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The Efficacy of Tembelekan Leaf Essential Oil (Lantana camara L.) as a Bioinsecticide for Aedes aegypti Mosquito Control

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Abstract

Indonesia, as a tropical region, is susceptible to infectious diseases such as Dengue Fever (DHF), which poses a risk of mortality in humans. The management of DHF vectors can be achieved through the application of chemical insecticides; however, these may have detrimental effects on human health. Therefore, a remedy in the form of bioinsecticides is necessary. Tembelekan leaves contain numerous active components, including lantadine, essential oils, flavonoids, alkaloids, saponins, and tannins. This study aims to evaluate the efficacy of essential oil from tembelekan leaves (Lantana camara) as a bioinsecticide for killing Aedes aegypti mosquitoes. The research involved administering tembelekan leaf essential oil at concentrations of 0.5%, 0.75%, 1%, and 1.25%, with observations conducted at the 1st and 2nd hours, resulting in a mortality rate of approximately 10% to 95%. This indicates that the efficacy of tembelekan leaf essential oil falls within the effective category for exterminating mosquitoes. In conclusion, tembelekan leaf essential oil is effective in exterminating Aedes aegypti mosquitoes.

Keywords: Bioinsecticide, Lantana camara, Aedes aegypti

INTRODUCTION

Indonesia is a tropical environment susceptible to tropical infectious illnesses, including dengue hemorrhagic fever (DHF), which can be fatal to humans. DHF can be transmitted via the bites of the *Aedes aegypti* mosquito, which harbors the dengue virus (1). The rise in instances persists, particularly during the wet season. The rainy season creates numerous water puddles that serve as hatching sites for mosquitoes (2). In 2023, the Ministry of Health reported that the total number of dengue fever cases in Indonesia, as of October 2023, reached 68,996. Simultaneously, the death toll from dengue fever has reached 498 cases. Dengue fever cases have been documented in 464 districts or cities throughout 34 provinces, whilst fatalities attributed to dengue fever have been recorded in 195 districts or cities within 32 provinces. In 2023, the Provincial Health Office of Lampung documented 201 cases of dengue fever in Bandar Lampung City (4). Preventive interventions against dengue fever transmission can be implemented through vector control. Dengue fever cannot be transmitted in the absence of a virus carrier or the parasites responsible for its causation. Controlling the DHF vector can be achieved by disrupting the life cycle of the *Aedes aegypti* mosquito. The mosquito life cycle comprises eggs, larvae, pupae, and adult mosquitoes. One method to disrupt the mosquito life cycle is during the adult stage, as female mosquitoes require blood for oviposition development. Consequently, if the insect fails to ingest blood and perishes before mating, the reproductive cycle of the *Aedes aegypti* mosquito will be interrupted (3).

Vector control for dengue disease can be achieved with the application of chemical pesticides containing transfluthrin, bioallethrin, d-allethrin, pralethrin, and cyphenothrin. Prolonged application of chemical insecticides can induce resistance in *Aedes aegypti* mosquitoes and may present significant health hazards to humans, including diminished erythrocyte levels resulting in anemia, decreased enzyme activity crucial for nerve transmission, compromised liver

function, and disturbances in reproductive, respiratory, and cardiovascular systems, along with a potential carcinogenic effect. To mitigate any future dangers, it is prudent to substitute chemical insecticides with bio-insecticides produced from plants that possess active components such as essential oils, alkaloids, saponins, flavonoids, phenolics, terpenoids, and tannins. The tembelekan plant (*Lantana camara* L.) possesses a strong odour, rendering it a possible bio-insecticide and insect repellent. Tembelekan (*Lantana camara* L.) is a natural plant regarded as a weed. This plant possesses a powerful aroma and potential as an insect repellent. The leaf of the plant can be utilised as a bioinsecticide. The tembelekan plant's leaves encompass various active components, including lantadine, essential oils, flavonoids, alkaloids, saponins, and tannins. Lantana plants are highly prevalent due to their ease of growth. Nonetheless, the application of plants classified as weeds remains insufficient; so, employing these plants as biological larvicides could elevate their status to that of a more advantageous species (18).

