

Chemical Composition and Insecticidal Activities of Essential Oils against the Pulse Beetle

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Supplementary material

Sr. No.	Name	RI ^a	RI ^b	Area%	Mode of Identification
1	α -pinene	939	939	0.65	MS, RI
2	Sabinene	976	976	0.33	MS, RI
3	β -pinene	980	982	1.03	MS, RI
4	β -phellandrene	1031	1028	0.46	MS, RI
5	Limonene	1031	1033	2.43	MS, RI
6	1,8-cineole	1033	1037	6.31	MS, RI
7	γ -terpinene	1062	1061	0.17	MS, RI
8	<i>cis</i> -sabinene hydrate	1068	1073	0.24	MS, RI
9	Menthone	1154	1161	29.54	MS, RI
10	Menthofuran	1164	1168	6.49	MS, RI
11	Menthol	1173	1173	0.63	MS, RI
12	<i>neo</i> -isomenthol	1188	1184	38.64	MS, RI
13	α -terpineol	1189	1196	0.40	MS, RI
14	Carvone	1242	1240	0.66	MS, RI
15	Piperitone	1252	1256	0.37	MS, RI
16	<i>neo</i> -menthyl acetate	1275	1273	0.23	MS, RI
17	Menthyl acetate	1294	1290	7.55	MS, RI
18	Isomenthyl acetate	1306	1304	0.11	MS, RI
19	β -caryophyllene	1418	1421	2.06	MS, RI
20	β -farnesene	1443	1439	0.33	MS, RI
21	Germacrene-D	1480	1482	0.10	MS, RI
22	β -himachalene	1499	1500	0.44	MS, RI
23	Caryophyllene oxide	1581	1583	0.41	MS, RI
24	-	-	1914	0.18	MS, RI
25	-	-	1924	0.2	MS, RI
Total				100.0	
Monoterpene hydrocarbons*				5.07	
Oxygenated monoterpene*				83.28	
Sesquiterpene hydrocarbons*				2.93	
Oxygenated sesquiterpene*				0.41	

^aRetention index value of compounds in the literature (Adams 2007).

^bRetention index value determined relative to *n*-alkanes (C9-C24) on the DB-5 GC column.

*Percentage of compounds class in analyzed essential oil samples.

MI=Mode of Identification

Table S1. The chemical composition of essential oil of *Mentha piperita*

Sr. No.	Name	RI ^a	RI ^b	Area%	Mode of Identification
1	α -pinene	939	939	1.01	MS, RI
2	Sabinene	976	976	0.53	MS, RI
3	β -pinene	980	982	0.93	MS, RI
4	β -myrcene	991	990	1.83	MS, RI
5	β -phellandrene	1031	1028	0.33	MS, RI
6	Limonene	1031	1034	21.30	MS, RI
7	1,8-cineole	1033	1037	2.29	MS, RI
8	γ -terpinene	1062	1061	0.23	MS, RI
9	<i>cis</i> -sabinene hydrate	1068	1074	0.29	MS, RI
10	Menthone	1154	1158	0.52	MS, RI
11	4-terpineol	1177	1182	0.76	MS, RI
12	α -terpineol	1189	1195	0.22	MS, RI
13	<i>cis</i> -dihydrocarvone	1193	1197	1.40	MS, RI
14	<i>trans</i> -dihydrocarvone	1200	1204	0.21	MS, RI
15	Carvone	1242	1251	63.38	MS, RI
16	Piperitone	1252	1257	0.33	MS, RI
17	<i>iso</i> -dihydro carvyl acetate	1325	1324	0.22	MS, RI
18	<i>cis</i> -carvyl acetate	1362	1359	0.22	MS, RI
19	β -bourbonene	1384	1385	1.25	MS, RI
20	β -caryophyllene	1418	1421	0.98	MS, RI
21	β -farnesene	1443	1435	0.17	MS, RI
22	α -humulene	1454	1452	0.52	MS, RI
23	Germacrene-D	1480	1482	0.56	MS, RI
24	-	-	1914	0.22	MS, RI
25	-	-	1924	0.30	MS, RI
	Total			99.48	
	Monoterpene hydrocarbons*			26.16	
	Oxygenated monoterpene*			69.40	
	Sesquiterpene hydrocarbons*			3.48	
	Oxygenated sesquiterpene*			0	

^aRetention index value of compounds in the literature (Adams 2007).

