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ARTICLE REVIEW

Larvicide Activity and Anti-Mosquito Activity of Several Plants in Indonesia Against Aedes Aegypti: Review Articles

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Abstract: As one of the world's tropical countries with high air humidity, Indonesia is a breeding ground for mosquitoes such as *Aedes aegypti*, one of the dengue vectors. The search for alternative treatments using plants continues to date. *This* article review aims to find out and review scientific information from research that has been carried out related to plant activity as larvicide and anti-mosquito. The method of writing this article review uses literature studies through *search engines* in the form of *Google Scholar*, *PubMed*, and *NCBI*. 27 journals were obtained that were included in the inclusion criteria, The inclusion criteria used are national and international journals that discuss larvicide and anti-plant mosquito activities against *Aedes aegypti* mosquitoes, Journals published in the last 10 years (2012-2022), and journals in full-text form. From the results of searches related to plants that have activity as a larvicide and anti-mosquito *Aedes aegypti,* there are as many as 27 plant species, as many as 16 plant species have activity as a larvicide and 11 plant species have activity as anti-mosquito activity. Some of these plants can be used as natural insecticides that are environmentally friendly and contain secondary metabolites such as alkaloids, flavonoids, tannins, phenols, terpenoids, saponins and steroids that are effective as substances that kill larvae and repel mosquitoes.

Keywords: Anti-mosquito, *Aedes aegypti*, herbal plants, larvicide

INTRODUCTION

In Indonesia, the number of dengue haemorrhagic fever (DHF) cases continues to increase and the spread of this disease is getting wider. DHF is a serious public health problem. [1] According to the Ministry of Health of the Republic of Indonesia, dengue fever has existed in Indonesia since 1968 and until now dengue cases are spread in 472 districts/cities from 34 provinces and resulted in death in 219 districts/cities from 34 provinces.[2] The development or prevalence of DHF cases in 2020 has reached 71,633 people, and Java Island has

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the highest cases, especially in West Java Province.[2]

Dengue virus is an infection that causes dengue haemorrhagic fever (DHF).[3] *Aedes aegypti* mosquitoes carrying the dengue virus are the main vectors of Dengue Haemorrhagic Fever (DHF).[3] One anthropophilic species that has environmental harmony is *Aedes aegypti.*[3] This dengue virus is found in areas with tropical and subtropical climates.[3] Female mosquitoes carrying the dengue virus attack humans and usually transmit the disease during the day.[3] Moreover, mosquitoes breed rapidly, especially in tropical regions such as Indonesia. [3]

Clinical manifestations of dengue virus infection occur without symptoms or with symptoms similar to mild flu or commonly known as Dengue Fever, but it can also become more severe so that it can be life-threatening or commonly known as Dengue Haemorrhagic Fever (DHF) as well as Dengue Shock Syndrome (DSS). [4]

Until now, there is still no effective vaccine to protect the four dengue virus serotypes (DEN-1, DEN-2, DEN-3, and DEN-4), therefore the control is still by eradicating the main vector directly as a target in reducing dengue cases that occur.[3] How to overcome or control DHF is done by eradicating the main vector of the cause, namely mosquitoes and also the larvae of these mosquitoes. [33]

Mosquito control can be done either by environmental, biological or chemical control. [1] One way of controlling mosquitoes that is usually done chemically is by using pesticides. [5] One of the pesticides that can be used as a vector controller and disease-carrying animals is the organo-phosphate (OP) pesticide which works by inhibiting the cholinesterase enzyme, and one of the OPs that is often used in vector control activities, namely larvicide.[5]

Currently, mosquito repellent, spray, candles, and lotions are available on the market and made from chemicals that are widely used by the public to control mosquitoes.[34] Chemical insecticides leave residues whose active components are difficult for nature to decompose. [35] By replacing chemical insecticides with natural insecticides, these negative impacts can be avoided. [35]

Biological control using natural materials to control insect pests has been widely used by the community for a long time. [3] But now it is rare for people to use larvicide made from natural ingredients which are certainly more environmentally friendly than using chemical control, and also because of the lack of information about plants that can be used as larvicide/insecticide among the community.[36]

Based on the description above, it is necessary to conduct a literature study on plants that have activity as larvicide and anti-mosquito and it is hoped that the review of this article can be scientific information to further researchers and people who do not know the benefits of plants that have activity as larvicide and anti-mosquito.