This study seeks to evaluate the efficacy of essential oils as a bioinsecticide in exterminating *Aedes aegypti* mosquitoes.

METHOD

1. Study Design

This research is a quantitative study employing an experimental methodology to investigate the effects of providing essential oil derived from tembelekan leaves (*Lantana camara* L.) on *Aedes aegypti* mosquitoes. The researchers will utilize adult *Aedes aegypti* mosquitoes as specimens, having cultivated them from the egg stage to maturity.

2. Study Location and Duration

The Unila Laboratory is scheduled to perform the investigation from April to September 2024.

3. Research Instrument

The following materials and instruments were used Fresh tembelekan leaves (*Lantana camara* L.), Distillation apparatus (for essential oil extraction), Glass test chambers (48 total), Adult *Aedes aegypti* mosquitoes, Aspirators, Paper cups and gauze, Aquades (as negative control), Commercial mosquito repellent (as positive control)

4. Distillation Extraction

Eight kilograms of half-dried tembelekan (*Lantana camara* L.) leaves are then put into a kettle with an upper and lower division created by a filter dividing the contents. The lantana leaves are placed in the upper portion of the filter, and water that has been heated to a boiling point (between 100 and 105°C) is placed in the lower portion. The separator receives the oil-and-steam mixture from the kettle. The condenser will provide cool air as it enters the separator, converting the vapor phase to liquid. Because the water and the oil have different specific gravities, the essential oil that is created will separate from the water. After that, the yield will be computed. The essential oil components are then filtered.

5. Efficacy Test of Bioinsecticide

We will categorize the developing *Aedes aegypti* eggs into six groups, each including 25 pupae, and confine them in cages to facilitate their maturation into mosquitoes. Subsequently, prepare 48 pristine and dry glass chambers. Apply uniformly to the walls of the glass chamber using 100 ml of essential oil solution derived from tembelekan leaves at concentrations of 0.5%, 0.75%, 1%, and 1.25%. Subsequently, put 25 *Aedes aegypti* mosquitoes into each glass chamber utilizing an aspirator, and allow them to acclimate for 1 minute. Monitor the movement of the mosquitoes within the glass chamber.

Table 1. Details of the sample treatment used

Mosquitoes sample	Treatment	Amount of Mosquitoes x Repitition	Total Sample
Aedes aegypti	K (-)	25 x 4	100
	K (+)	25 x 4	100
	0.5%	25 x 4	100
	0.75%	25 x 4	100
	1%	25 x 4	100
	1.25%	25 x 4	100
	Total		**600**

Quantify the number of mosquitoes that perish in the glass box at intervals of 1st, 2nd, 3rd, 4th, 5th, 6th hours. Subsequently, relocate the mosquitoes from each treatment into the designated paper cups and secure them with gauze. Monitor and tally the fatalities of mosquitoes in each remaining specimen within the paper cup hourly for a duration of 24 hours. Subsequently, apply the mortality formula to determine the quantity of deceased larvae. A insecticide concentration that results in mosquitoes mortality between 10% and 95% is deemed effective, whereas a mortality rate beyond 95% is classified as very effective. (11).

RESULT

Essential Oil Yield of Tembelekan Leaf

Table 2 presents the computed yield value for the essential oil obtained through the steam distillation procedure.

Table 2. Yield Calculation Results

Wet Weight	Essential Oil	Yield Value
1500	210	14

Table 1 presents the volume of essential oil extracted from the distillation of tembelekan leaves, measured in milliliters. This study reports a 14% production of essential oil from tembelekan leaves (*Lantana camara*).

Result of the Tembelekan Leaf Extract (*Lantana camara*) Bioinsecticide Evaluation Against *Aedes aegypti* Mosquitoes

Table 3 displays the mortality statistics from the biolarvicidal assay of lantana leaf extract (*Lantana camara*) on *Aedes aegypti* larvae in stages III and IV.

