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Repellent effect of plant leaves extract of tomato (*Solanum lycopersicum* L.) against *Aedes aegypti* mosquitoes

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Abstract

Avoiding the bites of *Aedes aegypti* is the best way to prevent transmission of dengue hemorrhagic fever (DHF). One effective way to avoid mosquito bites is to apply a repellent lotion. This research is an effort to find natural ingredients for mosquito repellent lotions. The purpose of this research is to determine the repellent effect of the ethanol extract of tomato (*Solanum lycopersicum* L.) leaves, known to rich in alkaloids and saponin, against *Aedes* mosquitoes. The repellent lotion of tomato leaves extract was prepared in five concentration levels namely 0% (control), 10%, 20%, 30%, 40% and 50%. By applying a completely randomized design, five cages were prepared with 25 mosquitoes each, into which volunteers were asked to put their bare hands.The results showed that tomato leaf extract had a repellent effect on *Aedes aegypti* mosquito in a concentration-dependent manner.At the concentration of 10% the extract repels mosquito bites by 36%, while the extract with a concentration of 50% able to repel mosquito bites by up to 83%. It can be concluded that tomato leaf extract has a repellent effect on *Aedes aegypti* mosquitoes and has the potential to be developed as a mosquito repellent lotion.

Keywords: *Aedes aegypti*; *Solanum lycopersicum*; Tomato; Mosquito Repellent Lotion; Repellent Effect; Dengue Hemorrhagic Fever

1. Introduction

Indonesia is one among five countries in South-East Asia (India, Indonesia, Myanmar, Sri Lanka and Thailand) that most highly endemic for dengue hemorrhagic fever (DHF). *Aedes aegypti* mosquito is the main vector that transmits the virus causing the disease. The DHF viruses are transmitted to humans through the bites of infected female mosquitoes. [1]

Dengue fever occurs throughout the year, especially during the rainy season and can affect all age groups. Many attempts have been made to control this disease, including eradicating the mosquito breeding sites using chemical larvicides. However, the use of larvicide made from synthetic chemicals is known to cause resistance. [2]

Another method commonly used to eradicate mosquitoes is the application of fogging. Unfortunately, this method is only effective in killing adult mosquitoes but less effective in killing larvae and eggs. [3] This is because the eggs and larvae of *Ae.aegypti* are usually found in water that stagnate a container or vessel. Therefore, theoretically, *Aedes aegypti* breeds in clean water that is not in contact with groundwater. [4]

Therefore, the best way to prevent dengue transmission is to avoid mosquito bites by applying repellents such as repellent lotions. The advantage of using lotion, besides preventing mosquito bites, can also prevent contamination of the air in the house by the use of volatile toxic materials.[5] In addition, the use of topical lotions is relatively fast, practical, and can be rubbed evenly on the skin. [6]

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In an effort to find mosquito repellent materials that are safe for humans, it is necessary to search for natural materials. One of the plants that should be suspected of having repellent properties is the tomato. This is because the leaves of this plant contain secondary metabolites such as alkaloids and saponins. Alkaloids are compounds that are toxic and inhibit the process of metamorphosis in insects. While saponins are toxic compounds in the stomach that cause decreased mucosal tension so that they can interfere with the secretion of digestive enzymes and absorption of food. In addition, tomato leaves also produce a distinctive odor that insects tend to avoid. [7, 8]

2. Material and methods

2.1. Plant sample and extraction

The tomato plant samples used in this study were obtained from tomato fields in Liwa, West Lampung. Wet fresh leaves are washed and drained, then air-dried (not dried directly in the sun). After drying, the leaves are crushed with a blender to become a fine powder (simplicia). The dried tomato leaf powder was macerated in 96% ethanol for 24 hours and repeated three times. The extract is then evaporated in a rotary evaporator. The viscous extract was then diluted serially with ethanol. There were five levels of extract concentration prepared namely 0% (control), 10%, 20%, 30%,40% and 50%.

2.2. The mosquitoes

Eggs are placed in a plastic bowl filled with water for 1-3 days until they hatch into instar larvae stages I-IV for 12-13 days. During its development, the larvae are given pellets until they reach the pupal phase. The pupae are transferred to a bowl filled with water and left in the cage for 1-2 days until they develop into adult mosquitoes. Adult mosquitoes are fed a sucrose solution. Six cages (25x25x25cm^3) were prepared for testing, each cage containing 25 female *Ae. aegypti* mosquitoes. One day (24 hours) before the bite test, the mosquitoes were fasted (no food was given).

2.3. The repellency test

Mosquito repellency testing was carried out following WHOPES recommendations (2009) where the active ingredient to be tested for its efficacy was rubbed on the forearm of the volunteer's left hand.[9] Volunteers were asked to insert their arms into the mosquito cage for 30 seconds in a period of 1 hour for 6 hours. The number of mosquitoes that landed during 30 seconds of exposure was counted. Each bite test step using a different extract treatment was repeated four times. Therefore the total unit of bite test is 24.

