0.83
36	20.663	Phenylethyl tiglate	1582	benzyl esters	C ₁₃ H ₁₆ O ₂	204	0.39	-
37	21.708	Methoxyeugenol	1597	phenols	C ₁₁ H ₁₄ O ₃	194	1.08	-
38	22.567	Lauryl acetate	1607	esters	C ₁₄ H ₂₈ O ₂	228	1.53	-
39	28.499	Methyl <i>p</i> -methoxycinnamate	1668	benzyl esters	C ₁₁ H ₁₂ O ₃	192	0.20	-

- not identified

^a Kovats Retention indices relative to C₈-C₂₀ *n*-alkanes on DB-5MS column.

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Table 4.12 Identification of volatile constituents of *A. odorata* flowers (fresh)

No.	Rt (min)	Compounds	KI ^a	Chemical groups	Formula	MW	Relative content (%)		
							Essential oil	Absolute	Fresh flowers
1	3.842	<i>trans-beta</i> -Ocimene	1046	monoterpenes	C ₁₀ H ₁₆	136	-	-	5.43
2	9.405	<i>alpha</i> -Terpinolene	1335	monoterpenes	C ₁₀ H ₁₆	136	-	0.06	-
3	9.472	<i>delta</i> -Elemene	1338	sesquiterpenes	C ₁₅ H ₂₄	204	0.23	-	-
4	10.664	<i>alpha</i> -Copaene	1379	sesquiterpenes	C ₁₅ H ₂₄	204	0.30	0.04	0.18
5	10.923	<i>alpha</i> -Cedrene	1391	sesquiterpenes	C ₁₅ H ₂₄	204	3.10	0.85	1.56
6	11.054	<i>beta</i> -Elemene	1394	sesquiterpenes	C ₁₅ H ₂₄	204	0.20	-	-
7	11.732	<i>beta</i> -Gurjunene	1414	sesquiterpenes	C ₁₅ H ₂₄	204	0.44	-	-
8	11.828	<i>alpha-cis</i> -Bergamotene	1413	sesquiterpenes	C ₁₅ H ₂₄	204	0.31	0.06	-
9	12.063	<i>beta</i> -Cedrene	1421	sesquiterpenes	C ₁₅ H ₂₄	204	18.02	14.28	20.49
10	12.150	<i>trans</i> -Caryophyllene	1423	sesquiterpenes	C ₁₅ H ₂₄	204	0.08	0.10	0.43
11	12.367	<i>gamma</i> -Murolene	1431	sesquiterpenes	C ₁₅ H ₂₄	204	1.14	2.88	-
12	12.431	<i>alpha-trans</i> -Bergamotene	1433	sesquiterpenes	C ₁₅ H ₂₄	204	3.13	1.05	0.93
13	12.650	Widdrene	1435	sesquiterpenes	C ₁₅ H ₂₄	204	0.21	0.14	-
14	12.839	Unknown	1438	sesquiterpenes	C ₁₅ H ₂₄	204	0.50	-	-
15	13.164	<i>trans-beta</i> -Farnesene	1448	sesquiterpenes	C ₁₅ H ₂₄	204	8.63	6.00	3.05
16	13.338	<i>alpha</i> -Humulene	1455	sesquiterpenes	C ₁₅ H ₂₄	204	17.06	16.87	17.39
17	13.666	Khusimene	1455	sesquiterpenes	C ₁₅ H ₂₄	204	19.40	23.04	22.18
18	13.758	<i>alpha</i> -Amorphene	1461	sesquiterpenes	C ₁₅ H ₂₄	204	-	6.56	-
19	13.884	<i>beta</i> -Cubebene	1464	sesquiterpenes	C ₁₅ H ₂₄	204	4.40	-	2.69
20	14.074	Unknown from lime oil	1467	sesquiterpenes	C ₁₅ H ₂₄	204	8.48	6.09	4.57
21	14.210	Alloaromadendrene	1471	sesquiterpenes	C ₁₅ H ₂₄	204	0.50	-	-
21	14.263	<i>alpha</i> -Acoradiene	1475	sesquiterpenes	C ₁₅ H ₂₄	204	1.31	1.21	-
22	14.650	Germacrene D	1485	sesquiterpenes	C ₁₅ H ₂₄	204	1.35	3.29	1.34
23	14.863	<i>trans-alpha</i> -Farnesene	1489	sesquiterpenes	C ₁₅ H ₂₄	204	-	1.25	0.26
24	15.221	bicyclogermacrene	1497	sesquiterpenes	C ₁₅ H ₂₄	204	-	0.52	-
25	15.511	<i>trans-alpha</i> -Bisabolene	1503	sesquiterpenes	C ₁₅ H ₂₄	204	0.34	-	-
26	15.899	<i>beta</i> -Bisabolene	1506	sesquiterpenes	C ₁₅ H ₂₄	204	4.46	1.98	0.43
27	16.469	<i>delta</i> -Cadinene	1521	sesquiterpenes	C ₁₅ H ₂₄	204	1.16	-	-
28	16.617	<i>beta</i> -Sesquiphellandrene	1522	sesquiterpenes	C ₁₅ H ₂₄	204	4.10	2.87	0.64
29	16.797	<i>cis</i> -Farnesol	1525	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	-	0.60	-
30	18.861	Germacrene B	1554	sesquiterpenes	C ₁₅ H ₂₄	204	0.43	0.32	-
31	18.973	Nerolidol	1555	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	-	0.46	-
32	20.168	Spathulenol	1578	sesquiterpene alcohols	C ₁₅ H ₂₄ O	220	0.49	-	-
33	25.554	Methyl jasmonate	1643	esters	C ₁₃ H ₂₀ O ₃	224	-	8.29	17.89

- not identified

^a Kovats Retention indices relative to C₈-C₂₀ *n*-alkanes on DB-5MS column.**Table 4.13** Identification of volatile constituents of *A. odorata* flowers (dried)

No.	Rt (min)	Compounds	KI ^a	Chemical groups	Formula	MW	Relative content (%)		
							Essential oil	Absolute	Dried flowers
1	3.160	6-Methyl-5-hepten-2-one	- ^b	miscellaneous	C ₈ H ₁₄ O	126	-	-	12.27
2	4.312	cis-Linalool oxide	1081	monoterpene alcohols	C ₁₀ H ₁₈ O ₂	170	0.09	-	0.71
3	4.542	trans-Linalool oxide	1097	monoterpene alcohols	C ₁₀ H ₁₈ O ₂	170	0.06	-	0.31
4	4.633	Linalool	1103	monoterpene alcohols	C ₁₀ H ₁₈ O	154	-	-	0.17
5	4.692	n-Nonanal	1005	aldehyde	C ₉ H ₁₈ O	142	-	-	0.13
6	7.745	Carvenone	1269	monoterpene ketones	C ₁₀ H ₁₆ O	152	0.08	-	-
7	9.805	alpha-Cubebene	1351	sesquiterpenes	C ₁₅ H ₂₄	204	0.96	0.52	2.15
8	10.490	alpha-Ylangene	1376	sesquiterpenes	C ₁₅ H ₂₄	204	0.48	-	0.62
9	10.682	alpha-Copaene	1377	sesquiterpenes	C ₁₅ H ₂₄	204	5.56	6.47	22.26
10	10.930	beta-Cubebene	1390	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	4.62
11	10.932	alpha-Cedrene	1391	sesquiterpenes	C ₁₅ H ₂₆	206	0.90	0.97	-
12	11.063	beta-Elemene	1394	sesquiterpenes	C ₁₅ H ₂₄	204	0.30	-	-
13	11.261	cis-Jasmone	1401	miscellaneous	C ₁₁ H ₁₆ O	164	0.48	-	-
14	12.054	beta-Cedrene	1421	sesquiterpenes	C ₁₅ H ₂₄	204	5.80	10.72	-
15	12.164	trans-Caryophyllene	1423	sesquiterpenes	C ₁₅ H ₂₄	204	1.53	1.13	15.51
16	12.271	unknown	1428				-	0.65	-
17	12.543	trans-alpha-Bergamotene	1435	sesquiterpenes	C ₁₅ H ₂₄	204	0.94	1.17	0.43
18	13.123	trans-beta-Farnesene	1446	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	0.22
19	13.210	beta-Sesquiphellandrene	1448	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	0.43
20	13.268	Unknown	1453				0.39	-	-
21	13.408	alpha-Humulene	1455	sesquiterpenes	C ₁₅ H ₂₄	204	6.81	13.70	3.22
22	13.648	Khusimene	1455	sesquiterpenes	C ₁₅ H ₂₄	204	9.03	20.17	-
23	13.746	Alloaromadendrene	1460	sesquiterpenes	C ₁₅ H ₂₄	204	2.02	2.02	1.77
24	13.883	Germacrene D	1468	sesquiterpenes	C ₁₅ H ₂₄	204	0.40	-	-
25	13.996	Unknown from lime oil	1470	sesquiterpenes	C ₁₅ H ₂₄	204	2.84	5.36	-
26	14.219	beta-Cadinene	1475	sesquiterpenes	C ₁₅ H ₂₄	204	0.40	-	-
27	14.351	alpha-Amorphene	1478	sesquiterpenes	C ₁₅ H ₂₄	204	1.61	1.11	0.35
28	14.510	Germacrene D	1482	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	1.55
29	14.599	alpha-Curcumene	1481	miscellaneous	C ₁₅ H ₂₂	202	0.41	0.14	-
30	14.607	Isocaryophyllene	1481	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	0.71
31	14.856	alpha-Bergamotene	1487	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	13.62
32	14.921	beta-Selinene	1490	sesquiterpenes	C ₁₅ H ₂₄	204	-	1.35	-
33	15.042	Humulen-(V1)	1493	sesquiterpenes	C ₁₅ H ₂₄	204	2.71	-	-
34	15.398	alpha-Selinene	1497	sesquiterpenes	C ₁₅ H ₂₄	204	2.22	1.72	1.18
35	15.479	alpha-Murolene	1500	sesquiterpenes	C ₁₅ H ₂₄	204	1.22	0.93	0.22
36	15.721	Farnesene	1506	sesquiterpenes	C ₁₅ H ₂₄	204	0.60	-	-
37	15.920	beta-Bisabolene	1506	sesquiterpenes	C ₁₅ H ₂₄	204	2.18	3.20	1.27
38	16.541	delta-Cadinene	1521	sesquiterpenes	C ₁₅ H ₂₄	204	12.35	15.74	15.59
39	16.731	Calamenene	1524	miscellaneous	C ₁₅ H ₂₂	202	1.28	1.04	-
40	17.862	alpha-Calacorene	1543	miscellaneous	C ₁₅ H ₂₀	200	5.73	4.43	-
41	20.244	Spathulenol	1578	sesquiterpene alcohols	C ₁₅ H ₂₄ O	220	4.17	0.69	-
42	20.560	Caryophyllene oxide	1583	oxygenated sesquiterpenes	C ₁₅ H ₂₄ O	220	9.85	3.86	0.51
43	21.258	Salvial-4(14)-en-1-one	1595	sesquiterpene ketones	C ₁₅ H ₂₄ O	220	0.93	-	-
44	22.544	Humulene oxide	1608	oxygenated sesquiterpenes	C ₁₅ H ₂₄ O	220	4.73	1.08	-
45	23.162	Unknown	1616				1.62	-	-
46	23.962	Unknown	1625				3.50	-	-
47	28.087	Cadalene	1668	benzene	C ₁₅ H ₁₈	198	5.57	1.84	-

