

Research Article



복숭아혹진딧물 방제용 식물추출물 탐색 및 살충성분 구명

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¹LG (), ² ,

Screening of Plant Extracts and Identification of their Insecticidal Metabolites against *Myzus persicae*

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Abstract

BACKGROUND: Green peach aphid (*Myzus persicae*) is an insect pest that significantly affects crop production. A number of pesticides have been used for aphid control, but their concerns on insect resistance and food safety have required alternative methods for pest management. In an effort to find for an alternative approach to aphid control, we screened plants extracts and examined their potentiality as insecticidal bio-resources.

METHODS AND RESULTS: Two hundred and ninety eight plant extracts were examined for insecticidal activity against the aphid, and the best candidate among them was chosen for further study. The extracts from *Cinnamomum camphora* was determined to be the best candidate exhibiting insecticidal activity more than 60% at a level of 1,000 µg/mL. GC/MS analyses detected camphor, borneol, 4-terpineol, α-terpineol and caryophyllene oxide as major compositions from the extracts obtained by hydrodistillation. Caryophyllene oxide exhibited the highest insecticidal activity with a LC₅₀ value of 237 µg/mL. Camphor lowered significantly the LC₅₀ value of caryophyllene oxide and

increased largely its concentration in aphid, suggesting that camphor played a role in enhancing the insecticidal activity of caryophyllene oxide.

CONCLUSION: This study suggested that camphor and caryophyllene oxide may be used as an insecticidal bio-resource for insect control against green peach aphid.

Key words: Aphid, Biopesticide, Camphor, *Cinnamomum camphora*

서 론

가 ,
 OECD 가 ,
 . 1990 3
 5
 2017 4 5
 . 2000
 26,807 M/T 2013 19,061 M/T
 가 (Kim et al., 2016).

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가 .