METHODS

This article review was created using the literature review process. The publications that are the subject of review of this article taken over the last ten years (2012–2022) come from national and international journals online using search

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engines including Google Scholar, Science Direct, PubMed, and NCBI using the keywords "Larvicide activity", "Larvacide for Aedes aegypti", "Larvacide activity of plant for Aedes aegypti", "anti-mosquito activity", "anti-mosquito activity of Aedes aegypti" and "larvicide activity in *Aedes aegypti*". Furthermore, the criteria for inclusion and exclusion were determined. The publication of articles discussing plant larvicide activity against *Aedes aegypti* mosquitoes both nationally and internationally, journals published in the last ten years (2012-2022), and journals in full-text form (fully accessible) meet the inclusion criteria. While the publication of national and international articles was published in 2012, the journal is not in full-text form, and articles that do not cover plant larvicide activity against *Aedes aegypti* mosquitoes meet the exclusion criteria.

RESULTS

The following data from the review results are summarized from various sources used, obtained from several plants that have larvicide and anti-mosquito activity. From the results of the literature study search conducted, as many as 27 plants were reported to have acted as larvicide and mosquito repellent.

Table 1. The results of observations of several plants that have larvicide activity against *Aedes aegypti* mosquito larvae with plant parts, solvent, the content of secondary metabolites, concentration, observation time and LC_{50} value which is different from each plant

No	Plant Name	Plant Parts	Solvent	Secondary Methanolite	Concentration (ppm)	LC_{50} (ppm)		
						24 Hours	48 Hours	72 Hours
1.	*Carica pubescens* (Pepaya gunung)[6]	Leaf	Methanol	Alkaloids, flavonoids, phenols	0, 125, 500 and 1000		869.81	579.09
2.	*Stenochlaena palustri* (Burm. F) Bedd (Kelakai)[7]	Fruit	Ethanol	Saponins, alkaloids, tannins	312, 625, 1251, 2502, 5005, 10011, and 20022		7800	
3.	*Melaleuca leucadendra* (Eucalyptus)[8]	Leaf	Ethanol	Terpenoids, phenols, flavonoids	40, 100, 160, 200, 1000, 2000, 3000, dan 4000	3700		
4.	*Mirabilis jalapa* (Bunga pukul empat)[9]	Leaf	Ethanol	Alkaloids, saponins, tannins	312.5, 625, 1250, 5000, and 10000		3890	
5.	*Euphorbia tirucalli Linn* (Patah tulang)[10]	Stalk	Ethanol	Flavonoids, tannins	10, 31.62, 99.98, 316.14, and 1000		171,48	
6.	*Plectranthus amboinicusl* (Jintan)[11]	Leaf	Ethyl acetate	Flavonoids, steroids, alkaloids	10000, 18000, 32000, 56000, dan 100000		55600	
7.	*Brugmansia candidal* (kecubung)[12]	Flower	Methanol	Tropane alkaloids	100, 250, 500, and 1000		772	

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Table 1. Continuation

No	Plant Name	Plant Parts	Solvent	Secondary Methanolates	Concentration (ppm)	LC_{50} (ppm)		
						24 Hours	48 Hours	72 Hour
8.	*Derris elliptica* (Tuba)[13]	Root	Ethyl acetate	Tannins, terpenoids, flavonoids	10, 25, 50, and 100	34.945	6.461	
9.	*Piper betle* L. (Sirih)[14]	Leaf	Water	Terpenoids and phenols	1, 5, 10, 50, 100, 500, and 1000	92.7	59.8	
10.	*Combretocarpus rotundatus* (*Miq.*) Danser (Tumih)[15]	Leaf	Ethyl acetate	Alkaloids, flavonoids and saponins	0, 5, 10, 25, 50, 75, and 100	24.54		
11.	*Aegle marmelos* (L) Corr (Maja)[16]	Leaf	Ethyl acetate	Alkaloids, terpenoids and tannins	1000, 2000, 3000, 4000, 8000, and 16000	20300		
12.	*Manihot glaziovii* (Singkong Karet)[17]	Tuber peel	Methanol	Saponins and flavonoids	1800, 2400, 3000, 3600 and 4200	2104		
13.	*Leucaena leucocephala* (Lamtoro)[18]	Leaf	N-Hexan	alkaloids, saponins and tannins	1250, 2000, 2500, 3000, and 5000	3500		
14.	*Pluchea indica (L.) Less.* (Beluntas)[19]	Leaf	Petroleum ether	Saponins and tannins	1500, 2000, and 2500	1907		
15.	*Mangifera caesia* (Binjai)[20]	Leaf	Ethanol	Saponins, tannins and alkaloids	1000, 5000, 10000, 15000, and 20000	5493		
16.	*Alcalypha indica. L* (Anting-anting)[22]	Herbs	Ethyl acetate	Alkaloid's flavonoids, triterpenoids	450, 900, 1350, and 1800	72.443		