- not identified

^a Kovats Retention indices relative to C₈-C₂₀ *n*-alkanes on DB-5MS column.

^b Retention times is outside of retention times of homologous series of C₈-C₂₀ *n*-alkanes

Table 4.14 Identification of volatile constituents of *A. siamensis* flowers

No.	Rt (min)	Compounds	Kt ^a	Chemical groups	Formula	MW	Relative content (%)		
							Essential oil	Absolute	Fresh flowers
1	2.613	Isoamyl acetate	- ^b	esters	C ₇ H ₁₄ O ₂	130	-	0.45	0.43
2	3.308	<i>alpha</i> -Pinene	939	monoterpenes	C ₁₀ H ₁₆	136	17.38	31.94	5.78
3	3.783	Sabinene	979	monoterpenes	C ₁₀ H ₁₆	136	0.21	-	-
4	3.925	<i>beta</i> -Myrcene	991	monoterpenes	C ₁₀ H ₁₆	136	2.68	3.66	0.16
5	4.292	<i>alpha</i> -Phellandrene	1012	monoterpenes	C ₁₀ H ₁₆	136	0.86	0.77	-
6	4.662	Limonene	1031	monoterpenes	C ₁₀ H ₁₆	136	-	-	0.15
7	4.637	<i>cis</i> -Ocimene	1037	monoterpenes	C ₁₀ H ₁₆	136	3.61	4.86	-
8	4.708	<i>alpha</i> -Ocimene	1038	monoterpenes	C ₁₀ H ₁₆	136	-	4.15	-
9	4.767	<i>beta</i> -Phellandrene	1040	monoterpenes	C ₁₀ H ₁₆	136	0.52	-	-
10	4.943	<i>trans-beta</i> -Ocimene	1050	monoterpenes	C ₁₀ H ₁₆	136	0.63	5.33	-
11	5.853	<i>alpha</i> -Terpinolene	1092	monoterpenes	C ₁₀ H ₁₆	136	0.15	0.38	-
12	6.105	Linalool	1102	monoterpene alcohols	C ₁₀ H ₁₈ O	154	0.54	5.06	-
13	6.508	Phenethyl alcohol	1120	benzyl alcohols	C ₈ H ₁₀ O	122	-	7.89	-
14	7.992	Borneol	1183	monoterpene alcohols	C ₁₀ H ₁₈ O	154	-	0.39	-
15	8.485	<i>alpha</i> -Terpineol	1202	monoterpene alcohols	C ₁₀ H ₁₈ O	154	0.26	0.21	-
16	9.133	Nerol	1230	monoterpene alcohols	C ₁₀ H ₁₈ O	154	-	0.49	-
17	10.863	Bornyl acetate	1289	esters	C ₁₂ H ₂₀ O ₂	196	1.14	0.14	-
18	12.296	<i>alpha</i> -Cubebene	1350	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	0.13
19	12.940	<i>alpha</i> -Ylangene	1375	sesquiterpenes	C ₁₅ H ₂₄	204	0.51	-	0.75
20	13.092	<i>alpha</i> -Copaene	1377	sesquiterpenes	C ₁₅ H ₂₄	204	4.35	3.03	12.27
21	13.330	<i>beta</i> -Cubebene	1389	sesquiterpenes	C ₁₅ H ₂₄	204	-	-	0.54
22	13.442	<i>beta</i> -Elemene	1392	sesquiterpenes	C ₁₅ H ₂₄	204	0.42	-	-
23	13.825	Isocaryophyllene	1409	sesquiterpenes	C ₁₅ H ₂₄	204	-	1.61	-
24	14.377	<i>trans</i> -Caryophyllene	1423	sesquiterpenes	C ₁₅ H ₂₄	204	26.47	15.66	55.58
25	14.654	<i>alpha</i> -Bergamotene	1435	sesquiterpenes	C ₁₅ H ₂₄	204	1.37	0.83	1.70
26	14.822	Amyl benzoate	1443	aromatic esters	C ₁₂ H ₁₆ O ₂	192	-	0.27	-
27	15.190	Aromadendrene	1458	sesquiterpenes	C ₁₅ H ₂₄	204	0.19	-	-
28	15.402	<i>alpha</i> -Humulene	1461	sesquiterpenes	C ₁₅ H ₂₄	204	14.95	6.21	15.82
29	15.879	<i>alpha</i> -Amorphene	1482	sesquiterpenes	C ₁₅ H ₂₄	204	1.65	0.70	2.15
30	16.066	Germacrene-D	1485	sesquiterpenes	C ₁₅ H ₂₄	204	0.87	0.10	0.34
31	16.265	<i>beta</i> -Phenylethyl isovalerate	1495	benzyl esters	C ₁₃ H ₁₈ O ₂	206	-	0.31	-
32	16.424	<i>alpha</i> -Muurolene	1500	sesquiterpenes	C ₁₅ H ₂₄	204	0.95	0.18	0.33
33	16.962	<i>delta</i> -Cadinene	1523	sesquiterpenes	C ₁₅ H ₂₄	204	3.65	2.00	3.56
34	18.603	Caryophyllene oxide	1587	sesquiterpenes oxygenated	C ₁₅ H ₂₄ O	220	7.50	1.62	0.32
35	19.247	Veridiflorol	1618	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	5.83	0.84	-
36	19.622	unknown	1639				1.42	-	-
37	20.020	<i>delta</i> -Cadinol	1655	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	1.82	0.14	-
38	20.558	Isolongifolol	1683	sesquiterpene alcohols	C ₁₅ H ₂₆ O	222	0.87	-	-
39	22.264	Benzyl benzoate	1777	benzyl esters	C ₁₄ H ₁₂ O ₂	212	0.14	0.14	-
40	25.605	Ethyl palmitate	1991	esters	C ₁₈ H ₃₆ O ₂	284	-	0.66	-

- not identified

^a Kovats Retention indices relative to C₈-C₂₀ *n*-alkanes on DB-5MS column.

^b Retention times is outside of retention times of homologous series of C₈-C₂₀ *n*-alkanes

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GC-MS analysis of the essential oils and absolutes of four Thai aromatic flowers led to the identification of volatile composition as shown in Table 4.10-4.14. The composition of the essential oils and absolutes were interesting because the different extraction methods gave distinct minor composition and proportion of chemical groups as shown in Figure 4.15-4.23.