Table 3. Mortality Rates of *Aedes aegypti* Mosquitoes Administered Tembelekan Leaf Extract (*Lantana camara*)

Treatment	Mortalitas Nyamuk *Aedes aegypti*					
	1st hour (%)	2nd hour (%)	3rd hour (%)	4th hour (%)	5th hour (%)	6th hour (%)
0.5%	43	53	66	79	93	100
0.75%	58	64	78	93	97	100
1%	64	74	88	100	100	100
1.25%	68	88	100	100	100	100
K-	0	0	0	79	93	100
K+	100	100	100	93	97	100

Ket :
K- : Tanpa perlakuan hanya menggunakan aquades
K+ : Obat Nyamuk Komersil

Table 3 indicates that the essential oil of tembelekan leaves (*Lantana camara*) at concentrations of 0.5%, 0.75%, 1%, and 1.25% exhibited mortality rates between 10% and 95% during the 1st and 2nd hours of observation, thereby classifying it as effective in exterminating mosquitoes. At a dose of 1%, it exhibits the best efficacy in exterminating mosquitoes, with a fatality rate of 100% within 3 hours. Simultaneously, observations during the first and second hours indicated that over 50% of the larvae had perished. A concentration of 1% is classified as highly effective, achieving a mosquito fatality rate exceeding 95% within three hours. At a concentration of 1.25%, the essential oil bioinsecticide derived from tembelekan leaves achieves a 100% fatality rate in mosquitoes within three hours. At a concentration of 1%, mosquito death attained 100% by the fourth hour. A higher concentration of essential oil derived from tembelekan leaves correlates with a reduced time necessary to exterminate *Aedes aegypti* mosquitoes.

Result of Probit Test

Presented is the diagram for the LC_{50} and LC_{90} data analysis:

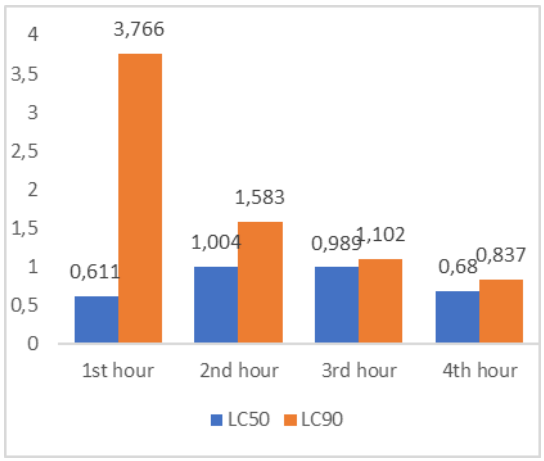

Figure 1. Probit Test Results of LC50 from Tembelekan Leaf Essential Oil (*Lantana camara*) Against *Aedes aegypti* Larvae

Meanwhile, the analysis of LT50 and LT90 data is as follows:

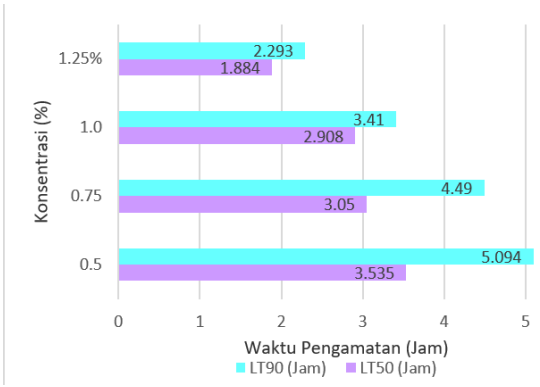

Figure 2: Results of a probit analysis for LT_{50} and LT_{90} of essential oil derived from Tembelekan leaves (Lantana camara) against Aedes aegypti larvae resulting in mortality

Figure 2 indicates that for each concentration, the LT_{50} and LT_{90} values decrease, suggesting that the time necessary to exterminate *Aedes aegypti* mosquitoes decreases with increasing concentration. The shorter the duration required to exterminate Aedes aegypti mosquitoes, the greater the toxicity of tembelekan leaf essential oil.