^bRetention index value determined relative to *n*-alkanes (C9-C24) on the DB-5 GC column.

*Percentage of compounds class in analyzed essential oil samples.

MI=Mode of Identification

Table S2. The chemical composition of essential oil of *Mentha spicata*

Sr. No.	Name	RI ^a	RI ^b	Area%	Mode of Identification
1	Limonene	1031	1033	3.60	MS, RI
2	β -ocimene	1040	1040	40.57	MS, RI
3	Dihydrotagetone	1054	1055	28.74	MS, RI
4	Z-ocimene	1128	1130	1.11	MS, RI
5	E-tagetone	1146	1147	0.71	MS, RI
6	Z-tagetone	1153	1155	11.63	MS, RI
7	Z-ocimenone	1231	1233	3.42	MS, RI
8	E-ocimenone	1239	1241	8.72	MS, RI
9	β -caryophyllene	1418	1422	0.73	MS, RI
10	Bicyclogermacrene	1494	1497	0.76	MS, RI
	Total			100.0	
	Monoterpene hydrocarbons*			45.28	
	Oxygenated monoterpene*			53.22	
	Sesquiterpene hydrocarbons*			1.49	
	Oxygenated sesquiterpene*			0.00	

^aRetention index value of compounds in the literature (Adams 2007).

^bRetention index value determined relative to *n*-alkanes (C9-C24) on the DB-5 GC column.

*Percentage of compounds class in analyzed essential oil samples.

MI=Mode of Identification

Table S3. The chemical composition of essential oil of *Tagetes minuta*

Conc. ($\mu\text{L/mL}$)	% Repellency; Hours after treatment (*Mean \pm SD)			
	<i>Mentha piperita</i>			
	1 h	2 h	3 h	4 h
8	92 \pm 4.89a	88 \pm 4.89a	92 \pm 4.89a	92 \pm 4.89a
6	72 \pm 10.19b	72 \pm 10.19b	68 \pm 10.19b	68 \pm 10.19a
4	44 \pm 7.48c	36 \pm 11.66c	28 \pm 20.59c	24 \pm 23.15b
2	32 \pm 13.56c	28 \pm 8.00c	16 \pm 4.00c	16 \pm 9.79b
1	12 \pm 8.00c	12 \pm 8.00c	12 \pm 4.89c	8 \pm 4.89b
	F _{4,24} =11.72; p<0.0001	F _{4,24} =12.79; p<0.0001	F _{4,24} =10.43; p<0.0001	F _{4,24} =8.50; p<0.0001
	<i>Mentha spicata</i>			
8	76 \pm 7.48a	80 \pm 8.94a	80 \pm 8.94a	84 \pm 9.79a
6	60 \pm 6.32ab	64 \pm 4.00b	64 \pm 4.00ab	72 \pm 4.89b
4	44 \pm 9.79bc	40 \pm 6.32c	40 \pm 6.32b	40 \pm 14.14c
2	40 \pm 10.95c	36 \pm 7.48cd	36 \pm 9.79c	32 \pm 12.00c
1	16 \pm 4.00c	12 \pm 4.89d	8 \pm 4.89c	8 \pm 4.89c
	F _{4,24} =7.73; p<0.001	F _{4,24} =16.03; p<0.0001	F _{4,24} =14.93 p<0.0001	F _{4,24} =9.70; p<0.001
	<i>Tagetes minuta</i>			
8	76 \pm 7.48a	84 \pm 11.66a	96 \pm 4.00a	96 \pm 4.00a
6	64 \pm 4.00ab	60 \pm 14.14ab	60 \pm 8.94b	60 \pm 11.66b
4	56 \pm 9.79ab	52 \pm 17.43ab	36 \pm 11.66c	36 \pm 9.79c
2	44 \pm 11.66b	36 \pm 7.48b	28 \pm 4.89c	28 \pm 4.89c
1	36 \pm 7.48b	26 \pm 7.60b	16 \pm 4.00c	16 \pm 4.89c
	F _{4,24} =3.49; p<0.026	F _{4,24} =3.29; p<0.032	F _{4,24} =18.44; p<0.0001	F _{4,24} =23.03; p<0.0001

*Mean of 5 replications; Means followed by the same letters within a column do not differ significantly by Tukey's HSD ($P \leq 0.05$).