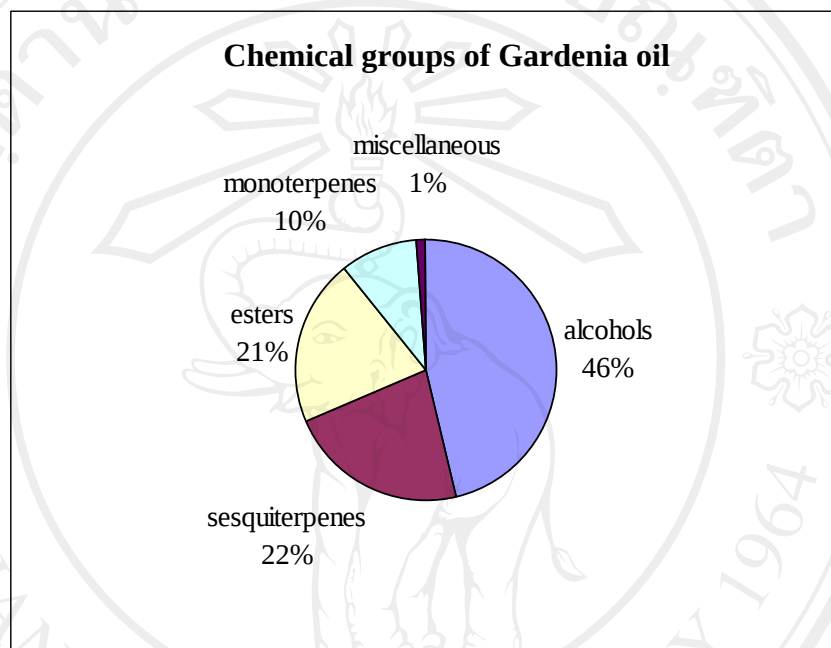


Figure 4.15 Chemical groups of Gardenia oil (fresh flowers)

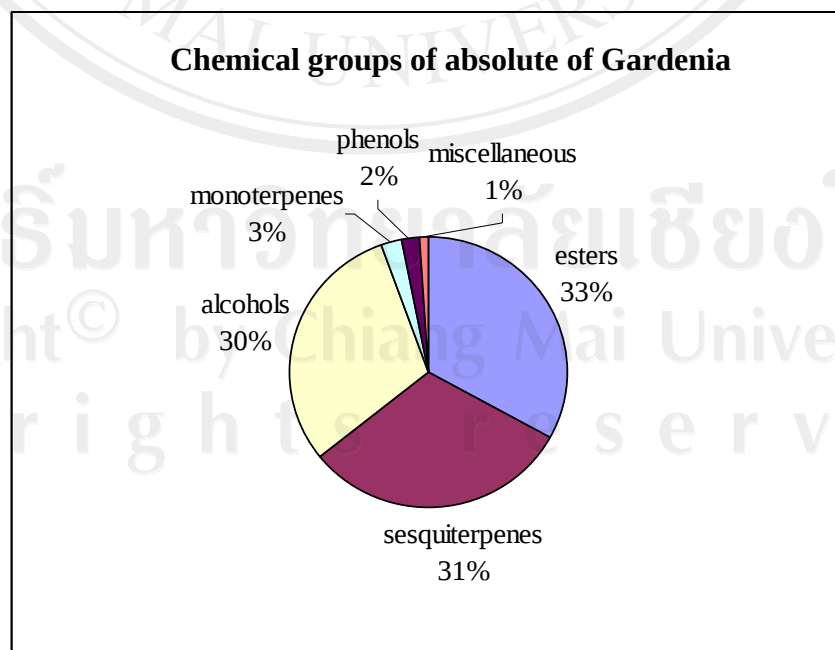


Figure 4.16 Chemical groups of absolute of Gardenia (fresh flowers)

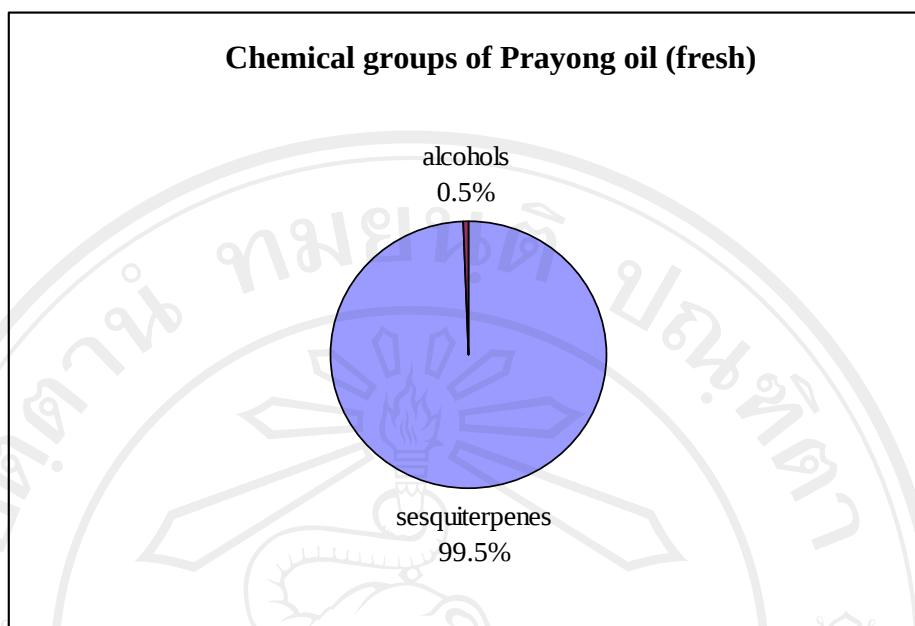


Figure 4.17 Chemical groups of Prayong oil (fresh flowers)

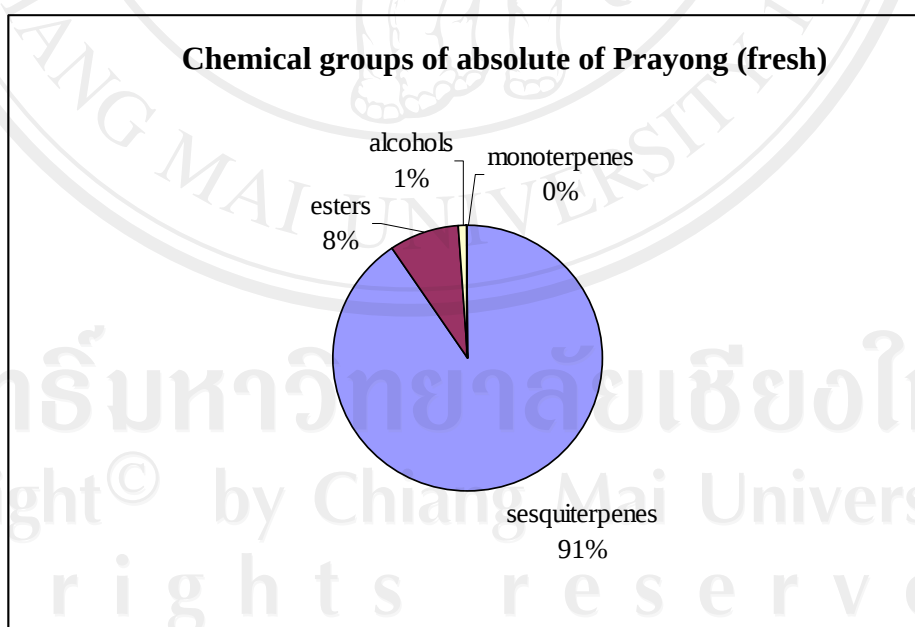


Figure 4.18 Chemical groups of absolute of Prayong (fresh flowers)

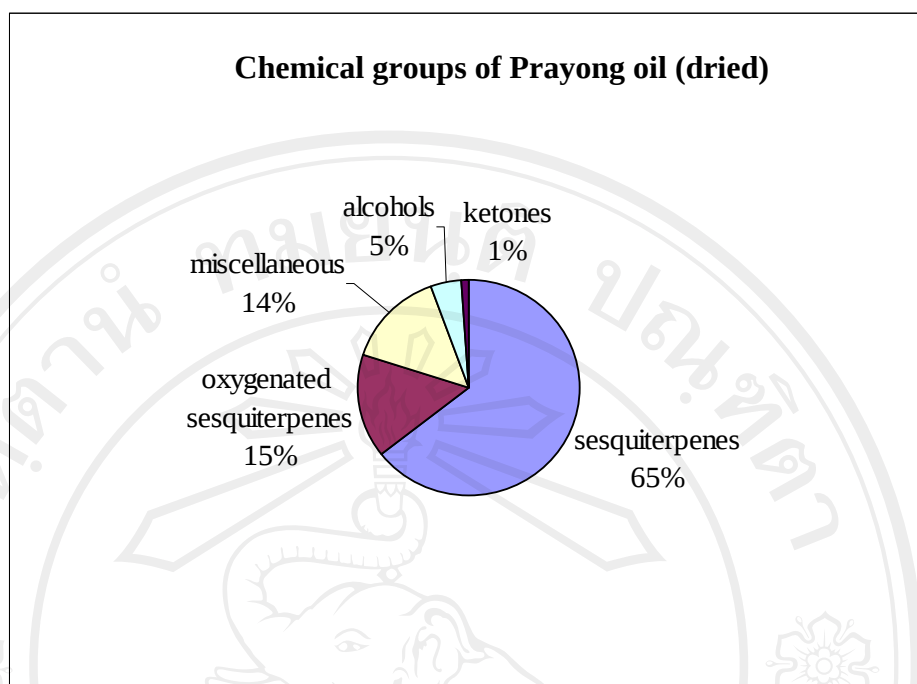


Figure 4.19 Chemical groups of Prayong oil (dried flowers)