Table 2. The results of observations of several plants that have anti-mosquito activity against *Aedes aegypti* mosquito larvae with plant parts, solvent, the content of secondary metabolites, concentration, and different protective power of each plant

No	Plant Name	Plant Parts	Solvent	Womb	Concentration (%)	Protection power (0-100%)
1.	*Mangifera foetida* Lour (Limus)[23]	Fruit peel	Ethanol	Alkaloids, flavonoids, saponins	5 and 10	100

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Table 2. Continuation

No	Plant Name	Plant Parts	Solvent	Womb	Concentration (%)	Protection power (0-100%)
2.	*Apium Graveolens* (Seledri)[24]	Leaf	Methanol	flavonoids, alkaloids, tannins	5, 10 and 15	100
3.	*Cymbopogon nardus* (Serai wangi)[25]	Herbs	Alcohol	flavonoids, phenolic terpenoids	70	98.3
4.	*Ocimum basillicum* L. (Kemangi)[26]	Herbs	Ethanol	Flavonoids, saponins, tannins	10, 20, 30, 40, 50	60
5.	*Evodia Suaveolens* (Zodia)[27]	Leaf	Water	Phenols, terpenoids	5, 10, 15, 20, 25, 30	91
6.	*Theobroma cacao* L. (Kakao)[28]	Fruit peel	Acetone	Tannins, polyphenols, alkaloids	6, 8, 10, 12	100
7.	*Illicium verum* (Lawang)[29]	Flower	Water	Flavonoids, Alkaloids Saponins	10, 20, 30, 40, 50	65,32
8.	*Sapindus rarak,* D.C (Lerak)[30]	Fruit	methanol	triterpenes, Alkaloids Steroids	0, 3, 7, 9	100
9.	*Citrus aurantifolia* (Jeruk nipis)[31]	Fruit peel	Air	Flavonoids, saponins, steroids	10, 15, 20 and 25	90
10.	*Tagetes erecta* (Tahi Ayam)[32]	Flower	Water	Alkaloids, flavonoids, saponins	0, 6, 8, 10,	88.86
11.	*Averrhoa bilimbi L.* (Belimbing wuluh)[33]	Fruit	Water	Flavonoids, saponins, alkaloids	45, 50, 55, 60	78

Table 3. LC_{50} Value range in killing *Aedes aegypti* mosquito larvae

No	LC_{50} (ppm)	Toxicity
1.	<30	Highly toxic
2.	30-1000	Toxic
3.	>1000	Non-toxic

Table 4. Range of *repellent* protection value (repulsion) against *Aedes aegypti mosquitoes.*

No	Protection Power (%)	Effectiveness
1.	>80	Effective
2.	<80	ineffective

Some plants that have larvicide and anti-mosquito activity and their mechanism of action in killing *mosquito larvae Aedes aegypti*

The results of searches related to plants that have activity as a larvicide and anti-mosquito *Aedes aegypti* there are as many as 27 plant species. 16 plant species of which have larvicide activity characterized by LC_{50} (*Medium Lethal Concentration*) which is an extract concentration that can kill 50% of the test organisms.[37] Based on Table 1, larvicide activity testing was carried out with different periods, namely for 24 hours, 48 hours and 72 hours. [37] The difference in the time of testing was done to see how high the concentration was given so that the mortality that occurred in larvae was higher. [37] Two species fall into the highly toxic category (LC_{50} <30 ppm), *Combretocarpus rotundatus* (Miq.), *Danser* (Tumih) and *Derris elliptica* (Tuba), Four species fall into the toxic category (LC_{50} 30-1000 ppm), namely *Piper betle* L. (Sirih),

