EFFECT OF ESSENTIAL OILS EXTRACTED FROM *Chromolaena odorata* (L.) R. M. KING & H. ROB. AGAINST *Macrotermes carbonarius* (HAGEN, 1858) AND *Globertermes sulphurous* (HAVILAND, 1898)

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ABSTRACT

Chromolaena odorata was examined for insecticidal properties against termites *Macrotermes carbonarius* and *Globertermes sulphurous*, where *G. sulphureus* and *M. carbonarius* workers and soldier colonies were collected from selected areas of Kuala Lumpur, Selangor and Pahang, respectively. Extracted essential oils were tested on *Macrotermes carbonarius* and *Globertermes sulphurous* worker and soldier termites. The results of the preliminary bioassay were subjected with ANOVA and Probit analysis to determine values of LC_{50}. Results showed that the essential oil of stem and leaves of *Chromolaena odorata* displayed lethal effects on tested termites. Probit analysis showed that there was a significant increase in termite mortality, when treated with leave and stem of *C. odarata* oil. Meanwhile, *M. carbonarius* soldier was not showed any significant different in both stem and leave of *C. odorata* oil. In fumigant assays, LC_{50} value for *M. carbonarius* worker was 44.7 ppm after 24 hours of treatment while for worker *G. sulphureus* worker the LC_{50} was 1118.92 ppm. The soldiers of *M. carbonarius* were more susceptible than soldiers of *G. sulphureus*. The LC_{50} for soldier *M. carbonarius* was 778.4 ppm while the LC_{50} was 1568.1 ppm for soldier *G. sulphureus* at 24 hours. Analysis using Gas chromatography–Flame Ionization Detector (GCFID) and Gas chromatography–mass spectrometry (GCMS) revealed number of potential compounds responsible for the mortality of termites such as α-pinene, germacrene D and β-pinene etc. In general, the GCMS should be preferred for qualitative analysis (identification of molecules when in doubt), and the GCFID for quantitative analysis (determining the percentage of each compound in an essential oil). Both stems and leaves of *C. odonata* essential oil could be used as an alternative protectant for wood and wood products against termites.

Keywords: *Chromolaena odorata*, *Macrotermes carbonarius*, *Globitermes sulphureus*, essential oil, insecticide, natural pesticides, termites.

ABSTRAK

Chromolaena odorata telah dikenalpasti mempunyai bahan insektisid dalam membasmi anai-anai *Macrotermes carbonarius* dan *Globertermes sulphurous*, di mana koloni pekerja dan askar *G. sulphurous* dan *M. carbonarius* telah dikutip di sekitar kawasan Kuala Lumpur, Selangor and Pahang. Ekstrak minyak pati telah diuji ke atas pekerja dan askar anai-anai *Macrotermes carbonarius* dan *Globertermes sulphurous*. Hasil daripada bioasai awalan melalui analisis ANOVA dan Probit analysis bagi menentukan nilai LC_{50}. Hasil menunjukkan minyak pati pada batang dan daun *Chromolaena odorata* menunjukkan kesan kematian ke atas anai-anai yang diuji. Analisis Probit menunjukkan terdapat kesan peningkatan signifikan ke atas kematian anai-anai apabila dirawat dengan minyak batang dan daun *C. odarata*. Selain itu, askar *M. carbonarius* tidak menunjukkan perbezaan signifikan kepada minyak pati batang dan daun *C. odorata*. Dalam asai asapan, nilai LC_{50} untuk pekerja *M. carbonarius* adalah 44.7 ppm selepas 24 jam tindak balas sementara LC_{50} pekerja *G. sulphureus* adalah 1118.92 ppm. Pekerja *M. carbonarius* lebih rentan daripada askar *G. sulphureus*. Nilai LC_{50} untuk pekerja *M. Carbonarius* adalah 778.4 ppm sementara LC_{50} adalah 1568.1 ppm untuk askar *G. sulphureus* pada 24 jam. Analisis Kromatografi Gas – Pengesan Pengionan Api (GCFID) dan Kromatografi–Spektrometri Jisim (GCMS) telah menunjukkan bilangan sebatian yang berpotensi dalam kematian seperti as α-pinene, germacrene D and β-pinene dan lain-lain. Secara umumnya, GCMS lebih kepada analisis kualititatif (pengecaman molekul bila diragui) dan GCFID untuk analisis kuantitatif (menentukan peratusan dalam setiap sebatian dalam minyak pati). Kedua-duanya, minyak pati batang dan daun *C. odorata* boleh digunakan sebagai bahan alternatif dalam pengawalan pada kayu dalam membasmi anai-anai.