(Positive List

Table 1. Continued

No.	Scientific name	Activity ¹⁾	No.	Scientific name	Activity ¹⁾	No.	Scientific name	Activity ¹⁾
49	<i>Capparis acutifolia</i>	-	66	<i>Chaenomeles speciosa</i>	-	83	<i>Cratoxylum ligustrinum</i>	-
50	<i>Carallia lucida</i>	-	67	<i>Cinnamomum camphora</i>	++	84	<i>Cryptolepis buchananii</i>	-
51	<i>Cardiospermum halicacabum</i> L.	-	68	<i>Cinnamomum glanduliferum</i>	+	85	<i>Cudrania pubescens</i>	-
52	<i>Careya sphaerica</i>	-	69	<i>Cinnamomum tamala</i>	+	86	<i>Dalbergia cochinchinensis</i>	-
53	<i>Carpinus poilanei</i>	-	70	<i>Cissus assamica</i>	-	87	<i>Dasymaschalon glaucum</i>	+
54	<i>Caryota mitis</i>	-	71	<i>Citrus medica</i> L.	-	88	<i>Dasymaschalon rostratum</i>	-
55	<i>Casearia kurzii</i>	-	72	<i>Clianthus scandens</i>	-	89	<i>Davallia formosana</i>	-
56	<i>Cassia auriculata</i> L.	-	73	<i>Cnestis palala</i>	-	90	<i>Debregeasia edulis</i>	-
57	<i>Cassia mimosoides</i> L.	-	74	<i>Cnestis ramiflora</i>	+	91	<i>Dehaasia cuneata</i> var. <i>longifolia</i>	+
58	<i>Cassia tora</i> L.	-	75	<i>Colocasia gigantea</i>	-	92	<i>Dendrotrophe umbellata</i>	+
59	<i>Castanopsise chidnocarpa</i>	++	76	<i>Combretum deciduum</i>	-	93	<i>Derris caudatilimba</i>	+
60	<i>Casuarina equisetifolia</i> L.	-	77	<i>Connarus paniculatus</i>	-	94	<i>Derris ferruginea</i>	-
61	<i>Catunaregam tomentosa</i>	-	78	<i>Corchorus olitorius</i> L.	-	95	<i>Desmos pedunculatus</i>	-
62	<i>Ceanothus asiaticus</i> L.	-	79	<i>Cordia wallichii</i>	-	96	<i>Dillenia ovata</i>	-
63	<i>Cedrela fissilis</i>	-	80	<i>Craniotome furcata</i>	-	97	<i>Diospyros ehretioides</i>	++
64	<i>Celastrus paniculatus</i>	-	81	<i>Crateva nurvala</i>	-	98	<i>Diospyros hayatae</i>	-
65	<i>Celtis philippinensis</i>	-	82	<i>Cratoxylum formosum</i>	-	99	<i>Diospyros rhodocalyx</i>	-
100	<i>Diplectria barbata</i>	-	117	<i>Ficus variolosa</i>	-	134	<i>Glochidion sphaerogynum</i>	-
101	<i>Dipterocarpus obtusifolius</i>	-	118	<i>Fortunella polyandra</i>	-	135	<i>Glycosmis parviflora</i>	-
102	<i>Elaeagnus delavayi</i>	-	119	<i>Garcinia hanburyi</i>	+	136	<i>Gomphia serrata</i>	-
103	<i>Elaeocarpus braceanus</i>	-	120	<i>Garcinia multiflora</i>	-	137	<i>Gomphostemma javanicum</i>	+
104	<i>Elaeocarpus floribundus</i>	-	121	<i>Garcinia paucinervis</i>	-	138	<i>Gordonia longicarpa</i>	-
105	<i>Elaeocarpus hainanensis</i>	-	122	<i>Garcinia pedunculata</i>	+	139	<i>Grewia astropetala</i>	-
106	<i>Elaeocarpus sylvestris</i>	-	123	<i>Garcinia subelliptica</i>	-	140	<i>Hedyotis tenelliflora</i>	-
107	<i>Engelhardia serrata</i> var. <i>cambodica</i>	-	124	<i>Gardenia cambodiana</i>	-	141	<i>Helicia formosana</i>	-
108	<i>Eriobotrya bengalensis</i>	-	125	<i>Gardenia philastreii</i>	-	142	<i>Helicia pyrrobotrya</i>	-
109	<i>Erythrina indica</i>	-	126	<i>Gelsemium elegans</i>	-	143	<i>Heteropanax fragrans</i>	-
110	<i>Erythralum scandens</i>	-	127	<i>Getonia floribunda</i>	-	144	<i>Hibiscus congestiflorus</i>	-
111	<i>Euodia leptota</i>	-	128	<i>Getonia floribunda</i> Roxb.	-	145	<i>Hibiscus mesnyi</i>	-
112	<i>Eurya japonica</i> var. <i>harmandii</i>	-	129	<i>Ginkgo biloba</i>	+	146	<i>Holarrhena pubescens</i>	-
113	<i>Fagraea fragrans</i>	-	130	<i>Glochidion balansae</i>	-	147	<i>Homalium hainanense</i>	-
114	<i>Ficus stricta</i>	-	131	<i>Glochidion eriocarpum</i>	-	148	<i>Hopea hainanensis</i>	-
115	<i>Ficus superba</i> var. <i>japonica</i>	-	132	<i>Glochidion falcatilimum</i>	-	149	<i>Hydnocarpus clemensorum</i>	-
116	<i>Ficus tinctoria</i> subsp. <i>gibbosa</i>	-	133	<i>Glochidion lanceolarium</i>	-	150	<i>Hygrophila salicifolia</i>	-
151	<i>Hymenopyramis brachiata</i>	-	168	<i>Lithocarpus fohaiensis</i>	-	185	<i>Meibomia godefroyana</i>	-
152	<i>Indosinia involucrata</i>	-	169	<i>Lithocarpus gigantophyllus</i>	-	186	<i>Melastoma normale</i>	-
153	<i>Inula helenium</i> L.	++	170	<i>Lithocarpus lepidocarpus</i>	-	187	<i>Melia azedarach</i> L.	-
154	<i>Irvingia malayana</i>	-	171	<i>Lithocarpus polystachyus</i>	-	188	<i>Melodorum hahnii</i>	-

¹⁾ Insecticidal activity: -, < 20%; +, 20~40%; ++, 40~60%; +++, > 60%.