Table S4. Repellency of essential oils against *Callosobruchus chinensis*

Conc. ($\mu\text{L/mL}$)	% Repellency; Hours after treatment (*Mean \pm SD)			
	1 h	2 h	3 h	4 h
	<i>Mentha spicata</i>			
8	76 \pm 11.66a	76 \pm 7.48a	52 \pm 4.89a	48.00 \pm 4.90a
6	52 \pm 10.19ab	56 \pm 4.00b	24 \pm 7.48b	24.00 \pm 7.48b
4	36 \pm 7.48bc	40 \pm 6.32c	16 \pm 4.00b	12.00 \pm 4.90b
2	24 \pm 9.79c	20 \pm 8.94c	12 \pm 4.89b	8.00 \pm 4.90b
1	8 \pm 4.89c	16 \pm 7.48c	8 \pm 4.89b	4.00 \pm 4.00b
	F _{4,24} =8.21; p<0.0001	F _{4,24} =12.67; p<0.0001	F _{4,24} =10.72; p<0.0001	F _{4,24} =10.94; p<0.0001
	<i>Tagetes minuta</i>			
8	64 \pm 7.48a	76 \pm 7.48a	52 \pm 8.00	51 \pm 4.89a
6	52 \pm 13.56ab	40 \pm 8.94b	32 \pm 4.89	40 \pm 6.32ab
4	40 \pm 8.94b	32 \pm 10.19b	28 \pm 14.96	24 \pm 9.79b
2	24 \pm 11.66b	24 \pm 11.66b	24 \pm 7.48	20 \pm 6.32b
1	20 \pm 8.94b	20 \pm 8.94b	20 \pm 8.94	16 \pm 7.48b
	F _{4,24} =3.20; p<0.035	F _{4,24} =5.49; p<0.004	F _{4,24} =1.73; p>0.18	F _{4,24} =4.33; p<0.01
	<i>Mentha piperita</i>			
8	80.00 \pm 6.32a	72.00 \pm 4.90a	80.00 \pm 6.32a	76.00 \pm 7.48a
6	64.00 \pm 13.27ab	60.00 \pm 6.32ab	56.00 \pm 7.48ab	64.00 \pm 11.66ab
4	64.00 \pm 7.48ab	40.00 \pm 6.32bc	48.00 \pm 4.90bc	52.00 \pm 10.20ab
2	36.00 \pm 7.48c	32.00 \pm 10.20bc	40.00 \pm 10.95c	36.00 \pm 7.48bc
1	24.00 \pm 4.00c	20.00 \pm 8.94c	16.00 \pm 7.48c	12.00 \pm 4.90c
	F _{4,24} =7.63; p<0.001	F _{4,24} =7.69; p<0.001	F _{4,24} =9.19; p<0.0001	F _{4,24} =8.30; p<0.0001

*Mean of 5 replications; Means followed by the same letters within a column do not differ significantly by Tukey's HSD ($P \leq 0.05$).