Kata Kunci: *Chromolaena odorata*, *Macrotermes carbonarius*, *Globitermes sulphureus*, minyak pati, insektisid, pestisid semulajadi, anai-anai

INTRODUCTION

Termites are serious economic threats to agriculture and urban structures in most subtropical and tropical countries including Malaysia (Kuswanto et al. 2015; Lee et al. 1999; Lee at al. 2003; Su & Scheffrahn 2000). A few termite species are present in rubber, oil palm and other crop plantations such as *Macrotermes gilvus*, *Globitermes sulphureus*, *Microtermes pakistanicus* and *Odontermes* sp. (Lee 2000; 2007; Lee & Sajap 2000). *Macrotermes carbonarius* has fascinated investigators by its mound architecture which are constructed and adapted to counteract the loss of heat as well as for their foraging (Korb 2003). The greatest problem with *M. carbonarius* is the ability to attack at wide range of crops at all stages of the growth cycle and the crop losses are estimated at between 3–100% (Debelo & Degaga 2015; Mitchell 2000). Termite control methods are still based on using synthetic chemicals which are not environmentally safe. The worldwide termites driven economic loss was estimated to be in the range of US $ 20 billion to US $ 40 billion (Rust & Su 2012), whereas in Southeast Asia only, it was valued around US $400 million per annum (Lee 2007). Prevention and treatment of termites relied heavily on the use of insecticides (Kuswanto et al. 2015) such as deltamethrin, bifenthrin, permethrin, chlorpyrifos, chlorfluazuron, hexaflumuron, triflumuron, imidacloprid, fipronil, and arsenic trioxide were some other example chemical that used in some termiticide products but also hazard to human being (Ewart & Cookson 2014). However, previous studies lacked empirical evidence on these two termite species against the essential oils (Moawad et al. 2012).

Essential plant oils, widely used as fragrances and flavours in the perfume and food industries, have long been reputed to repel insects (Isman 2000; 2016). Recent studies showed that some plant essential oils possess insect repellent, and fumigant insecticidal actions (Isman 2000;2006; Maia & Moore 2011; Zoubiri & Baaliouamer 2014; Oke et al. 2014; Jayakumar et al. 2017). Botanical insecticides have long been touted as attractive alternatives to synthetic chemical insecticides for pest management because they pose less threats to the environment and human health (El-Wakeil 2013; Isman 2006). Many essential plants oils have been recognized to have anti-termitic activities (Ahmed et al. 2011; Almeida et al. 2015; Chauhan & Raina 2006; Maistrello et al. 2001; Shahina et al. 2011; Pandey et al. 2014), which are obtained through steam distillation of herbs and medicinal plants (Pandey et al. 2014; Tan et al. 2015; Tum & Mainya 2016; Yatagai 1997).

Chromolaena odorata was classified under sunflower family Asteraceae, the largest angiosperm family, comprising 1528 genera and 22,750 species worldwide (Mabberley 1997; Vijayaraghavan et al. 2017). It is a perennial weed of plantation crops and cleared lands, which is one of the worst invading alien plant species in the humid and semi-humid tropics of the Old World (McFadyen & Skarratt 1996). Bakar (2004) reported that *C. odorata* was one of the invasive weed species in Malaysian agro-ecosystems. This plant was an important weed in rubber, oil palm, coconut and tobacco plantations in Malaysia (Azmi 2000; Muniappan et al. 2005). The Rubber Research Institute of Malaysia (FRIM) found *C. odorata* suppressed the growth of rubber trees compared with ground that was covered with small grasses or recommended legumes (Azmi 2000).