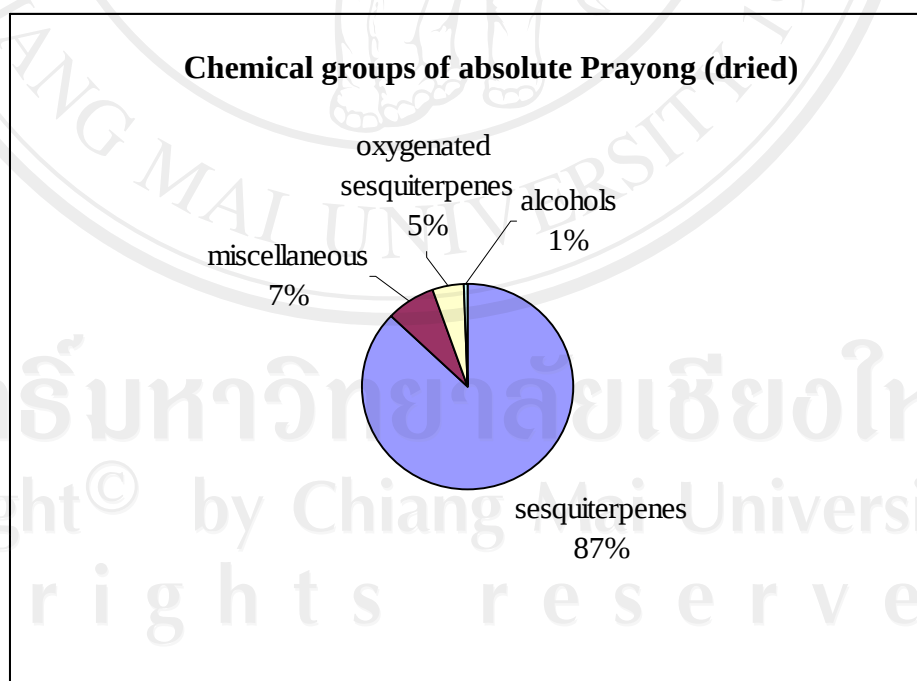


Figure 4.20 Chemical groups of absolute of Prayong (dried flowers)

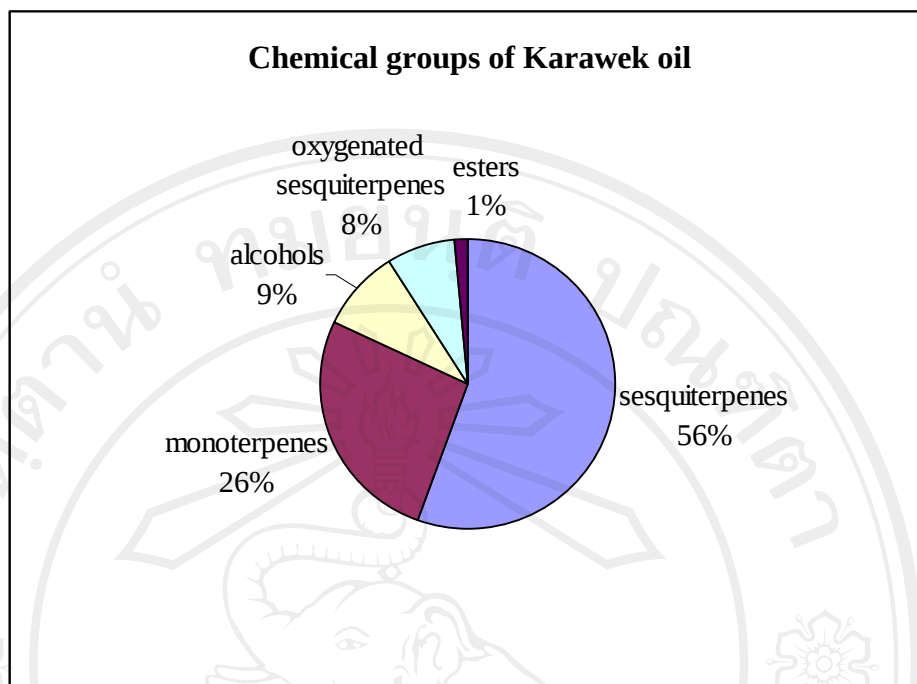


Figure 4.21 Chemical groups of Karawek oil (fresh flowers)

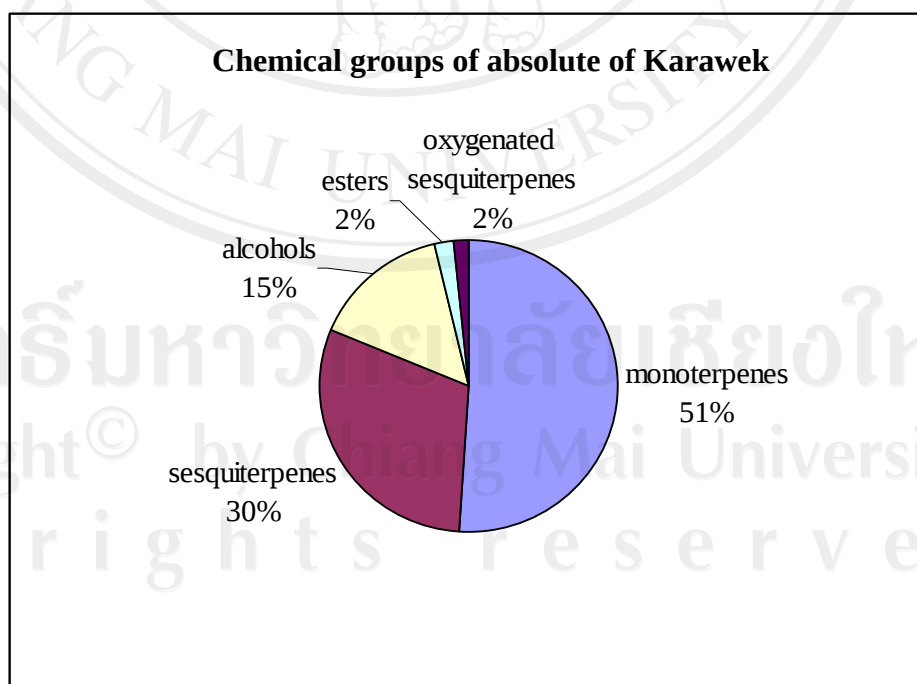


Figure 4.22 Chemical groups of absolute of Karawek (fresh flowers)

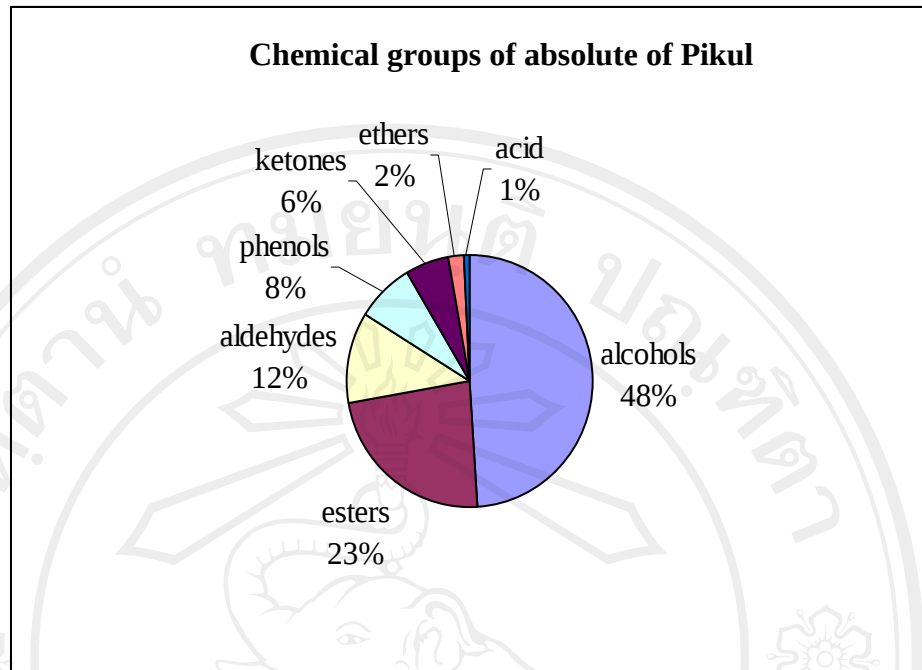


Figure 4.23 Chemical groups of absolute of Pikul (fresh flowers)

