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Toxicity activity of herbal essential oils against german cockroaches (*Blattella germanica* L.: Blattellidae)

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Abstract The herbal essential oils from *Cymbopogon citratus* (DC.) Stapf, *Cymbopogon nardus* L., *Eucalyptus citriodora* Hook., *Foeniculum valgare* Mill., *Mentha piperita* L., *Ocimum basilicum* L. and *Zingiber officinalle* Rosc. were tested for their toxicity against german cockroach (*Blattella germanica* L.) and compared them with chemical insecticide (cyperymethrin : Kumakai 10®). The knockdown was recorded at 10, 20, 30 and 60 minutes and mortality was also recorded at 24 hours. *M. piperita* oil had high toxicity against *B. germanica* with KT_{50} values of 39.11 minutes and LT_{50} values of 4.17 hrs, respectively. However, toxicity indicated the order of KT_{50} and LT_{50} against *B. germanica* in seven herbal essential oils as *M. piperita* oil > *C. citratus* oil > *F. valgare* oil > *E. citriodora* oil > *Z. officinalle* oil > *O. basilicum* oil > *C. nardus* oil. Unfortuately, the knockdown rate and mortality rate against *B. germanica* of all herbal essential oil was lower than cyperymethrin.

Keywords: Toxicity, *Blattella germanica*, herbal essential oil

Introduction

German cockroach (*Blattella germanica* (L.): Blatellidae: Blattodea), is an important household insect pest in Thailand and worldwide. It's always associated with indoor environments such as bathrooms, kitchens and food storage areas (Phillips, 2009; Nasirian *et al*., 2011). However, german cockroach also important insect vector, its generally transmit many pathogens such as viruses, fungi, bacteria, protozoa and helmithes that are harmful to human health (Tawatsin, 2006). Moreover, there is evidence that substances produced by german cockroach are involved in allergic symptoms (Arruda *et al*., 2001; Nasirian, 2010).

The major control of german cockroach are based on the chemical insecticides such as organophosphate and pyrethroids insecticides. Unfortunately,

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chemical insecticides are not safe for human, especially children, are not environmentally friendly and increasing resistance of german cockroach (Chang *et al*., 2012; Jung *et al*., 2007).

In addition, the natural products such as essential oil from plants utilized as cockroach insecticides limit the environmental impact of pesticides due to shorter latency, which may be beneficial for preventing the evotion of resistance and also have low toxicity to humans (Phillips, 2009).

The purpose of this study was to investigate the toxicity of herbal essential oils from *Cymbopogon citratus*, *Cymbopogon nardus*, *Eucalyptus citriodora*, *Foeniculum valgare*, *Mentha piperita*, *Ocimum basilicum* and *Zingiber officinalle* prepared as recommended by the Medicinal Plant Laboratory, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang (KMITL), of being used against adult of *Blattella germanica*.

Materials and methods

Test cockroaches

B. germanica eggs were obtained from the National Institute of Health, Department of Medical Sciences, Ministry of Public Health, Thailand. The cockroaches were reared in Entomology and Environment laboratory, Plant Production Technology Section, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang (KMITL). Nymphs and adult of *B. germanica* were fed on dog pellets in glass jars (22.5 cm diameter x 35 cm) at 32.50±1.25ºc , 64.50±3.50 %RH and 12h:12h light : dark cycle. *B. germanica* adult (aged 8 weeks) was employed for toxicity test under laboratory conditions.

Plant materials and herbal essential oils

The seven species of plants (*Cymbopogon citratus*, *Cymbopogon nardus*, *Eucalyptus citriodora*, *Foeniculum valgare*, *Mentha piperit*, *Ocimum basilicum* and *Zingiber officinalle*) were identified, authenticated and submitted at Plant Production Technology Section, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang (KMITL), Thailand. Each plant material was extracted for essential oils by water distillation. All essential oil was dissolved in ethyl alcohol and were kept at room temperature before testing.

Bioassay

The toxicity of herbal essential oils and cypermethrin were determined by fumigation method (Jung *et al*., 2007). Concentration of 0.24 µl/cm^2 of each herbal essential oils were applied to the filter paper (Whatman No.1, 5 cm in diameter). Each treated filter paper was placed on the bottom of a petri dish (5.5 diameter; 1.2 cm. high). After dying for 1 min., each petri dish was placed in the bottom of beaker (400 ml; PYREX®), and 10 adult of *B. germanica* (8 weeks) were separately in each beaker and covered with hygienic cling film for foods (Tops®) for 10 min. For negative control filter paper received 0.24 µl/cm^2 of ethyl alcohol and, for Positive control filter peper received 0.24 µl/cm^2 of cypermethrin. The knockdown rates were determined at 10, 20, 30 and 60 minutes and mortality also recorded 24 hrs after treated. *B. germanica* adult were considered to be knockdown if their bodies did not move, and if their bodies and appendages (antennae, legs) did not move when prodded with small soft brush (Chang *et al*., 2012). All treatments were replicated ten times.

Statistical analysis

The data were poled and analyzed by standard probit analysis to obtain a KT_{50} and LT_{50}. The knockdown and mortality data were statistically analyzed using one-way ANOVA and the data means were compared by Duncan's multiple range test. Statistical significance was set at $p<0.05$.