Table 1. Continued

No.	Scientific name	Activity ¹⁾	No.	Scientific name	Activity ¹⁾	No.	Scientific name	Activity ¹⁾
155	<i>Ixora coccinea</i> L.	-	172	<i>Litsea cubeba</i>	-	189	<i>Memecylon chevalieri</i>	-
156	<i>Jasminum pierreanum</i>	+	173	<i>Litsea monopetalata</i>	-	190	<i>Memecylon fruticosum</i>	-
157	<i>Keteleeria evelyniana</i>	-	174	<i>Macaranga denticulata</i>	-	191	<i>Mespilus bengalensis</i>	-
158	<i>Knema erratica</i>	-	175	<i>Macaranga kurzii</i>	-	192	<i>Michelia yunnanensis</i>	-
159	<i>Lagerstroemia speciosa</i>	+	176	<i>Macaranga trichocarpa</i>	-	193	<i>Microcos paniculata</i> L.	-
160	<i>Lansium domesticum</i>	-	177	<i>Machilus bombycina</i>	-	194	<i>Micromelum hirsutum</i>	-
161	<i>Lasianthus hoaensis</i>	-	178	<i>Machilus robusta</i>	-	195	<i>Miliusa velutina</i>	-
162	<i>Lasianthus japonicus</i>	-	179	<i>Machilus thunbergii</i> var. <i>condorensis</i>	-	196	<i>Millettia leptobotrya</i>	-
163	<i>Laurocerasus javanica</i>	-	180	<i>Maesa elongata</i>	-	197	<i>Mollugo pentaphylla</i> L.	-
164	<i>Laurocerasus undulata</i> .	-	181	<i>Maesa membranacea</i>	-	198	<i>Momordica subangulata</i>	-
165	<i>Lindera spicata</i>	-	182	<i>Mallotus apelta</i>	-	199	<i>Myxopyrum</i> <i>smilacifolium</i>	-
166	<i>Liquidambar formosana</i>	+	183	<i>Mallotus contubernalis</i>	-	200	<i>Neolitsea elaeocarpa</i>	-
167	<i>Lithocarpus annamensis</i>	-	184	<i>Manilkara zapota</i>	-	201	<i>Nicotiana tabacum</i> L.	+
202	<i>Nothaphoebe umbelliflora</i>	-	220	<i>Polygala oligosperma</i>	++	238	<i>Rothmannia wittii</i>	-
203	<i>Ochna integerrima</i>	+	221	<i>Polyosma dolichocarpa</i>	-	239	<i>Rourea minor</i>	-
204	<i>Olox obtusa</i>	-	222	<i>Prunus arborea</i>	-	240	<i>Rubus involucratus</i>	-
205	<i>Oldenlandia capitellata</i>	-	223	<i>Prunus fordiana</i>	-	241	<i>Rubus obcordatus</i>	-
206	<i>Ophiorrhiza japonica</i>	-	224	<i>Prunus zippeliana</i>	-	242	<i>Salacia chinensis</i> L.	-
207	<i>Ormosia pinnata</i>	-	225	<i>Pseudodissochaeta</i> <i>septentrionalis</i>	-	243	<i>Salacia noronhioides</i>	-
208	<i>Paliurus ramosissimus</i>	-	226	<i>Psychotria bonii</i>	-	244	<i>Salacia verrucosa</i>	-
209	<i>Pandanus acaulescens</i>	-	227	<i>Psychotria yunnanensis</i>	-	245	<i>Sansevieria trifasciata</i>	-
210	<i>Parabarium quintaretii</i>	-	228	<i>Pteridrys cnemidaria</i> C.	-	246	<i>Sapium sebiferum</i>	+
211	<i>Parthenocissus pedata</i>	-	229	<i>Pterospermum</i> <i>megalocarpum</i>	-	247	<i>Saprosma verrucosum</i>	-
212	<i>Peltophorum dasyrachis</i>	-	230	<i>Punica granatum</i> L.	-	248	<i>Sarcocephalus cordatus</i>	-
213	<i>Perilla frutescens</i>	-	231	<i>Pyrrosia nummularifolia</i>	-	249	<i>Sauropus macranthus</i>	+
214	<i>Peristrophe baphica</i>	-	232	<i>Rhaphidophora lancifolia</i>	+	250	<i>Schefflera elliptica</i>	-
215	<i>Phoebe tavoyana</i>	+	233	<i>Rhododendron oxyphyllum</i>	-	251	<i>Schima crenata</i>	-
55	<i>Casearia kurzii</i>	-	72	<i>Clianthus scandens</i>	-	89	<i>Davallia formosana</i>	-
216	<i>Phyllanthus welwitschianus</i>	-	234	<i>Rhododendron spiciferum</i>	-	252	<i>Schima wallichii</i>	-
217	<i>Polyalthia cerasoides</i>	-	235	<i>Rhoeo discolor</i>	-	253	<i>Schismatoglottis cadieri</i>	-
218	<i>Polyalthia oligogyna</i>	+	236	<i>Ricinus communis</i> L.	-	254	<i>Shorea siamensis</i>	-
219	<i>Polyalthia simiarum</i>	-	237	<i>Rinorea longiracemosa</i>	-	255	<i>Shorea vulgaris</i>	+
256	<i>Sinoadina racemosa</i>	+	271	<i>Syzygium baviense</i>	-	286	<i>Trigonostemon reidioides</i>	-
257	<i>Smilax macrocarpa</i>	-	272	<i>Syzygium chloranthum</i>	-	287	<i>Uncaria macrophylla</i>	-
258	<i>Sphenodesme thorelii</i>	-	273	<i>Syzygium cumini</i>	-	288	<i>Uraria crinita</i>	-
259	<i>Stixis scandens</i>	+	274	<i>Syzygium fastigiatum</i>	-	289	<i>Urobotrya siamensis</i>	-
260	<i>Strobilanthes echinata</i>	-	275	<i>Syzygium mekongense</i>	-	290	<i>Urophyllum chinense</i>	-
261	<i>Strophanthus wallichii</i>	-	276	<i>Syzygium oblatum</i>	-	291	<i>Uvaria rufa</i>	-
262	<i>Styrax rugosus</i>	-	277	<i>Tabernaemontana</i> <i>yunnanensis</i>	-	292	<i>Vaccinium duclouxii</i>	-
263	<i>Styrax suberifolius</i> var. <i>caloneurus</i>	-	278	<i>Tamarix chinensis</i>	-	293	<i>Vaccinium iteophyllum</i>	-
264	<i>Symphorema involucreatum</i>	-	279	<i>Terminalia alata</i>	-	294	<i>Vitis planicaulis</i>	-