Chromolaena odorata root exudates have the potential to inhibit crop growth (Ambika & Jayachandra 1984; Ambika & Poornima 2004; Cheng & Cheng 2015; Devi & Dutta 2012). Allelochemicals produced from the debris of *C. odorata* during its decomposition will not accumulate in soil as persistent pollutants (Ambika & Poornima 2004). The aerial part of *C. odorata* released volatile inhibitors, which can cause inhibition on crop growth (Ambika & Jayachandra 1984). The *C. odorata* residues that were allowed to decompose in the soil will remains as a toxic medium and stay in the soil to inhibit crop growth for more than six months. After the interval times, crop growth was promoted by the decomposing medium (Ambika & Jayachandra 1984). These species are generally used as traditional remedy to treat various ailments such as fresh leaves and extract was used for burns, soft tissue wounds, dysentery, headache, toothache, stop bleeding and skin infections (Owoyele et al. 2005; Phan et al. 2001; Tanhan et al. 2007). In medicine, *C. odorata* leaf extracts with salt are used as a gargle for sore throats and colds. It is also used to scent aromatic baths (Phan et al. 2001). However, there have been limited attempts to study the toxicity of *C. odorata* essential oils on economically important pests in crop open field conditions. The objective of this study was to assess the potential of *C. odorata* essential oils as toxicity properties towards worker and soldier termites of *G. sulphureus* and *M. gilvus* and to determine the chemical constituents of this plant essential oil.

MATERIALS AND METHODS

Termite

Globitermes sulphureus and *M. carbonarius* workers and soldier colonies were collected from Kuala Lumpur, Selangor and Pahang. Termite identifications was done using number of keys (Tasanathai et al. 2019; Triplehorn & Johnson 2005) and later on confirmed by termite expert Prof. Dr. Ahmad Said Sajap (Faculty of Forestry, Universiti Putra Malaysia, Serdang, Malaysia) confirmed the taxonomic of termite species. Collected termite species was separated according to the worker and soldier and placed in the plastic container.

Plant Material and Essential oil of *C. odorata*
Chromolaena odorata was collected around Selangor and Kuala Lumpur, Malaysia. The plant was cut and separated to leaves and branches, wash and keep in the fridge for further experiment.

The 6300 g leaves of *C. odorata* was cut into small pieces and immediately soaked in distilled water in a round-bottomed flask. The sample was distilled in a Clevenger-type apparatus for 8 to 10 hours (Franz & Novak 2010). The yield of the oil (11.35 g, 10.52%) was calculated based on the weight of the fresh plant material.

Bioassay
Bioassay with oil C. odorata
Both soldier and worker termites of *Macrotermes carbonarius* and *Globitermes sulphureus* were collected and tested with *C. odorata* essential oil. Each acetone-sterilized glass petri dish was added with a filter paper and 10µl of leave *C. odorata* essential oil was applied to the No. 1 Whatman filter paper and let dry. Then, 10 individuals of *M. carbonarius* worker was placed in each petri dish with 10 replications per treatments. The behaviour and mortality of the termites was observed and recorded under standard condition (27°C and darkness). All tests were replicated using *M. carbonarius* soldier, *G. sulphureus* worker and *G. sulphureus* soldier. Stem *C. odorata* essential oil was also used to test *M. carbonarius* soldier, *G. sulphureus* worker and *G. sulphureus* soldier.

Bioassay with C. odorata essential oil
The same procedure was repeated using 10µl of 300 ppm of leaves *C. odorata* essential oil. Then, 10 individuals of *M. carbonarius* worker was placed in each petri dish with 10 replications per treatments. The behaviour and number of dead termites was observed and recorded under standard condition (27°C under darkness). All tests were replicated using *M. carbonarius* soldiers, *G. sulphureus* workers and *G. sulphureus* soldiers with 500 ppm and 1000 ppm oils.

Gas Chromatograph Flame Ionization Detector (GC-FID)
The oil was analysed on a Shimadzu GC Q2010 equipped with a FID detector using fused silica capillary column HP-5ms, 5% phenylethylsiloxane (30.0 m × 25 µm ID × 0.25 µm film thickness) with helium as carrier gas at a flow rate of 1 mL per minute. The column temperature was programmed initially at 60°C for 10 minutes, then increased 3°C per minute to 230°C and was kept isothermally for 1 minute.