Table S5. Repellency of essential oils against *Callosobruchus maculatus*

Conc. ($\mu\text{L/mL}$)	% Inhibition; Hours after treatment (*Mean \pm SD)		
	24 h	48 h	72 h
	<i>Mentha piperita</i>		
20	100.00 \pm 0.00a	96.00 \pm 1.30a	90.80 \pm 1.50 a
10	85.40 \pm 2.54b	79.20 \pm 1.80b	77.00 \pm 1.48b
5	76.60 \pm 3.41b	72.00 \pm 1.84b	75.00 \pm 2.51b
2.5	52.80 \pm 3.60c	56.00 \pm 3.48c	60.20 \pm 3.31c
1.25	26.00 \pm 5.47d	34.20 \pm 2.75d	39.40 \pm 3.23d
	F _{4, 24} =88.50; P<0.0001	F _{4, 24} =98.76; P<0.0001	F _{4, 24} =59.41; P<0.0001
	<i>Mentha spicata</i>		
10	100.00 \pm 0.00a	95.40 \pm 1.40a	92.00 \pm 1.14a
8	98.00 \pm 2.00a	87.60 \pm 2.38ab	82.20 \pm 1.59ab
6	79.40 \pm 3.01b	76.20 \pm 5.11bc	67.40 \pm 8.13b
4	63.80 \pm 5.23c	62.60 \pm 3.26c	65.60 \pm 5.09b
2	38.40 \pm 4.58d	24.00 \pm 5.52d	20.60 \pm 4.02c
	F _{4, 24} =53.66; P<0.0001	F _{4, 24} =52.73; P<0.0001	F _{4, 24} =33.49; P<0.0001
	<i>Tagetes minuta</i>		
10	100.00 \pm 0.00a	100.00 \pm 0.00a	99.40 \pm 0.60a
8	100.00 \pm 0.00a	93.60 \pm 2.58a	93.20 \pm 1.28a
6	85.80 \pm 5.31ab	77.80 \pm 4.02b	79.40 \pm 2.46b
4	52.80 \pm 15.82bc	46.20 \pm 5.54c	51.40 \pm 2.73c
2	30.40 \pm 5.27c	36.00 \pm 2.35c	36.40 \pm 2.25d
	F _{4, 24} =15.68; P<0.0001	F _{4, 24} =68.66; P<0.0001	F _{4, 24} =178.98; P<0.0001

*Mean of 5 replications; Means followed by the same letters within a column do not differ significantly by Tukey's HSD ($P \leq 0.05$).

Table S6. Ovipositional inhibition of essential oils against *Callosobruchus chinensis*

Conc. ($\mu\text{L/mL}$)	% Inhibition; Hours after treatment (*Mean \pm SD)		
	24 h	48 h	72 h
	<i>Mentha piperita</i>		
12	100.00 \pm 0.00a	94.66 \pm 3.44a	77.60 \pm 2.51a
8	86.36 \pm 2.25a	87.26 \pm 1.59a	75.78 \pm 2.74a
4	62.54 \pm 4.06b	66.64 \pm 5.25b	58.26 \pm 6.46b
2	41.28 \pm 3.90b	44.58 \pm 2.41c	52.04 \pm 2.21b
1	15.28 \pm 5.28c	23.5 \pm 3.56d	28.24 \pm 0.69c
	$F_{4, 24}=89.86$; $P<0.0001$	$F_{4, 24}=72.46$; $P<0.0001$	$F_{4, 24}=33.26$; $P<0.0001$
	<i>Mentha spicata</i>		
12	94.26 \pm 3.66a	91.06 \pm 1.89a	75.12 \pm 3.32a
8	67.42 \pm 4.46b	71.88 \pm 3.85b	50.66 \pm 4.55b
4	52.6 \pm 1.68b	50.78 \pm 2.95c	35.78 \pm 2.71c
2	29.02 \pm 6.11c	27.91 \pm 5.66d	21.90 \pm 4.93d
1	18.44 \pm 4.77c	9.91 \pm 2.71e	8.24 \pm 2.12e
	$F_{4, 24}=47.75$; $P<0.0001$	$F_{4, 24}=80.04$; $P<0.0001$	$F_{4, 24}=49.54$; $P<0.0001$
	<i>Tagetes minuta</i>		
12	44.96 \pm 4.01	37.24 \pm 5.16a	35.68 \pm 4.09a
8	43.60 \pm 5.63	35.72 \pm 5.87ab	30.64 \pm 6.91ab
4	39.88 \pm 3.90	22.82 \pm 3.09bc	19.84 \pm 3.51ab
2	33.88 \pm 3.36	18.29 \pm 4.75c	17.14 \pm 1.97c
1	28.12 \pm 6.30	16.68 \pm 2.44c	14.15 \pm 2.24c
	$F_{4, 24}=2.17$; $P>0.1$	$F_{4, 24}=4.75$; $P<0.007$	$F_{4, 24}=4.96$; $P<0.006$

*Mean of 5 replications; Means followed by the same letters within a column do not differ significantly by Tukey's HSD ($P \leq 0.05$).

Table S7. Ovipositional inhibition of essential oils against *Callosobruchus maculatus*