1) Insecticidal activity: -, < 20%; +, 20~40%; ++, 40~60%; +++, > 60%.

Table 1. Continued

No.	Scientific name	Activity ¹⁾	No.	Scientific name	Activity ¹⁾	No.	Scientific name	Activity ¹⁾
265	<i>Symplocos glomerata</i>	-	280	<i>Tetrameles nudiflora</i>	-	295	<i>Walsura robusta</i>	-
266	<i>Symplocos glomerata</i> subsp. <i>congesta</i> var. <i>poilanei</i>	-	281	<i>Tetrastigma cruciatum</i>	-	296	<i>Zanthoxylum rhetsa</i>	-
267	<i>Symplocos henschelii</i>	-	282	<i>Tetrastigma erubescens</i>	-	297	<i>Zingiber cochinchinense</i>	+
268	<i>Symplocos longifolia</i>	-	283	<i>Tetrastigma laevigatum</i>	-	298	<i>Zizyphus jujuba</i> var. <i>inermis</i>	-
269	<i>Symplocos racemosa</i>	-	284	<i>Thevetia peruviana</i>	+			
270	<i>Syzygium albiflorum</i>	-	285	<i>Tinospora crispa</i>	-			

10,000 µg/mL

가 (Feng & Isman, 1995). 살충효능 시험 (2007) Kim 가 (30×30 mm) 3 (30×30 mm) 2 12

60% 1,000 µg/mL 가 10

가 가 3 Abbott (1925)