Gas Chromatography Mass Spectrometry (GC-MS)
GC-MS analysis was performed on an Agilent Technologies 6890N GC System equipped with 5975 inert mass selective detector (70 eV direct inlet) on fused silica capillary column HP-5ms (30.0 m × 25 mm ID × 0.25 µm film thickness) initially set at 60°C for 10 minutes, then increased to 230°C at 3°C per minute and held for 1 minute at 230°C using helium as the carrier gas at a flow rate of 1 mL per minute. The total ion chromatogram obtained was auto integrated by ChemStation and the components were identified by comparison with an accompanying mass spectra database. Retention indices were determined from the gas chromatogram by logarithmic interpolation between bracketing alkanes using a homologous series of n-alkanes as standards and in accordance with established method.

Statistical Analysis

Data were subjected to Analysis of Variance (ANOVA) and Probit analysis to determine values of LC_{50}. The analysis was done using StatPlus 2009 software.

RESULTS

Fumigant Toxicities of *C. odorata* Essential Oil

Upon released in petri dish, both *M. carbonarius* and *G. sulphureus* were walk fast around petri dish, make a noise, body was shaked and grouped together. Both soldiers and workers attacked and bited the filter paper. Table 1 showed the significant increase in termite mortality, when treated with leave and stem of *C. odaratum* essentil oil. In six hours treatment, *M. carbonarius* worker with leaves and stems, *G. sulphureus* soldier with leaves and stem of *C. odorata* essential oil showed significantly different with control (water) treatment (Table 1). Meanwhile, *M. carbonarius* soldier was not showed any statistically significant difference for both stems and leaves of *C. odorata* essential oil. After 18 hours treatment, all treated filter paper with stems and leaves of *C. odorata* oil showed statistically significantly difference with control filter paper (p<0.05). The mortality rates were increased with the increase of time exposure. This result showed *C. odorata* showed lethal effects on *M. carbonarius* and *G. sulphurous*, but no significant difference showed between stem and leaves *C. odorata*. LC_{50} (50% lethal concentration) graph (Figure 1) showed time of exposure increased with decreased dose needed to kill half of the termite. At six hours treatment, the lowest dosage was showed by *M. carbonarius* soldier (2154.51ppm), closely followed by *G. sulphurous* soldier (2396.41ppm), *M. carbonarius* worker (2493.14ppm) and *G. sulphurous* worker (2579.25ppm). The 12 hours application, the lowest LC_{50} was at 1019.05ppm on *M. carbonarius* worker followed by *M. carbonarius* soldier (1224.66ppm), *G. sulphurous* worker (2088.18ppm) and *G. sulphurous* soldier (2142.81ppm). In 18 hours, treatment, the lowest LC_{50} was at 565.97ppm on *M. carbonarius* worker followed by *M. carbonarius* soldier (1025.27ppm), *G. sulphurous* worker (1892.46ppm) and *G. sulphurous* soldier (2142.81ppm). In 24 hours, treatments showed the lowest LC_{50} was at 44.697ppm on *M. carbonarius* worker followed by *M. carbonarius* soldier (778.36ppm), *G. sulphurous* worker (1118.92ppm) and *G. sulphurous* soldier (1568.07ppm), respectively.

Table 1. Mortality of termite species against *C. odorata* essential oil.

Treatment	**Time of Observations (Hours)**			
	6	**12**	**18**	**24**
MSC	0^{a}	0^{a}	0.2^{a}	1.2^{a}
GSC	0^{a}	1^{ab}	3^{ab}	3.3^{ab}
MWC	0^{a}	0.2^{ab}	2^{ab}	3.7^{bc}
MSS	2^{ab}	3.2^{bc}	4.9^{c}	7.5^{cd}
MSL	2.4^{ab}	3.2^{bc}	5.2^{c}	6.8^{cd}
MWL	1.1^{b}	4^{bc}	8.6^{cd}	9.6^{d}
MWS	0.8^{b}	3.6^{bc}	8.2^{cd}	9.4^{d}
GSL	6.5^{cd}	10^{d}	10^{d}	10^{d}
GSS	8.4^{cd}	10^{d}	10^{d}	10^{d}

The numbers followed by the same character on the same column shown not significant with Turkey HSD[a] Test (p<0.05). MSC = *M. carbonarius* soldier with control; GSC = *G. sulphureus* soldier with control; MWC = *M.*

carbonarius worker with control; MSS = *M. carbonarius* soldier with stem of *C. odorata* oil; MSL = *M. carbonarius* soldier with leave of *C. odorata* oil; MWL = *M. carbonarius* worker with leave of *C. odorata* oil; MWS = *M. carbonarius* worker with stem of *C. odorata* oil; GLS = *G. sulphureus* soldier with leave of *C. odorata* oil and GSS = *G. sulphureus* soldier with stem of *C. odorata* oil.