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Brugmansia candidaI (Kecubung), *Euphorbia tirucalli Linn* (Patah tulang), and *Carica pubescens* (Pepaya gunung), and Nine species fall into the non-toxic category (LC_{50} >1000 ppm), namely *Mangifera caesia* (Binjai), *Pluchea indica* (L.) Less.[37] (Beluntas), *Leucaena leucocephala* (Lamtoro*), Manihot glaziovii* (Singkong Karet), *Aegle marmelos* (L) *Corr* (Maja), *Plectranthus amboinicus L* (Jintan), *Mirabilis jalapa* (Bunga pukul empat), *Melaleuca leucadendra* (Kayu putih), and *Stenochlaena palustri* (Burm. F), *Bedd* (Kelakai).[37]

Eleventh other plant species have anti-mosquito activity characterized by the amount of protection produced from the active substances in these plants. 8 species have a protective power of >80%, namely: *Sapindus rarak*, D.C (Lerak), *Theobroma cacao* L.[37] (Kakao), *Apium Graveolens* (seledri), *Mangifera foetida Lour* (Limus), *Cymbopogon nardus* (Serai wangi), *Evodia suaveolens* (Zodia), *Citrus aurantifolia* (Jeruk nipis), and *Tagetes erecta* (Tahi Ayam), and 3 species have a protective power of <80%, namely *Averrhoa bilimbi L*. (Belimbing wuluh), *Illicium verum* (Lawang), and *Ocimum basillicum* L. (Kemangi).[37]

The larvicide and anti-mosquito activity is thought to be because the plant has secondary metabolites such as alkaloids, flavonoids, tannins, phenols, terpenoids, saponins and steroids.[6] Secondary metabolites such as alkaloids work by disrupting the insect's central nervous system by acting on neurotransmitter receptors so that muscle movements are not controlled and the larval body becomes paralyzed. [6] Flavonoids work as toxins for larval respiration so that larvae will experience respiratory problems and will eventually die,[6] In addition, flavonoids also have juvenile hormone activity which will affect the development and metamorphosis of insects so that the insect cannot reach the adult phase.[15] Saponins have the ability of enterotoxicity which is the ability to damage and kill eggs in mosquitoes to cause disruption of reproduction and fertility in female insects, 9 in addition, saponins can also work by lowering the surface tension of the larval mucosa, causing damage to the gastrointestinal tract which results in disruption of nutritional fulfilment. [18] Tannins work by disturbing the larval muscles, besides those tannins can also enter through the digestive tract of larvae causing impaired protein absorption in the intestine by decreasing the activity of digestive enzymes and food absorption so that larvae lack nutrients and can end in death.[11] And terpenoid class compounds in the form of linalool work by affecting the nervous system in insects by producing odours that are not liked by mosquitoes.[28]

CONCLUSION

Larvicide and mosquito-repellent activity has been reported in 27 plant species. 16 plant species have larvicide activity, with 2 plant species including the highly toxic category, 4 species including toxic categories and 9 plant species including the non-toxic category. While 11 other plant species have anti-mosquito activity, with 8 species effectively protecting against mosquitoes and 4 species not effectively protecting against mosquitoes. Some of these plants can be used as natural insecticides that are

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environmentally friendly and contain secondary metabolites such as alkaloids, flavonoids, tannins, phenols, terpenoids, saponins and steroids that are effective as substances kill larvae and repel mosquitoes.