살충활성 물질의 추출 및 분리

80% (v/v) ethanol (Liu *et al.*, 2012) (99 g) 4 40°C

재료 및 방법

공시 해충 (*Myzus persicae*) ethanol 24 2 (99 g) 2 L 6 *n*-hexane

25 ± 2°C, 16L : 8D, 65 ± 5% 가 clevenger-type 2 가

3 2 가

시약 및 용매 HPLC (Fisher Scientific, USA) *n*-hexane silica gel Keisegel 60 (230~400 mesh) Merck 20 g silica gel (230-400 mesh, Merck) (20 mm i.d., 50 cm length) Aldrich (USA) Sigma-EP *n*-hexane (Hex) ethyl acetate (EtOAc) Juicei Chemical Co., Japan EtOAc 가 2

천연식물 추출물 298 bed volume

살충활성 물질의 분석 (gas chromatography)

dimethyl sulfoxide:methanol (4:1, v/v)

mass spectrometer, GC/MS) . GC/
 MS Shimadzu QP2010 (Tohyo, Japan)
 DB-5 capillary (0.25 mm i.d.×30 m)
 injector 가 250°C, interface
 가 250°C, (electron impact, EI)
 70 eV . Column 40°C
 2 250°C 10°C
 가 1 mL/
 min split mode 20:1
 C₆-C₂₆ alkane
 (Libbey, 1991).
 Kovats index

활성물질의 살충작용

(NOEC, no observed effect concentration)
 NOEC

100

n-hexane

(100) *n*-hexane

tissue homogenizer

10

8,000 rpm

membrane

filter

GC/MS

GC/MS

(selective ion monitoring,

SIM mode)

결과 및 고찰

살충활성 식물추출물의 탐색 및 선발

298

Table 1

(*Castanopsise chidnocarpa*),

(*Diospyros ehretioides*), (*Polygala oligosperma*),

(*Amydrium hainanense*), (*Inula*

helenium L.) 40~60%

20%

(*Cinnamomum camphora*)

62.1% 가 40~60%

(Table 2).

Table 2. Aphid mortalities of the plant extracts as the best candidates selected from Table 1

Plant extract	Concentration (mg/L)	Mortality (%) ¹⁾
<i>Amydrium hainanense</i>	1,000	35.1±14.0 b ²⁾
<i>Castanopsise chidnocarpa</i>	1,000	56.7±37.5 b
<i>Cinnamomum camphora</i>	1,000	62.1±12.3 a
<i>Diospyros ehretioides</i>	1,000	48.5±16.8 b
<i>Inula helenium</i> L.	1,000	32.4±18.7 b
<i>Polygala oligosperma</i>	1,000	21.6±12.3 b

¹⁾ The data are means±SD of triplicate.

²⁾ Means with different superscripts within a column are significantly different at the 5% level by Duncan's multiple range test.

(Carmin spider mite, *Tetranychus cinnabarinus*)
 (Sertkaya et al., 2010)

(*Lasioderma serricorne*) (*Sitophilus oryzae* L.)
 (Kim

et al., 2003, Liu et al., 2010).

가

녹나무 추출물의 살충효능

가

(Fig. 1).

1,000 µg/mL 96.1% 250
 µg/mL 82.7%

56.1% 21.9%

275.1 µg/mL

0.3% 2

Zhang

(2016) (Lemongrass, *Cymbopogon citratus*)

(*Ligusticum chuanxiong*)

(*Aphis citricola*)

Munneke (2004) 가 (*Solanum melongena*)

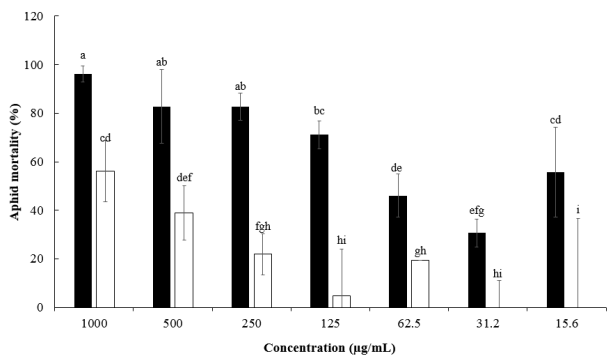


Figure 1. Aphid mortalities of the extracts of *Cinnamomum camphora* obtained by hydrodistillation () and solvent extraction methods (). Means with different superscripts within a column are significantly different at the 5% level by Duncan’s multiple range test.