Thin Layer Chromatography

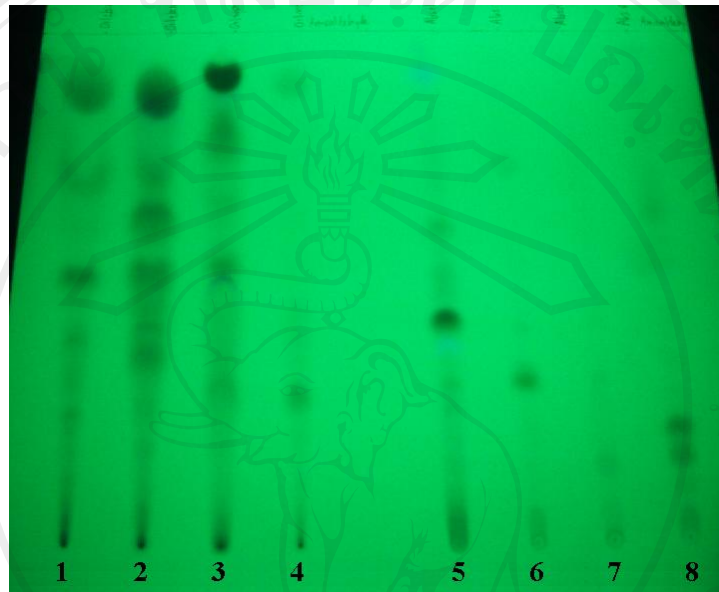
Stationary phase

Silica gel 60 F254

Mobile phase

Toluene : Ethylacetate (95 : 5)

Detection under UV light (254 nm)



1 = Essential oil from fresh flowers of *A. odorata*

2 = Essential oil from dried flowers of *A. odorata*

3 = Essential oil from fresh flowers of *G. jasminoides*

4 = Essential oil from fresh flowers of *A. Siamensis*

5 = Absolute from dried flowers of *A. odorata*

6 = Absolute from fresh flowers of *G. jasminoides*

7 = Absolute from fresh flowers of *A. Siamensis*

8 = Absolute from fresh flowers of *M. elengi*

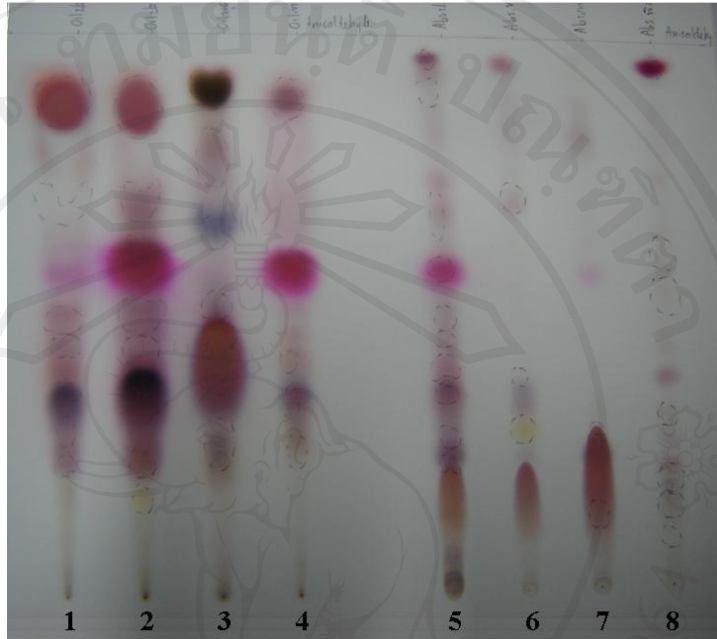
Stationary phase

Silica gel 60 F254

Mobile phase

Toluene : Ethylacetate (95 : 5)

Detection with *anisaldehyde* spraying reagent



- 1 = Essential oil from fresh flowers of *A. odorata*
- 2 = Essential oil from dried flowers of *A. odorata*
- 3 = Essential oil from fresh flowers of *G. jasminoides*
- 4 = Essential oil from fresh flowers of *A. Siamensis*
- 5 = Absolute from dried flowers of *A. odorata*
- 6 = Absolute from fresh flowers of *G. jasminoides*
- 7 = Absolute from fresh flowers of *A. Siamensis*
- 8 = Absolute from fresh flowers of *M. elengi*

Table 4.15 R_f values of chemical compositions of Prayong oil (fresh flowers)

Spot	R _f value	Detection with		
		UV 254	UV 366	<i>Anisaldehyde</i>
1	0.17	-	-	light brown
2	0.23	quenching	-	-
3	0.25	-	-	light violet
4	0.32	quenching	-	-
5	0.33	-	-	violet
6	0.36	quenching	-	-
7	0.40	-	-	light pink
8	0.43	quenching	-	light violet
9	0.49	quenching	-	light violet
10	0.55	-	-	violet
11	0.67	quenching	-	-
12	0.73	-	-	brown
13	0.82	-	violet	-
14	0.88	quenching	-	reddy pink

Table 4.16 R_f values of chemical compositions of Prayong oil (dried flowers)

Spot	R _f value	Detection with		
		UV 254	UV 366	Anisaldehyde
1	0.17	quenching	-	yellow brown
2	0.23	quenching	-	reddy pink
3	0.25	-	-	violet
4	0.31	-	-	reddy pink
5	0.33	quenching	-	reddy pink
6	0.36	-	-	dark violet
7	0.39	quenching	-	dark violet
8	0.40	-	-	pink
9	0.43	quenching	-	violet
10	0.49	quenching	violet	violet
11	0.55	-	-	violet
12	0.59	quenching	violet	dark pink
13	0.68	quenching	violet	violet
14	0.71	-	violet	-
15	0.87	quenching	violet	reddy pink

Table 4.17 R_f values of chemical compositions of absolute of Prayong (dried flowers)

Spot	R _f value	Detection with		
		UV 254	UV 366	Anisaldehyde
1	0.07	-	-	light violet
2	0.17	quenching	-	orange brown
3	0.23	quenching	-	reddy pink
4	0.25	-	-	violet
5	0.27	quenching	-	-
6	0.34	quenching	blue	violet
7	0.39	quenching	-	light pink
8	0.44	quenching	-	light pink
9	0.48	quenching	-	light pink
10	0.57	quenching	-	dark pink
11	0.67	quenching	-	light violet
12	0.73	-	-	light pink
13	0.82	-	-	light pink
14	0.90	quenching	violet	-
15	0.96	quenching	violet	violet

Table 4.18 R_f values of chemical compositions of Gardenia oil (fresh flowers)

Spot	R _f value	Detection with		
		UV 254	UV 366	Anisaldehyde
1	0.21	-	-	light violet
2	0.26	quenching	-	light violet
3	0.41	quenching	-	reddy pink
4	0.47	quenching	violet	reddy pink
5	0.50	quenching	-	light violet
6	0.63	quenching	-	-
7	0.65	-	-	dark blue
8	0.78	quenching	-	light violet
9	0.86	-	violet	-
10	0.90	quenching	-	Black

Table 4.19 R_f values of chemical compositions of absolute of Gardenia (fresh flowers)

Spot	R _f value	Detection with		
		UV 254	UV 366	Anisaldehyde
1	0.03	quenching	-	-
2	0.17	-	-	orange
3	0.23	-	-	light violet
4	0.27	quenching	-	yellow
5	0.32	-	-	light violet
6	0.37	quenching	-	-
7	0.73	quenching	-	light pink
8	0.81	-	-	light violet
9	0.95	-	-	violet

Table 4.20 R_f values of chemical compositions of Karawek oil (fresh flowers)

Spot	R _f value	Detection with		
		UV 254	UV 366	<i>Anisaldehyde</i>
1	0.25	quenching	-	-
2	0.27	-	-	brown
3	0.33	quenching	-	-
4	0.35	-	-	violet
5	0.41	quenching	-	light pink
6	0.45	-	-	light violet
7	0.56	-	-	dark pink
8	0.66	-	-	light pink
9	0.89	quenching	-	violet

Table 4.21 R_f values of chemical compositions of absolute of Karawek (fresh flowers)

Spot	R _f value	Detection with		
		UV 254	UV 366	<i>Anisaldehyde</i>
1	0.12	quenching	-	light violet
2	0.20	-	-	orange
3	0.28	quenching	-	-
4	0.56	-	-	pink
5	0.81	-	-	light violet
6	0.88	-	-	light violet
7	0.93	quenching	-	-
8	0.95	-	-	light violet

Table 4.22 Rf values of chemical compositions of absolute of Pikul (fresh flowers)