REFERENCES

1. Yoeyoen AI, Tri W. Situasi penyakit demam berdarah di indonesia tahun 2017. InfoDatin RI. Jakarta.2018.
2. Kementrian Kesehatan Indonesia. Informasi singkat DBD 2020. Indonesia. 2020.
3. Alice M, Mudatsir M, R. Tedjo S, Allison I. Epidemiology of dengue hemorrhagic fever in Indonesia: analysis of five decades data from the national disease surveillance. Harapan et al. BMC Res Notes [serial online]. 2019; 350(12);6-2. DOI: https://doi.org/10.1186/s13104-019-4379-9
4. Menteri Kesehatan Republik Indonesia. PERMENKES NO.50 Tahun 2017, Tentang standar baku mutu kesehatan lingkungan dan persyaratan kesehatan untuk vektor dan binatang pembawa penyakit serta pengendaliannya. Indonesia: 2017.
5. Yoke A, Mutiara W. Potensi tanaman di indonesia sebagai larvasida alami untuk *aedes aegypti.* SPIRAKEL [Serial Online]. 2016; 2(8). DOI: 10.22435/spirakel.v8i2.6166.37-46
6. Sofia ER, Sulisetijono, Nur Q. Larvicidal activity of *Carica pubescens* leaf and petiole extract against *Aedes aegypti* L. larvae. AIP Conference Proceedings. 2021. doi: https://doi.org/10.1063/5.0053084
7. Dwi PSWM, Agung B, Erida W. Uji aktivitas larvasida ekstrak etanol kelakai (*stenochlaena palustris* (burm. F.) Bedd) terhadap larva nyamuk *aedes aegypti*. Homeostasis. 2021;4(1): 7-24.
8. Mitoriana P, Desi S. Larvicidal activity of *Melaleuca leucadendra* Leaves extract against *Aedes aegypti*. *Caspian J. Environ*. 2021;19(19): 277-285.
9. Alfina H, Erida W, Lisda H. Uji aktivitas ekstrak etanol daun bunga pukul empat (*mirabilis jalapa*) sebagai larvasida dan insect growth regulator terhadap larva *aedes aegypti*. Homeostasis. 2021;4(1): 245-356.
10. Yusnidar Y, Kriana E, Seta D. Larvicidal activity test of ethanolic extract of (*euphorbia tirucalli* linn) stem on *aedes aegypti* larvae. Sys Rev Pharm. 2020; 11(3): 388 392.
11. Sogandi, Fadhli G. Efek larvasida fraksi etil asetat daun bangun-bangun (*plectranthus amboinicus*) terhadap mortalitas larva *aedes aegypti.* Aspirator. 2020;12(1): 27 – 36. doi: 10.22435/asp.v12i1.1288.
12. Setiawan KH, Didi T, Dita M, Anugerah F, Titik K, Ikhsan G, Sulaeman Y. Larvicidal activity of *Brugmansia candida* against *Aedes aegypti* and *Culex quinquefasciatus* (Diptera: Culicidae). Journal of Biology & Biology Education Biosaintifika. 2020;12(3): 363-369.
13. Sayono S, Risyandi A, Didik S. Larvacidal activity of ethyl acetate extract of *Derris elliptica* root against the thrid-instar larba of cypermethrin-resistant *Aedes aegypti* offspring. J Arthropod-Borne Dis. 2020;14(4): 391–399.
14. Riesna M, Penny HH. Larvicidal, adulticidal, and oviposition-deterrent activity of *Piper betle* L.essential oil to

E-ISSN: 2528-410X

Aedes aegypti. Veterinary World. 2019;12(3): 367-371. doi: 10.14202/vetworld.2019.367-371