Table 3. Chemical compositions of the extracts of *Cinnamomum camphora*

LRI ¹⁾	Composition	Identification ²⁾	Relative ratio (area %)
940	β-Pinene	RI MS	0.53
1032	Limonene	RI MS	0.69
1042	β-Ocimene	RI MS	0.38
1148	Camphor	RI MS Ref	74.97
1169	Borneol	RI MS Ref	1.53
1174	4-Terpineol	RI MS Ref	2.24
1192	α-Terpineol	RI MS Ref	4.08
1418	β-Caryophyllen	RI MS	8.93
1456	Humulene	RI MS	1.46
1481	Germacrene D	RI MS	0.90
1582	Caryophyllene oxid	RI MS Ref	4.29

¹⁾ LRI, linear retention indices on DB-5 column.

²⁾ Identification; RI, retention index; MS, mass spectrum; Ref, reference materials, retention time identical to authentic compounds.

(*Macrosiphum euphorbiae*)

녹나무 추출물의 살충활성물질 분석

GC/MS

. GC/MS 11

linear retention index (LRI)

Kovats index (Senatore *et al.*, 2005, Pistelli *et al.*, 2013)

Table 3

. GC/MS

1%

camphor가 74.79%, β-caryophyllen 8.93%, caryophyllene oxid 4.29%, α-terpineol 4.08%, 4-terpineol

Table 4. Aphid mortalities of the elution fraction from silica gel column chromatography

Fractions number	Elution solvent (v/v)	Concentration (mg /L)	Mortality (%) ¹⁾
Control	-	-	-2.86±8.5
Elution 1	HEX:EtOAc (10:0)	250	20.0±4.9 e
Elution 2	HEX:EtOAc (7:3)	250	91.4±8.5 a
Elution 3	HEX:EtOAc (5:5)	250	22.8±8.5 de
Elution 4	HEX:EtOAc (3:7)	250	31.4±0.0 cd
Elution 5	MeOH (10)	250	37.1±4.9 e

¹⁾ The data are means±SD of triplicate. Means with different superscripts within a column are significantly different at the 5% level by Duncan’s multiple range test.

Table 5. Chemical composition of the Elution 3 from Table 4

No	LRI ¹⁾	Composition	Retention time (min)	Ratio (area %)
1	1148	Camphor	17.9	60.4
2	1169	Borneol	18.3	5.7
3	1174	4-Terpineol	18.4	8.0
4	1192	α-Terpineol	18.5	11.0
5	1582	Caryophyllene oxide	24.3	14.9

¹⁾ LRI, linear retention indices on DB-5 column.

2.24%, borneol 1.53%, humulene 1.46%, camphor가 가, camphor 7가

silica gel

30% ethyl

acetate n-hexane

90%

40%

(Table 4).

90%

GC/MS

camphor가 60.4%, borneol 5.7%, 4-terpineol 8.0%, α-terpineol 11.0%, caryophyllene oxide가 14.9% Table 2

camphor가 가

(Table 5). 5가

5가

LC₅₀

24 borneol, 4-terpineol, α-terpineol, caryophyllene oxide 551, 915, 551, 237 µg/mL 48 498, 681, 484, 241 µg/mL (Table 6). caryophyllene

Table 6. LC₅₀ values of commercial metabolites of *Cinnamomum camphora*

Metabolite	LC ₅₀ values (µg/mL) ¹⁾			
	24 h		48 h	
	LC ₅₀	95% CL ²⁾	LC ₅₀	95% CL ²⁾
Camphor	> 1,000	-	> 1,000	-
Borneol	551	457-686	498	418-612
4-Terpineol	915	725-1277	681	475-1208
α-Terpineol	551	461-677	484	393-617
Caryophyllene oxide	237	170-344	241	171-348

¹⁾ The data are means±SD of triplicate.

²⁾ 95% confidence limit

Table 7. LC₅₀ values of commercial metabolite mixed with camphor at a level of no observed effect concentration

Metabolite	LC ₅₀ values (µg/mL) ¹⁾			
	24 h		48 h	
	LC ₅₀	Synergism ratio ²⁾	LC ₅₀	Synergism ratio ²⁾
Borneol	440	1.25	556	0.89
4-Terpineol	717	1.27	796	0.85
α-Terpineol	523	1.05	492	0.98
Caryophyllene oxide	162	1.46	112	2.15

¹⁾ The data are means±SD of triplicate.