DISCUSSION

The optimal yield is 100%, as indicated by the yield standards. A compound is deemed exceptional if its yield surpasses 90%, very good if it exceeds 80%, decent if it exceeds 70%, fair if it exceeds 50%, and poor if it is below 40% (12). The yield of this study, below 40%, categorizes it as low. The minimal essential oil content in lantana leaves is shown by the yield value, which reflects the efficiency of the extraction procedure and the quality of the resultant extract. A low yield indicates that the distillation process can recover only a minimal fraction of the active chemicals.

According to the comprehensive data in Table 2, the death rates for each concentration of 0.5%, 0.75%, 1%, and 1.25% varied from 10% to 100% between the 1st hour and the 6th hour. This conforms to the criteria established by the WHO, which stipulates that an insecticide is deemed effective if it can eliminate between 10% and 95% of the total test mosquitoes (11). Observations of mosquito mortality were undertaken only until the sixth hour, as all mosquitoes at each concentration had perished by that time. This study demonstrates that essential oil derived from lantana leaves is efficacious in exterminating Aedes aegypti mosquitoes. The negative control group (water) did not induce larval mortality, indicating that the test subjects were well managed and no extraneous influences contributed to larval death.

Essential oils exterminate mosquitoes by infiltrating their bodies via the respiratory system, resulting in nerve disturbance and respiratory injury. This causes the insect to suffocate, resulting in its demise. The primary constituents of lantana leaf essential oil include β-caryophyllene (35.70%), caryophyllene oxide (10.04%), caryophyllene (16.37%), β-elemene (6.41%), germacrene-D (15.85%), α-humelene (9.31%), germacrene (6.19%), and eucalyptol (10.75%). The chemicals β-caryophyllene, caryophyllene oxide, caryophyllene, germacrene-D, germacrene, and eucalyptol present in lantana leaf essential oil are recognized for their larvicidal properties. β-caryophyllene functions as a larvicide by influencing the neurological system and hormonal regulation in mosquitoes, resulting in mortality. Furthermore, β-

caryophyllene can impede mosquito development by interfering with protein and DNA synthesis. Eucalyptol disrupts the neurological system of mosquitoes and functions as a stomach toxin, impairing their eating capability, finally inhibiting growth and resulting in mortality (19).

The probit test's LC_{50} value depicted in Figure 1 indicates that the concentration is minimal during the initial hour, at 0.611%. This concentration of essential oil derived from tembelekan leaves can eliminate 50% of the test mosquitoes. The LC_{90} value for all concentrations from the 1st hour to the 3rd hour exhibits a decline. Consequently, prolonged usage of essential oil derived from tembelekan leaves results in a decreased concentration necessary to exterminate 90% of mosquitoes.

Figure 2 illustrates that employing a low quantity of essential oil derived from tembelekan leaves requires an extended duration to eliminate 50% of the examined insects. A 1.25% concentration of essential oil from tembelekan leaves may exterminate 50% of Aedes aegypti mosquitoes in 1.884 hours, while 90% mortality is achieved in 2.293 hours. For the lowest concentration of 0.5%, the LT_{50} and LT_{90} values are 3.535 hours and 5.094 hours, respectively.

Prolonged use of bioinsecticides has a diminished long-term impact on the environment. The residues from the bioinsecticides will evaporate in the environment, therefore preventing any detrimental impacts on the health of the community utilizing essential oil bioinsecticides derived from lantana leaves. Moreover, the application of essential oil bioinsecticides can mitigate the effects of resistance in Aedes aegypti mosquitoes caused by chemical pesticides.

CONCLUSION

Bioinsecticides derived from tembelekan leaf essential oil (*Lantana camara* L.) effectively exterminate *Aedes aegypti* mosquitoes. Bioinsecticides exert a diminished environmental impact over time as their residues volatilize into the atmosphere. The utilization of the essential oil bioinsecticide derived from lantana leaves will not adversely affect the health of neighbouring residents. The application of essential oil bioinsecticides can mitigate the effects of resistance in Aedes aegypti mosquitoes caused by chemical pesticides.

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