Spot	Rf value	Detection with		
		UV 254	UV 366	<i>Anisaldehyde</i>
1	0.09	quenching	-	-
2	0.13	quenching	-	-
3	0.15	-	-	light violet
4	0.19	quenching	-	-
5	0.21	-	-	light violet
6	0.26	-	-	light violet
7	0.30	quenching	-	-
8	0.37	-	-	violet
9	0.42	-	-	light brown
10	0.51	quenching	-	-
11	0.55	-	-	light violet
12	0.60	quenching	-	-
13	0.74	-	-	light brown
14	0.81	-	-	light brown
15	0.85	-	-	light brown
16	0.95	quenching	-	red

4.3 Antimicrobial activities

Antimicrobial activities of the essential oils and absolutes from four Thai aromatic flowers against the pathogenic organisms of public health significance were shown in Table 4.23-4.29

Table 4.23 Antimicrobial activity against *Staphylococcus aureus* (ATCC 6538)

Plant materials		Inhibition Zone (mm)			
		No. 1	No. 2	No. 3	Average*
<i>G. jasminoides</i> (fresh flowers)	Essential oil	16	17	19	17.3±1.5
	Absolute	18	19	20	19.0±1.0
<i>M. elengi</i> (fresh flowers)	Absolute	9	10	10	9.7±0.6
<i>A. odorata</i> (fresh flowers)	Essential oil	16	17	20	16.7±2.1
	Absolute	11	11	10	10.7±0.6
<i>A. odorata</i> (dried flowers)	Essential oil	12	13	12	12.3±0.6
	Absolute	-	-	-	-
<i>A. siamensis</i> (fresh flowers)	Essential oil	11	14	13	12.7±1.5
	Absolute	7	7	7	7.0±0.0
Chloramphenicol 5 mg%		30	32	29	30.3±1.5

* Average ± SD

- no inhibition zone

Table 4.24 Antimicrobial activity against *Staphylococcus epidermidis*

Plant materials		Inhibition Zone (mm)			
		No. 1	No. 2	No. 3	Average*
<i>G. jasminoides</i> (fresh flowers)	Essential oil	19	21	22	20.7±1.5
	Absolute	12	12	13	12.3±0.6
<i>M. elengi</i> (fresh flowers)	Absolute	-	-	-	-
<i>A. odorata</i> (fresh flowers)	Essential oil	16	17	17	16.7±0.6
<i>A. odorata</i> (dried flowers)	Essential oil	11	12	14	12.3±1.5
	Absolute	16	16	16	16.0±0.0
<i>A. siamensis</i> (fresh flowers)	Essential oil	16	16	14	15.3±1.2
	Absolute	-	-	-	-
Chloramphenicol 5 mg%		38	38	38	38.0±0.0

* Average ± SD

- no inhibition zone

Table 4.25 Antimicrobial activity against *Salmonella* Typhi (DMST 22842)

Plant materials		Inhibition Zone (mm)			
		No. 1	No. 2	No. 3	Average*
<i>G. jasminoides</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>M. elengi</i> (fresh flowers)	Absolute	11	11	10	10.7±0.6
<i>A. odorata</i> (fresh flowers)	Essential oil	-	-	-	-
<i>A. odorata</i> (dried flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. siamensis</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
Chloramphenicol 5% mg/ml		30	28	28	28.7±1.2

* Average ± SD

- no inhibition zone

Table 4.26 Antimicrobial activity against *Escherichia coli* (ATCC 10536)

Plant materials		Inhibition Zone (mm)			
		No. 1	No. 2	No. 3	Average*
<i>G. jasminoides</i> (fresh flowers)	Essential oil	15	15	15	15.0±0.0
	Absolute	-	-	-	-
<i>M. elengi</i> (fresh flowers)	Absolute	10	10	11	10.3±0.6
<i>A. odorata</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. odorata</i> (dried flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. siamensis</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
Chloramphenicol 5 mg%		28	28	27	27.7±0.6

* Average ± SD

- no inhibition zone

Table 4.27 Antimicrobial activity against *Pseudomonas aeruginosa* (ATCC 9027)

Plant materials		Inhibition Zone (mm)			
		No. 1	No. 2	No. 3	Average*
<i>G. jasminoides</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>M. elengi</i> (fresh flowers)	Absolute	-	-	-	-
<i>A. odorata</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. odorata</i> (dried flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. siamensis</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
Chloramphenicol 5 mg%		14	14	14	14.0±0.0

* Average ± SD

- no inhibition zone

Table 4.28 Antimicrobial activity against *Candida albicans* (ATCC 10231)

Plant materials		Inhibition Zone (mm)			
		No. 1	No. 2	No. 3	Average*
<i>G. jasminoides</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	14	13	15	14.0±1.0
<i>M. elengi</i> (fresh flowers)	Absolute	17	18	19	18.0±1.0
<i>A. odorata</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. odorata</i> (dried flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. siamensis</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-

* Average ± SD

- no inhibition zone

Table 4.29 Antimicrobial activity against *Aspergillus niger* (ATCC 16404)

Plant materials		Inhibition Zone (mm)			
		No. 1	No. 2	No. 3	Average*
<i>G. jasminoides</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>M. elengi</i> (fresh flowers)	Absolute	-	-	-	-
<i>A. odorata</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. odorata</i> (dried flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-
<i>A. siamensis</i> (fresh flowers)	Essential oil	-	-	-	-
	Absolute	-	-	-	-

* Average ± SD

- no inhibition zone

4.4 Antioxidant activities

In ABTS scavenging activity, the absolute of Pikul exhibited the highest activity among the other absolutes with TEAC value of 104.41 mg Trolox/1 g absolute. The antioxidant activities of studied absolutes range widely from 2.10 to 104.41 mg Trolox/1 g absolute. And Gardenia oil presented the highest activity among the other essential oils with TEAC value of 2.56 mg Trolox/1 ml essential oil. The antioxidant activities of essential oils range widely from 0.17 to 2.56 mg Trolox/1 ml essential oil. (Table 4.30 and Figure 4.24-4.25)

In Ferric reducing antioxidant power, the absolute of Pikul exhibited the highest activity among the other absolute with FRAP value of 144.88 mg Fe^{2+} /1 g absolute. The reducing power of studied absolutes range widely from 0.98 to 144.80 mg Fe^{2+} /1 g absolute. And Gardenia oil presented the highest reducing power among the other essential oils with FRAP value of 7.27 mg Fe^{2+} /1 ml essential oil. The reducing power of essential oils range widely from 0.13 to 7.27 mg Fe^{2+} /1 ml essential oil. (Table 4.31 and Figure 4.26-4.27)

Table 4.30 Antioxidant activities of essential oils and absolutes of *G. jasminoides*, *M. elengi*, *A. odorata*, *A. siamensis* by ABTS method

Flowers		Conc. (g/ ml)	Quantity (μ L)	Absorbance at 734 nm			% Inhibition	Equivalent to Trolox (μ g)	TEAC (mg of Trolox/mL Sample)	TEAC (mg of Trolox/ g Sample)	Equivalent to Ascorbic acid (ug)	mg of Ascorbic acid/mL Sample	mg of Ascorbic acid/g Sample
				1	2	Avg.							
<i>G. jasminoides</i> (fresh flowers)	Essential oil	-	4	0.2413	0.2443	0.2428	72.15	10.242	2.56	-	7.02	1.76	-
	Absolute	0.0048	20	0.7006	0.7000	0.7003	19.67	2.829	-	29.71	1.58	-	16.56
	Lipids	0.0202	20	0.6198	0.6236	0.6217	28.68	4.103	-	10.16	2.51	-	6.22
<i>M. elengi</i> (fresh flowers)	Absolute	0.0170	5	0.3251	0.3271	0.3261	62.59	8.892	-	104.41	6.03	-	70.81
	Lipids	0.0200	20	0.3687	0.3738	0.3713	57.41	8.161	-	20.40	5.49	-	13.73
<i>A. odorata</i> (fresh flowers)	Essential oil	-	4	0.7757	0.7733	0.7745	11.16	1.627	0.41	-	0.69	0.17	-
	Absolute	0.0688	20	0.4736	0.4754	0.4745	45.57	6.488	-	4.72	4.27	-	3.10
	Lipids	0.0201	20	0.8152	0.8174	0.8163	6.36	0.950	-	2.36	0.20	-	0.49
<i>A. odorata</i> (dried flowers)	Essential oil	-	4	0.4885	0.4874	0.4880	44.03	6.270	1.57	-	4.10	1.03	-
	Absolute	0.1509	20	0.4849	0.4834	0.4842	44.46	6.331	-	2.10	4.15	-	1.37
	Lipids	0.0200	20	0.7979	0.8022	0.8001	8.22	1.213	-	3.03	0.39	-	0.98
<i>A. siamensis</i> (fresh flowers)	Essential oil	-	20	0.6610	0.6615	0.6613	24.15	3.462	0.17	-	2.04	0.10	-
	Absolute	0.1375	20	0.3983	0.3966	0.3975	54.41	7.736	-	2.81	5.18	-	1.88
	Lipids	0.0201	20	0.8194	0.8207	0.8201	5.93	0.889	-	2.21	0.15	-	0.38
<i>Z. cassumunar</i> (rhizome)	Essential oil	-	1	0.3481	0.3424	0.3453	60.40	8.582	8.58	-	5.80	5.80	-