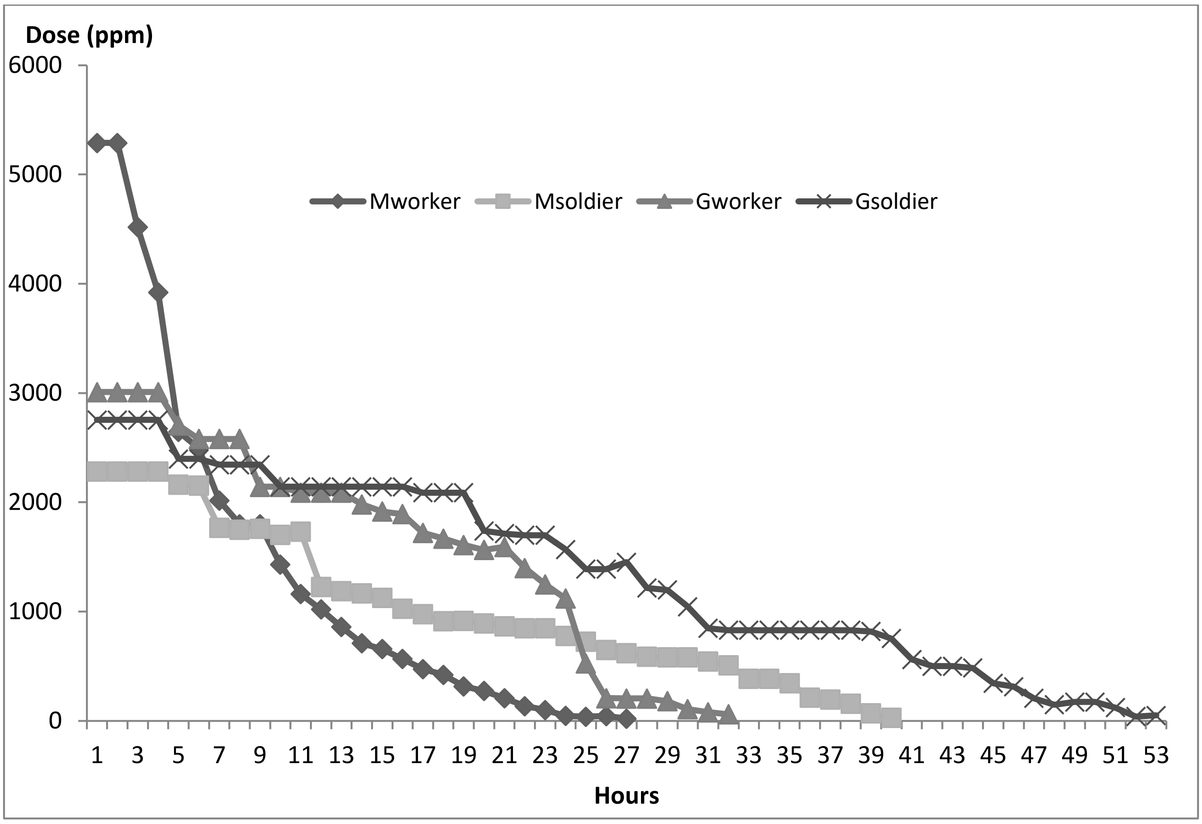

Figure 1. LC_{50} of *C. odoratum* against *M. carbonarius* and *G. sulphureus.*

Note: Mworker = *M. carbonarius* worker; Msoldier = *M. carbonarius* worker; Gworker = *G. sulphureus* worker; Gsoldier = *G. sulphureus* soldier.

The minimum average weight for an individual of *G. sulphureus* worker was 3.3 mg followed by *G. sulphureus* soldier (4.5 mg), *M. carbonarius* worker (6.6 mg) and *M. carbonarius* soldier (3.56 mg). The lowest dosage was needed to kill an individual was at 0.068 mg/L (*M. carbonarius* worker followed by *M. carbonarius* soldier (0.711 mg/L), *G. sulphureus* soldier (3.391 mg/L) and *G. sulphureus* worker (3.485 mg/L) in 24 hours applications (Table 2).