The effectiveness of the repellent in protecting volunteer was determined using formula bellows:

$$Protection\ (\%) = \left(\frac{\sum C - \sum T}{\sum C}\right) \text{x } 100\%$$

Where:

C = number of mosquitoes landed on the control arm

T = number of mosquitoes landed on the treated arm

2.4. Statistical analysis

The number of *Aedes aegypti* mosquitoes. that landed on the forearms of volunteers who were given different treatments were analyzed using one way ANOVA. Furthermore, the significance of the difference between treatments was calculated using the LSD (Least Significant Difference) post hoc test at a significance level of 5%.

3. Results and discussion

Number of mosquitoes landed on volunteers forearms given six different treatments are presented in Table 1. The data clearly show that the higher the concentration of tomato leaves extract rubbed on volunteer's arms, the lower the number of mosquitoes that landed on the arm skin in question (P< .000). Next, Table 2 presents the repellency of tomato leaf extract against *Aedes aegypti* mosquitoes which is calculated using the percent protection formula. The percent protection data is the inverse of the number of mosquitoes that landed on volunteer's arms. The results of the statistical analysis of the percent repellency are in line with the number of mosquito landings. The higher the concentration of the extract used, the higher the percentage of protection (F-value of 912.79; P<.000).

Table 1 Number of mosquitoes landed on volunteers forearm in 30s per hour for 6 hours of bite test

No. Repeat	Number of mosquitoes landed in 6 hours testing by extract concentration					
	0%	**10%**	**20%**	**30%**	**40%**	**50%**
1	149	62	50	36	14	3
2	147	61	51	38	11	1
3	147	57	48	30	9	0
4	147	58	48	33	8	1
Mean	147.5^{a}	59.5^{b}	49.25^{c}	34.25^{d}	10.5^{e}	1.25^{f}
SD	1.00	2.38	1.50	3.50	2.65	1.26

Mean values followed by the different superscript are statistically different at $\alpha = 0.05$

Table 2 Repellency (percentage of protection) of tomato leaves extract against *Aedes* mosquito bites

No. Repeat	Protection by extract concentration (%)					
	0%	**10%**	**20%**	**30%**	**40%**	**50%**
1	0.33	34.78	41.17	49.70	66.96	81.48
2	0.99	35.25	40.64	48.44	70.07	84.39
3	0.99	37.36	42.32	53.76	73.34	86.11
4	0.99	36.80	42.32	51.75	74.17	84.39
Mean	0.82^{a}	36.04^{b}	41.61^{c}	50.91^{d}	71.13^{e}	83.09^{f}
SD	0.33	1.23	0.84	2.34	3.30	1.92

Mean values followed by the different superscript are statistically different at $\alpha = 0.05$

The data from this study clearly indicated that mosquitoes did not avoid the arms of volunteers rubbed with tomato leaf extract. This is presumably because tomato leaves contain secondary metabolites such as alkaloids and saponins. Basil leaf extract (*Ocimum sanctum* Linn), which also contains these two compounds, has also been shown to be used as a repellent for *Ae.aegypti* mosquitoes. [10] The repellent effect of alkaloids on mosquito bites is related to their toxic properties on the nerves of insects and having a characteristic odor that insects tend to avoid.[11]

The protective activity of repellents against mosquitoes is influenced by several factors such as warmth, humidity, odor, presence or absence of CO_2 and visual stimuli. Mosquitoes prefer a warm atmosphere and prefer hands that evaporate less moisture than those that emit a lot of moisture. Mosquitoes prefer dark colors over light ones. High levels of CO2 tend to attract mosquitoes to land, because CO_2 is a signal for mosquitoes that their prey is present. So, abiotic factors that affect the number of mosquitoes that land on the skin include air humidity, air temperature, and body temperature. [12]

The protection mechanism of tomato leaf extract against mosquitoes in this study is not entirely clear. Is it related to its irritant, repellent, or toxic activity. But the results of the study are in line with Deletre *at al.* (2013) research that although the mechanisms for the irritant, repellent and toxic properties are independently of each other, the repellency of the extract applied depends on the concentration.[13].

One of the plants that have been widely used insecticides and repellents is pyrethrum extracts from flower heads of *Chrysanthemum* spp. However, the molecular basis of pyrethrum repellency remains unknown. However, mosquito An. gambiae is known to be able to detect citronellal molecules through the olfactory nerve cells in their antennae which are controlled by the TRPA1 gene.[14]

Whatever the repellency mechanism of tomato leaf extract against *Aedesaegypti* mosquitoes, it doesn't matter in terms of practical daily use. The most important thing is how to maintain the duration of the protection provided by the extract against mosquitoes.[15]

4. Conclusion

Tomato leaf extract revealed to have repellent effect against *Aedesaegypti* mosquito in concentration-dependent manner. Thus it can be concluded that plant leaf extract of tomato (*Solanumlycopersicum* L.) can be developed into a mosquito repellent lotion.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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