15. Renhart J, Royda DED, Lies I. Aktivitas larvasida ekstrak daun tumih (*Combretocarpus rotundatus* (Miq.) Danser) terhadap larva *Aedes aegypti.* Jurnal Ilmu Kehutanan. 2019;13: 77-86.
16. Monica PS, Rina PS. Efektivitas ekstrak daun maja (*Aegle marmelos* (L) Corr) sebagai larvasida *Aedes aegypti*. Jurnal Kedokteran Yarsi. 2019;27(1): 001-009.
17. Sayono S, Fitria AS, Risyandi A. In-vitro study on the larvicidal activity of *Manihot glaziovii* peel extract against *Aedes aegypti* larvae. Annals of Parasitology. 2019;65(4): 403–410. doi: doi: 10.17420/ap6504.227
18. Novyan L, Nidyasari C, Fitratul A, Hikmah C. Larvicidal activity of different solvent extracts of *Leucaena leucocephala* against *Aedes aegypti*. Journal of Entomology and Zoology Studies. 2018; 6(3): 589-593.
19. Desyana NS, Muhamat, Khoerul A. Uji aktivitas fraksi petroleum eter daun beluntas (*pluchea indica* (l.) Less.) Sebagai larvasida terhadap nyamuk *aedes aegypti*. Jurnal Pharmascience. 2018;5(2): 86-97.
20. Isfarani N, Istana, Erida W. Aktivitas larvasida ekstrak etanol daun binjai (*mangifera caesia*) terhadap larva *aedes aegypti*. Berkala Kedokteran. 2017; 13(1): 61-68.
21. Dina P, Eka AP, Meta S. Uji aktivitas larvasida ekstrak etil asetat herba anting-anting (*alcalypha indica*. L) terhadap larva nyamuk *aedes aegypti*. Farmagaine. 2015;2(1): 16-23.
22. Sofi NS, Ghina SN, Erwin E, Dimas DI, Yusransyah. Formulasi dan aktivitas lotion antinyamuk *aedes aegypti* dari ekstrak kulit buah limus (*Mangifera foetida Lour).* Jurnal Ilmiah Kebidanan Delima. 2022;10(1): 46-57.
23. Adma HDY, Erida Q, Lisda H. Ujl aktivitas repelen ekstrak etanol daun seledrl (*Apium graveolens*) terhadap nyamuk *Aedes aegypti*. Homeostasis. 2021;4(1): 245-254.
24. Rd Halim, Adela F. Aktivitas minyak sereh wangi sebagai anti nyamuk. Jurnal Kesmas Jambi (JKMJ). 2020;4(1): 28-34.
25. Risa A, Kiki MY, Esti RS. Potensi minyak atsiri herba kemangi (*Ocimum basillicum* L.) hasil destilasi uap dan air sebagai anti nyamuk terhadap nyamuk *Aedes aegypti*. Prodising Farmasi. 2020;6(2): 854-860. doi: http://dx.doi.org/10.29313/.v6i2.24011
26. Annia A, Betta K, M Yusran. Efektivitas dari tanaman zodia (*Evodia Suaveolens*) sebagai insektisida nabati nyamuk *Aedes aegypti* penyebab demam berdarah. Medula. 2019;9(2): 351-358.
27. Dewi C, Tutik. The mosquito repellent potential of cocoa peel gel extract (*Theobroma cacao* L.) against *Aedes aegypti*. Jurnal Analis Farmasi. 2019;4(2): 84-90.
28. Eva L, Bondan FW, Adil U, Dian ID. Potensi minyak atsiri bunga lawang (*Illicium verum*) sebagai repelen nyamuk *Aedes aegypti*. *BALBA*. 2019;15(1): 13-22. doi: http://doi.org/10.22435/blb.V15i1.408
29. Marmi K, Eka Z. Uji efektivitas ekstrak buah lerak (*Sapindus rarak,* D.C)

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sebagai repelan anti nyamuk *Aedes aegypti*. *Proceeding of Biology Education*. 2018;2(1): 42-49. doi: https://doi.org/10.21009/pbe.2-1.6

30. Berliana NRSA, Kenny C. Uji efektivitas infusa kulit buah jeruk nipis (*Citrus aurantifolia*) dengan pembanding spray anti nyamuk bermerk terhadap nyamuk *Aedes aegypti*. Jurnal Sains dan Teknologi Laboratorium Medik. 2017;2(1): 14-18.
31. Nurhayatun N, Saiasa, Diah R, Saifauqi N, Rulia M. Formulasi lotion ekstrak air daun tahi ayam (*Tageteserecta* L.) sebagai repellent nyamuk. Journal of Healthcare Technology and Medicine. 2018;4(1).
32. Siska DL, Ocky DS, Retno S. Efektivitas air perasan buah belimbing wuluh (*Averrhoa bilimbi* L.) Sebagai anti nyamuk *Aedes aegypti*. Analisis Kesehatan Sains. 2017;6(1).
33. Atikasari, E., dan Sulistyorini, L. Pengendalian vektor nyamuk aedes aegypti di rumah sakit kota surabaya. The Indonesian Journal of Public Health. 2018. *13*(1), 71-82.
34. Adrianto, H., Trop, M. K., Subekti, S. Pengendalian nyamuk *Aedes*: dari teori, laboratorium, hingga implementasi di komunitas. CV Jejak (Jejak Publisher); 2023.
35. Krisman, Y., Ardiningsih, P., Syahbanu, I. Aktivitas bioinsektisida ekstrak daun belimbing wuluh (*Averrhoa bilimbi*) terhadap kecoak (*Periplaneta americana*). Jurnal Kimia Khatulistiwa, 2016; *5*(3).
36. Haidah, N., dan Sulistio, I. Book Chapter Temu kunci (*Boesenbergia pandurate* Roxb) sebagai obat anti nyamuk *Aedes aegypti* dan Culex. Nas Media Pustaka; 2022.
37. Zulfiana, D., Krishanti, N. P. R. A., Wikantyoso, B., Zulfitri, A. Bakteri entomopatogen sebagai agen biokontrol terhadap larva *Spodoptera litura* (F.). Berita Biologi, 2017; *16*(1), 13-21.