²⁾ The LC₅₀ values of single treatments in Table 6 were divided by the LC₅₀ value of each metabolite mixture with camphor.

oxide 2~3
 . Caryophyllene oxide bicyclic sesquiterpene sodium
 channel modulator
 (*sitophilu zeamais*) (*tribolium castaneum*)
 (Bettarini et al, 1993).
 caryophyllene oxide
 , camphor
 70% silica
 gel (Table 5) LC₅₀ 1,000 µg/mL (Table 7).
 caryophyllene oxide
 가 camphor camphor
 camphor
 LC₅₀ 24
 borneol, 4-terpineol, α-terpineol, caryophyllene
 oxide LC₅₀ 440, 717, 523, 162 µg/mL
 (Table 7). LC₅₀ camphor
 LC₅₀ (Table 6)
 0.89, 0.85, 0.98, 2.15 (Table 7).
 Caryophyllene oxide camphor
 LC₅₀ 2
 camphor가
 . Tak(2015)

caryophyllene oxide
 Wu (2017) (Thyme)
 thymol terpinene, linalool
 (*Tetranychus cinnabarinus*)
 . Regnault-
 Roger (1997) α-terpinene terpinen-4-ol
 (*Spodoptera litura*)
 . Camphor
 caryophyllen oxide가
 Camphor의 협력작용
 camphor가 caryophyllen
 oxide 가
 (Tak & Isman, 2015). camphor
 가 caryophyllene oxide
 caryophyllene oxide
 . Camphor 500 µg/mL
 camphor
 . Caryophyllene oxide 125 µg/mL 62.5 µg/mL
 caryophyllene oxide
 495 ng/adult 392 ng/adult
 . caryophyllene oxide 500 µg/mL
 camphor
 caryophyllene oxide
 1.2~1.7 868 ng/adult 477 ng/adult
 . camphor
 caryophyllene oxide 575 ng/adult
 377 ng/adult camphor
 caryophyllene oxide가
 . Tak(2015)

Table 8. Concentration of camphor and caryophyllen oxide found in aphid extracts

Treatment	Concentration (µg/mL)	Concentration (ng/adult)	
		Camphor	Caryophyllene oxide
Control	-	ND ¹⁾	ND ¹⁾
Camphor	500	ND ¹⁾	-
Caryophyllene oxide	125	-	495±83
	62.5	-	392±68
Camphor+ Caryophyllene oxide	125	575±38	868±106
	62.5	377±3.6	477±85

¹⁾ Not detected.

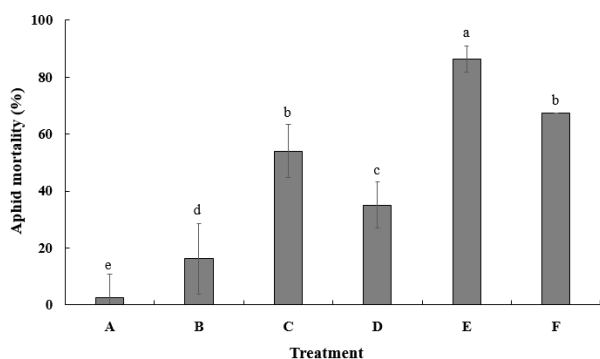


Figure 2. Aphid mortalities of control (A), camphor at 500 µg/mL (B), caryophyllene oxide at 125 µg/mL (C), caryophyllene oxide 62.5 µg/mL (D), the mixture of caryophyllene oxide (125 µg/mL) and camphor (500 µg/mL) (E), the mixture of caryophyllene oxide (62.5 µg/mL) and camphor (500 µg/mL) (F). Means with different superscripts within a column are significantly different at the 5% level by Duncan’s multiple range test.

1,8-cineole camphor

(Table 8).

가

, camphor caryophyllene oxide

Fig. 2

. Caryophyllene oxide 125 µg/mL 62.5 µg/mL

caryophyllene oxide

500 µg/mL camphor

1.8~2.0 가

Table

6 Table 7

가

camphor caryophyllene oxide

camphor caryophyllene oxide

가

Note

The authors declare no conflict of interest.

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