Table 4.31 Antioxidant activities of essential oils and absolutes of *G. jasminoides*, *M. elengi*, *A. odorata* and *A. siamensis* by FRAP method

Flowers		Conc. (g/ ml)	Quantity (μL)	Absorbance at 734 nm			Equiv. to FeSO ₄ (μg)	FRAP		Equiv. to Trolox (ug)	TEAC		Equiv. to Ascorbic acid (ug)	mg of Ascorbic acid/ ml Sample	mg of Ascorbic acid/ g Sample
				1	2	Avg.		mg Fe ²⁺ / ml Sample	mg Fe ²⁺ / g Sample		mg of Trolox/ml Sample	mg of Trolox/g Sample			
<i>G. jasminoides</i> (fresh flowers)	Essential oil	-	2	0.5800	0.5810	0.5805	14.54	7.27	-	6.73	3.36	-	4.82	2.41	-
	Absolute	0.0048	40	0.5855	0.6000	0.5928	14.85	-	77.96	6.87	-	36.08	4.92	-	25.82
	Lipids	0.0196	40	0.5159	0.5130	0.5145	12.90	-	16.45	5.95	-	7.60	4.29	-	5.47
<i>M. elengi</i> (fresh flowers)	Absolute	0.0170	5	0.4965	0.4872	0.4919	12.33	-	144.80	5.69	-	66.80	4.11	-	48.22
	Lipids	0.0201	20	0.5372	0.5415	0.5394	13.52	-	33.63	6.25	-	15.54	4.49	-	11.17
<i>A. odorata</i> (fresh flowers)	Essential oil	-	20	0.5498	0.5514	0.5506	13.80	0.69	-	6.38	0.32	-	4.58	0.23	-
	Absolute	0.0688	40	0.2342	0.2381	0.2362	5.96	-	2.17	2.69	-	0.98	2.05	-	0.75
	Lipids	0.0199	40	0.3419	0.3415	0.3417	8.59	-	10.79	3.93	-	4.94	2.90	-	3.64
<i>A. odorata</i> (dried flowers)	Essential oil	-	2	0.3715	0.3778	0.3747	9.41	4.71	-	4.32	2.16	-	3.17	1.58	-
	Absolute	0.1509	40	0.2301	0.2380	0.2341	5.90	-	0.98	2.67	-	0.44	2.04	-	0.34
	Lipids	0.0199	40	0.3607	0.3651	0.3629	9.12	-	11.45	4.18	-	5.25	3.07	-	3.86
<i>A. Siamensis</i> (fresh flowers)	Essential oil	-	40	0.2031	0.2055	0.2043	5.16	0.13	-	2.32	0.06	-	1.80	0.04	-
	Absolute	0.1375	40	0.3650	0.3668	0.3659	9.12	-	1.67	4.21	-	0.77	3.09	-	0.56
	Lipids	0.2000	40	0.1514	0.1477	0.1496	3.80	-	4.75	1.68	-	2.10	1.36	-	1.69
<i>Z. cassumunar</i> (rhizome)	Essential oil	-	1	0.6102	0.6171	0.6137	15.37	15.37	-	7.12	7.12	-	5.09	5.09	-

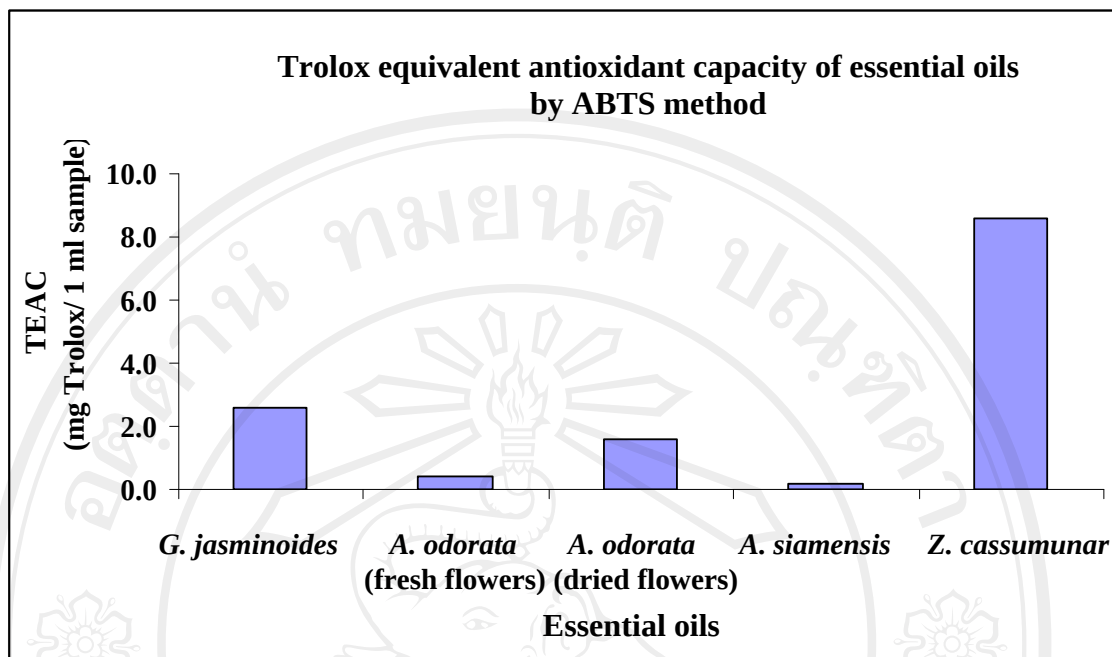


Figure 4.24 Trolox equivalent antioxidant capacity of essential oils by ABTS method

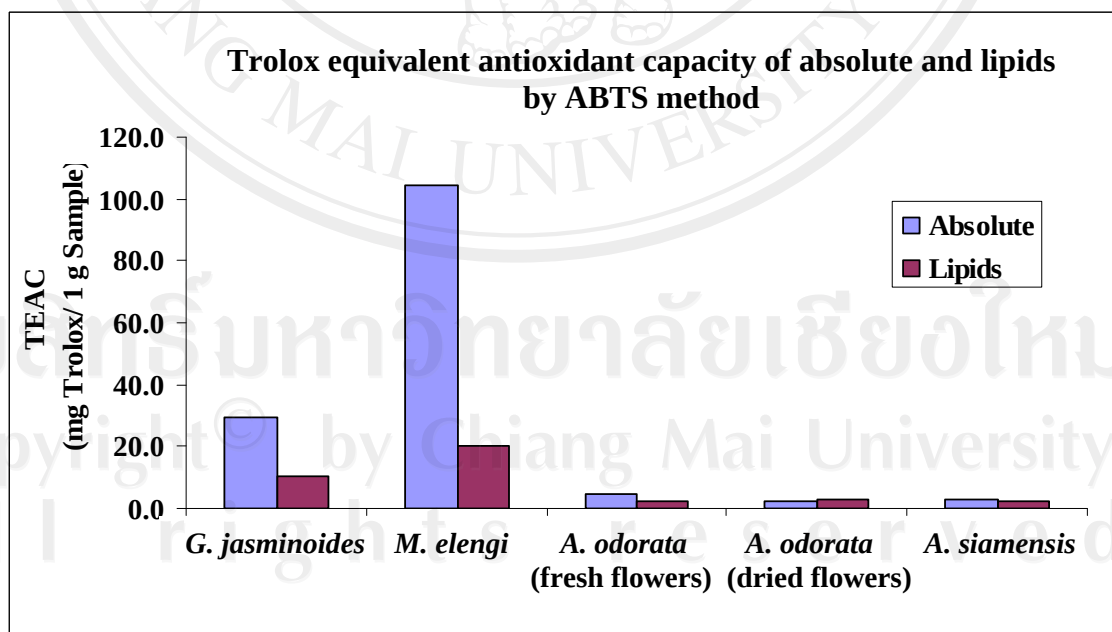


Figure 4.25 Trolox equivalent antioxidant capacity of absolute and lipids by ABTS method