Table 2. LC_{50} of *C. odorata* towards *M. carbonarius* and *G. sulphureus.*

Species	**Weight (N=100) (mg)**	**Average weight (N=1) (mg)**	**LC_{50} (mg/L)**			
			6 Hours	**12 Hours**	**18 Hours**	**24 Hours**
Globitermes sulphureus (worker)	330	3.3	7.816	6.328	5.054	3.391
Globitermes sulphureus (soldier)	450	4.5	5.325	4.762	4.640	3.485
Macrotermes carbonarius (worker)	660	6.6	3.777	1.544	0.638	0.068
Macrotermes carbonarius (soldier)	3560	3.56	1.161	1.045	0.731	0.711

Chemicals Constituent of *C. odorata* Essential Oil

Water distillation of the fresh leaves 6300 g yielded 11.35 g (10.52%) of oil with strong odour. The constituents identified in the essential oil of the leaves of *C. odorata* are listed in Table 3. The constituents were identified by matching their mass spectra and retention indices with reference libraries. Twenty-four components comprising 90.3% of the total components detected from the leaf oil were identified. The major components identified were α-pinene (17.58%), germacrene D (11.56%), β-pinene (9.95%), geyrene (9.15%) and β-caryophylene (8.76%) all amounting to 57.00% of the total oil

Table 3. Chemical Constituents leaf oil of *C. odorata*.

PEAK	CHEMICAL CONSTITUENTS	RETENTION TIME	RETENTION INDICES (RI)		PERCENTAGE (%)	METHOD OF IDENTIFICATION
			C. odorata	Reference	*C. odorata*	
1	*α-thujene*	10.173	921	930[3]	0.2653	MS,RI
2	*α-pinene*	10.679	928	939[3]	17.5797	MS,RI
3	*sabinene*	13.147	966	975[3]	1.9901	MS,RI
4	*β-pinene*	13.357	969	979[3]	9.9462	MS,RI
5	*β-myrcene*	14.309	984	991[3]	1.3478	MS,RI
6	*p-cymene*	16.370	1016	1025[3]	0.8610	MS,RI
7	*limonene*	16.623	1020	1029[3]	1.0813	MS,RI
8	*β-ocimene*	17.923	1042	1037[3]	0.9820	MS,RI
9	*geyrene*	23.350	1134	1142[4]	9.1502	MS,RI
10	*pregeijerene*	30.939	1283	1287[3]	0.6199	MS,RI
11	δ-*elemene*	33.239	1332	1338[3]	0.2358	MS,RI
12	*α-copaene*	35.026	1371	1377[3]	2.2731	MS,RI
13	*β-elemene*	35.757	1387	1391[3]	1.6684	MS,RI
14	*caryophyllene*	37.027	1415	1419[3]	8.7563	MS,RI
15	*α-humulene*	38.456	1449	1455[3]	2.9644	MS,RI
16	*α-amorphene*	39.453	1472	–	0.4217	MS

17	*germacrene D*	39.704	1478	1485[3]	11.5624	MS,RI
18	*epi-bicyclosesquiphellandrene*	40.072	1487	1482[5]	0.4978	MS,RI
19	*4-epi-cubedol*	40.215	1490	1494[3]	1.0479	MS,RI
20	*bicyclogermacrene*	40.269	1492	1500[3]	1.2526	MS,RI
21	*α-muurolene*	40.392	1495	1500[3]	0.5322	MS,RI
22	*δ-cadinene*	41.373	1519	1523[3]	4.2525	MS,RI
23	*elemol*	42.422	1544	1550[3]	0.5261	MS,RI
24	*Compound X*	43.677	1576	–	4.6506	MS
25	*caryophyllene oxide*	43.874	1581	1583[3]	5.6262	MS,RI
26	*phytol*	57.063	1952	1943[3]	0.2063	MS,RI
				Total leaf oil (%)	90.30	

(MS: mass spectrum, RI: retention indices)