Results and discussions

The knockdown rates and KT_{50} values for the seven essential oils at 0.24 µl/cm^2 concentration against *B. germanica* as shown in Table 1. The essential oil derived from *M. piperita* oil was the highest efficient with a KT_{50} values of 39.11 minutes. In the cypermethrin (Positive control) had 100% knockdown at 20, 30 and 60 minutes. The KT_{50} values of 2.49 minutes. All herbal essential oils showed significant differences over Negative control ($P<0.05$). The seven essential oils gave KT_{50} values from 51.61 to 81.22 minutes (*E. citriodora* oil > *Z. officinale* oil > *F. vulgare* oil > *C. citratus* oil > *O. basilicum* oil > *C. nardus* oil).

The mortality rates and LT_{50} values for the herbal essential oils are shown in Table 2. *M. piperita* oil gave LT_{50} rates of 4.17 hrs and 83.00% mortality, respectively. In the cypermethrin (Positive control), the mortality rates of 91.00%, with LT_{50} at <1.00 hrs. All herbal essential oils showed significant difference over negative control ($P<0.05$).

Mentha piperita oil has been found to be toxic and mortality flying insect. Phillips and Appel, (2010) reports the main components of *M. piperita* contains (-)-Menthone was highly toxic to medium and small nymphs against German cockroach, with LC_{50} of 9.0 mg/liter air by fumigation, at 24 hours. Phillips *et al*. (2010) found the main components of *M. piperita* contains (-)-Menthone was the most toxic to adult male and female against German cockroaches, with LD_{50} values of 0.126 and 0.773 mg per cockroach, respectively; by Topical at 24 hours. However, Sinthusiri and Soonwera (2013) found *M. piperita* gave good KT_{50} and mortality rates of 5.36 minutes and 100% and LC_{50} of 2.62 minutes, respectively, against adult *Musca domestica*. Hanan (2013) reports the essential oil from *M. piperita* shown high toxic against *M. domestica* larvae, with LC_{50} and LC_{75} values of 2.5% (225ppm) and 3% (270ppm), respectively. Moreover, Manimaran *et al*. (2012) found *M. piperita* oil shown high knockdown rates against three adult mosquitoes species: *Culex quinquefasciatus*, *Aedes aegypti* and *Anopheles stephensi* with KT_{50} values of 30.64, 30.57 and 31.10 minutes, respectively.

Our findings show *M. piperita* has insecticidal properties against *B. germanica*, Some of the chemical compoments of these oils may interfere with the nervous systems in insects. The phytochemical constituents of *M. piperita* are appreciable such as menthol, menthone, isomenthone and limonene, respectively. (Freire *et al.*, 2012; Saharkhiz *et al*., 2012). These constituents have pro perties to act as antiseptic, antispasmodic, anesthetic, antifungal and insecticide (Mckay and Blumberg, 2006; Phasomkusolsil and Soonwera, 2012). Therefore, the product from plant-based compounds for anti-German cockroach has been developed for German cockroach treatment.

Table 1. KT_{50} values and knockdown rate of *B. germanica* to seven herbal essential oils in ethyl alcohol at 0.24 µl/cm^2

Herbal essential oils	**% knockdown / Time (min.)**				**KT_{50} (min)**
	10min	20min	30min	60 min	
C. citratus oil	0^{D}	0^{C}	$1.0±3.2^{E}$	$39.0±15.2^{BCD}$	64.00
C. nardus oil	$3.0±6.7^{CD}$	$8.0±19.3^{C}$	$8.0±19.3^{DE}$	$31.0±36.7^{CDE}$	81.22
E. citriodora oil	$6.0±10.7^{CD}$	$10.0±10.5^{C}$	$46.0±34.7^{BC}$	$52.0±32.6^{BC}$	51.63
F. valgare oil	$6.0±8.4^{CD}$	$10.0±14.1^{C}$	$32.0±34.3^{CD}$	$42.0±38.2^{BCD}$	63.66
M. piperita oil	$34±40.3^{B}$	$35.0±41.4^{B}$	$56.0±39.2^{B}$	$59.0±20.8^{B}$	39.11
O. basilicum oil	$5.0±8.5^{CD}$	$5.0±10.7^{C}$	$5.0±10.8^{E}$	$41.0±32.8^{BCD}$	69.58
Z. officinalle oil	$12.0±25.7^{BC}$	$21.0±35.1^{BC}$	$23.0±34.3^{CDE}$	$57.0±36.5^{B}$	54.24
Negative control (ethyl alcohol)	0^{D}	0^{C}	0^{E}	0^{E}	NA
Positive control (cypermethrin)	$92.0±17.5^{A}$	100^{A}	100^{A}	100^{A}	2.49

KT_{50} = 50% knockdown time: NA = not computed by Probit analysis.
Mean % knockdown in each column followed by the same letter are not significantly different (one-way ANOVA and Duncan's multiple range test).

Tabal 2. The toxicity of seven herbal essential oils against *B. germanica*

Herbal essential oils	% Mortality	LT_{50} (hrs)
C. citratus oil	74.00^{AB}	7.67
C. nardus oil	35.00^{E}	46.71
E. citriodora oil	67.00^{ABCD}	12.36
F. valgare oil	72.00^{BC}	8.45
M. piperita oil	83.00^{A}	4.17
O. basilicum oil	58.00^{CDE}	20.79
Z. officinalle oil	67.00^{ABCD}	13.02
Negative control (ethyl alcohol)	0^{F}	NA
Positive control (cypermethrin)	91.00^{A}	<1.00
CV.(%)	40.41	

LT_{50} = 50% lethal time: in each column followed by the same letter are not significantly different (one-way ANOVA and Duncan's multiple range test).

Conclusion

This present study reveals and points out the potential of herbal essential oils to be used as botanical insecticides aginst *B. germanica*.

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