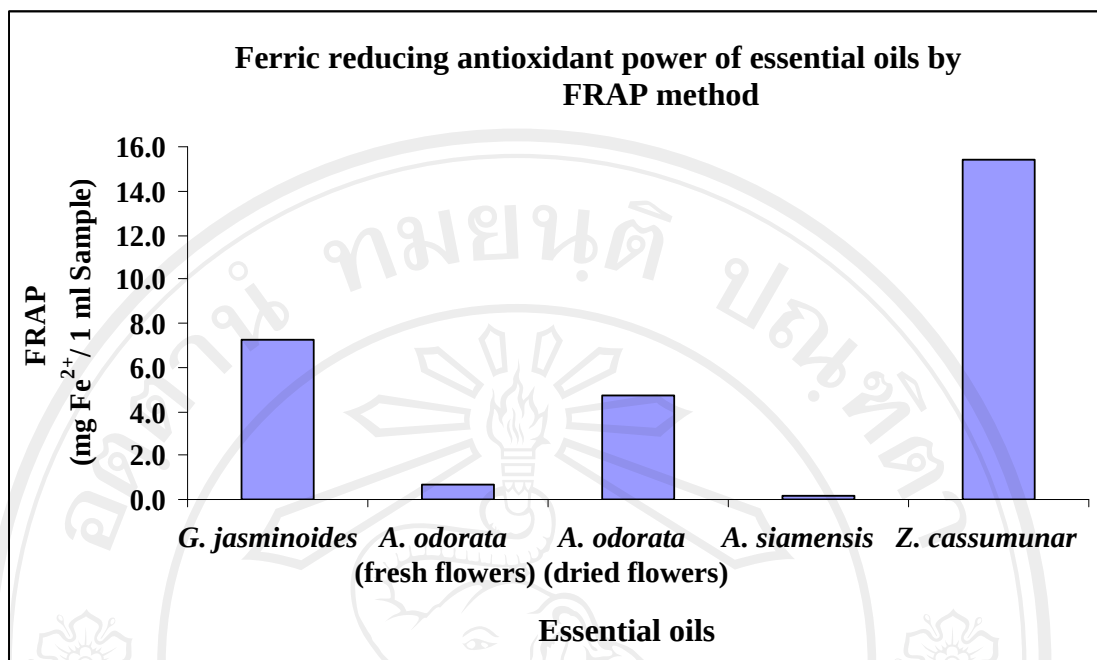


Figure 4.26 Ferric reducing antioxidant power of essential oils by FRAP method

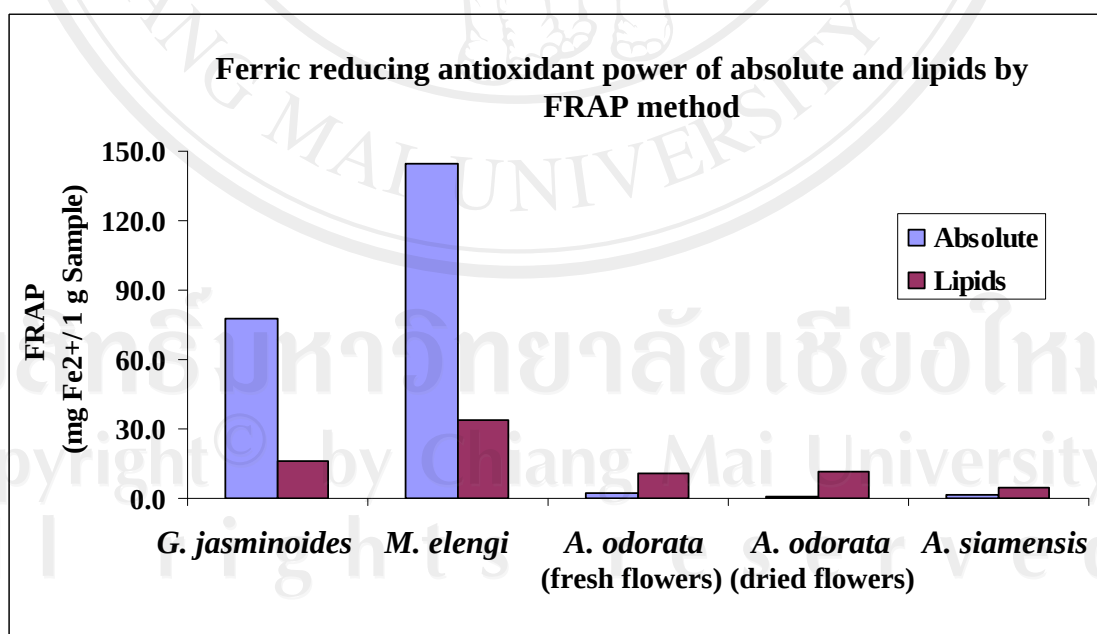


Figure 4.27 Ferric reducing antioxidant power of absolute and lipids by FRAP method

4.5 Effects on central nervous system

Table 4.32 Effects of inhalation of essential oils of *A. odorata* and *A. siamensis* on locomotor activity in the open-field test. The locomotor activity was recorded as distance traveled and evaluated continuously for 1 hour by Opto-Varimex activity cages. Data are presented as mean $\pm$ SEM.

	n	Distance traveled (cm)			
		0-20 min	21-40 min	41-60 min	0-60 min
Control	7	2858.1 $\pm$ 80.0	1053.5 $\pm$ 108.4	547.0 $\pm$ 99.7	4458.6 $\pm$ 187.0
<i>A. odorata</i>	7	2697.6 $\pm$ 157.4	758.3 $\pm$ 131.9	304.7 $\pm$ 69.8	3760.6 $\pm$ 290.7
<i>A. siamensis</i>	7	2385.2 $\pm$ 209.2	634.0 $\pm$ 207.2	411.6 $\pm$ 101.2	3430.7 $\pm$ 342.1

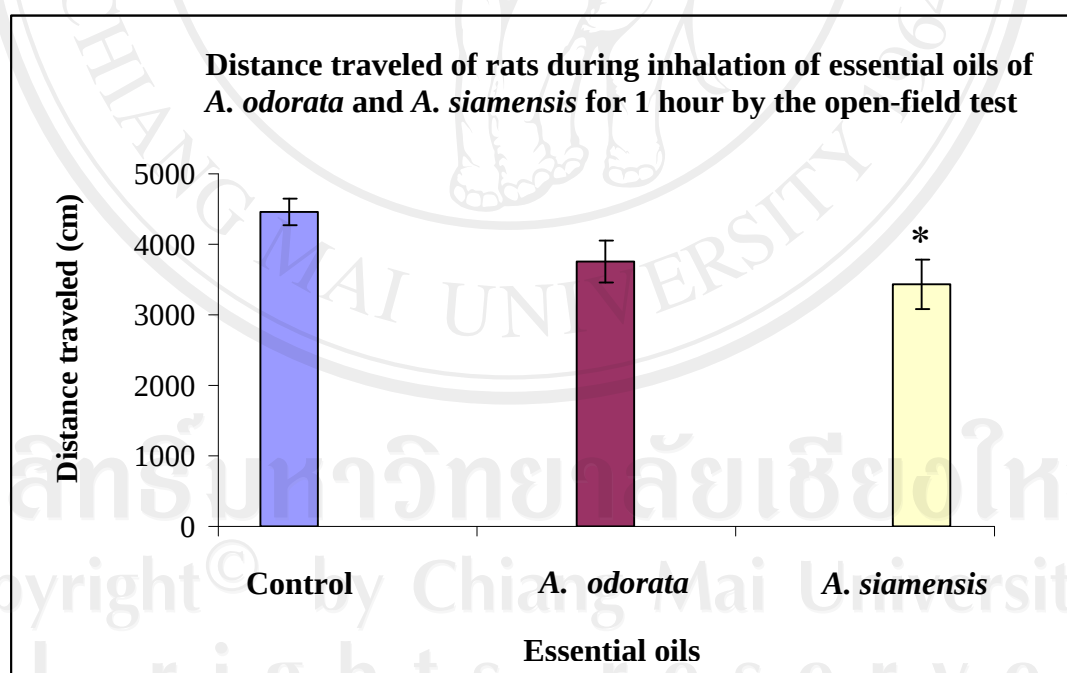


Figure 4.28 Distance traveled of rats during inhalation of essential oils of *A. odorata* and *A. siamensis* for 1 hour by the open-field test. Only essential oil of *A. siamensis* significantly decreased distance traveled compared with that of the control (* $p < 0.05$). The decrease of locomotor activity indicates the sedative effects of test substance.

Pentobarbital Induced Sleeping Time

Inhalation of essential oils of *A. odorata* and *A. siamensis* altered the pentobarbital induced sleeping time more than 15 % compared with that of the control. Diazepam, 2 mg/kg i.p., a positive control showed a +88 % prolongation in comparison with the normal control. One way ANOVA revealed that the effects of *A. odorata* and *A. Siamensis* differ from the control with statistical significance ($P < 0.05$).

Table 4.33 Effects of inhalation of essential oils of *A. odorata* and *A. siamensis* by pentobarbital induced sleeping time. Diazepam, 2 mg/kg i.p., was used as a positive control. Data are presented as mean $\pm$ SEM.

	n	Pentobarbital sleep time (min)	Control (%)
Control	10	78.1 $\pm$ 2.4	
Diazepam (2 mg/ kg, i.p.)	10	147.2 $\pm$ 4.9	+88
<i>A. odorata</i>	10	92.5 $\pm$ 3.2	+18
<i>A. siamensis</i>	10	92.4 $\pm$ 2.2	+18