DISSCUSION

This study showed the effects of *C. odorata* essential oil against both *M. carbonarius* and *G. sulphurous*, in which fumigant effect of essential oil at 0.068 mg/L dose effectively reduce *M. carbonarius* worker followed by *M. carbonarius* soldier (0.711 mg/L), *G. sulphureus* soldier (3.391 mg/L) and *G. sulphureus* worker (3.485 mg/L) in 24 hours applications. Isoborneol and cedar wood oil caused 100% mortality of *R. santonensis* with dose of 276 g/ml air (Blaske & Hertel 2001). Cornelius et al. (1997) found that the higher mortality activity was seen for *C. formosanus* with citral, geraniol and eugenol, with 2.2, 2.1 and 0.27 g/ml air within 48 hours application respectively. LC_{50} value for *R. flavipes* was between 36 and 73 g/ml air in 24 hours after application while the doses between 14 and 36 g/ml air was needed for 7 days treatment of *R. flavipes*. The *C. odorata* essential oil has potential for *M. carbonarius* and *G. sulphureus* control because of no or little harmful effects on environments and human, low cost production and easily growing in tropic conditions. Isman (2000) reported plants essential oils are known to possess ovicidal, repellent and insecticidal activities against arthropod pests. Essential oils exhibit various and variable antimicrobial activities, including antifungal, antiviral, antibacterial, insecticidal, and antioxidant properties (Prabuseenivasan et al. 2006).

Chemical components of *C. odorata* oil showed latent lethal effects on *M. carbonarius* and *G. sulphureus.* Some of the previous studies have reported the acaricidal and/or insecticidal effects of plant essential oils are related to their chemical compositions (Isman et al. 2001; Tapondjou et al. 2002; Pascual-Villalobus & Ballesta-Acosta 2003). The major components identified were α-pinene (17.58%), germacrene D (11.56%), β-pinene (9.95%), geyrene (9.15%) and β-caryophylene (8.76%) all amounting to 57.00% of the total *C. odoratum* oil. Similar results were obtained in *Pistacia lentiscus* var. chia oil (Koutsoudaki et al.2005) and *Eucalyptus globules* oil (Gupta et al. 2011) although there was some difference in ratio of some chemicals. Koutsoudaki et al. (2005) reported the α-pinene showed the highest resistance to *Escherichia coli*, *Staphylococcus aureus*, and *Bacillus subtilis.* β-myrcene showed variation in the antibacterial activity and other compound such as p-cymene and limonene showed only moderate antibacterial activity.

Many plant essential oils and their isolates have fumigant action, such as essential oil of *Anethum graveolens* (dill weed) and *Rosmarinus officinalis* (rosemary) towards *Reticulitermes flavipes* (Clausen & Yang 2008), *Nepeta cataria* towards *Reticulitermes flavipes* (Kollar) and *R. virginicus* (Banks) (Peterson & Ems-Wilson 2003), *Ruta graveolens* and *Cuminum cyminum* towards *Microcerotermis gabriles* (Thamer 2008), and isolates like d-limonene (Tripathi et al. 2003) towards stored-product beetle *Rhyzopertha dominica* (F.) have been well documented as fumigants. These findings indicate that the route of action for the oils was largely in the vapour phase via respiratory system, although the exact mode of action of these oils remains unknown. Conventional pesticides lead to develop resistance among many insect pests (Hawkins et al. 2018), which require to look for alternatives.

Among the alternative strategies, the use of plants, insecticidal allelochemicals appears to be promising. Aromatic plants and their essential oils are among the most efficient botanicals (Catherine 1997). This is because most of the traditional insecticides can affect the nervous system (Valles & Koehler 1997). Essential oil compounds and their derivatives are considered an alternative means of controlling many harmful insects and their rapid degradation in the environment have increased specificity that favor beneficial insects

(Pillmoor et al. 1993). In the coming years, natural products may play important role in pest control, including control of termites.

CONCLUSION

This natural product is better because it ensures food safety, cheap, safe and target specific. Definitely using naturally produced biopesticide for control is better than using harmful convectional chemical insecticides which is non-degradable and toxic to human health. The study of *Chromolaena odorata* essential oil extracts towards termites *Globitermus sulphureus* and *Macrotermes carbonarius* was conducted in order to increased usage of affordable eco-friendly natural biopesticide. The results showed that the essential oil of stem and leaves of *C. odorata* had displayed lethal effects on tested termites.

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