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Effectiveness of Essential Oils as Natural Bioinsecticides for Aedes aegypti Mosquitoes Causing Dengue Fever (DHF): A Systematic Literature Review

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ABSTRACT

Dengue Hemorrhagic Fever (DHF) is one of the endemic diseases in Indonesia caused by the Aedes aegypti mosquito. Excessive use of synthetic insecticides in mosquito control efforts can have negative impacts on the environment and human health. Therefore, more environmentally friendly alternatives are needed, such as natural bioinsecticides from essential oils. This article is a literature review that aims to examine the effectiveness of various essential oils, including those from clove flowers (Syzygium aromaticum), lime (Citrus aurantifolia), betel leaf (Piper betle Linn), lemongrass (Cymbopogon citratus), and young areca nut (Areca catechu) as bioinsecticides against Aedes aegypti mosquitoes. The method used was a Systematic Literature Review (SLR) with a PRISMA approach to literature published between 2010 and 2025. Of the 4.916 articles found, five experimental articles were selected for in-depth analysis. The results showed that all essential oils had potential as bioinsecticides, with clove oil showing the highest effectiveness (LC_{50} value = 3.434%) and young areca nut oil showing the fastest action (LT_{50} = 56.967 minutes). The content of active compounds such as eugenol, linalool, tannin, and terpenoids in essential oils plays an important role in the mechanism of toxicity and repellency against mosquitoes. Clove oil is the most effective, safe, and environmentally friendly alternative in controlling mosquitoes that cause dengue fever.

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INTRODUCTION

Mosquitoes are among the primary insects responsible for the transmission of diseases. Numerous human diseases are caused by mosquitoes, including malaria transmitted by *Anopheles* mosquitoes; filariasis (elephantiasis) transmitted by *Culex* sp., *Mansonia* sp., *Aedes* sp., and *Anopheles* sp.; chikungunya transmitted by *Aedes aegypti*, *Aedes albopictus*, *Culex* sp., and *Mansonia* sp.; and dengue fever transmitted by *Aedes aegypti* [1]. Data from the World Health Organization (WHO) indicate that mosquitoes, as vectors of several infectious diseases, are responsible for millions of deaths each year. This is partly because adult mosquitoes can fly more than 20 miles from their breeding sites in water. In addition, mosquito distribution can expand passively due to external factors such as wind, or through the movement of goods or materials containing water [2].

In Indonesia, dengue hemorrhagic fever (DHF) continues to be a major public health concern. By the 17th week of 2024, a total of 88.593 DHF cases and 621 deaths had been reported across 174 districts/cities in 28 provinces. In 2023 and early 2024, DHF cases decreased by approximately 35%. However, by the 22nd week of 2024, the number of cases increased again to

119.709, exceeding the total number of DHF cases in 2023, which reached 114.720 [3]. Although the number of DHF cases continues to rise, the mortality rate has declined. There were 894 deaths due to DHF in 2023, while 777 deaths had been recorded by the 22nd week of 2024. The five districts/cities with the highest number of DHF cases in 2024 are Bandung, Depok, Tangerang, West Jakarta, and East Jakarta. Meanwhile, the five districts/cities with the highest incidence rates (IR) are Kendari, Gianyar, West Kutai, Klungkung, and Tomohon. In 2024, the highest number of DHF-related deaths occurred in Bandung, Klaten, Subang, Kendal, and Jepara [3].

To address the DHF problem, insecticides are commonly used to control insects, particularly mosquitoes. In the community, anti-mosquito insecticides are available in various forms, such as coils, electric vaporizers, sprays, and lotions. However, these products contain various active chemical compounds, including organochlorines, organophosphates, carbamates, pyrethroids, and DEET [4]. The use of synthetic insecticides can cause environmental damage, as they not only kill mosquitoes but also harm other beneficial insects. Furthermore, synthetic insecticides may disrupt the human respiratory system. Therefore, to reduce reliance on synthetic insecticides, natural bioinsecticides have been developed, including those derived from essential oils.

This study aims to identify and evaluate the effectiveness of various essential oils as bioinsecticides against *Aedes aegypti* and to compare their toxicity based on LC_{50} and LT_{50} parameters reported in experimental studies. The essential oils examined include clove oil (*Syzygium aromaticum*), lime oil (*Citrus aurantifolia*), lemongrass oil (*Cymbopogon citratus*), young areca nut (*Areca catechu*), and betel leaf oil (*Piper betle* Linn.). Essential oils contain terpenoid and phenylpropanoid derivatives, which contribute to their effectiveness as mosquito control agents. These compounds exhibit both insecticidal and repellent properties, enabling them to repel or even kill mosquitoes. Terpenoid and phenylpropanoid derivatives play crucial roles in repelling and eliminating mosquitoes through various biological mechanisms. As repellents, terpenoid compounds such as linalool and geraniol interfere with the mosquito olfactory receptors by producing odors that disrupt their ability to detect carbon dioxide and human body odor, thereby reducing biting activity. In contrast, phenylpropanoid compounds such as eugenol and safrole produce strong odors that are disliked by mosquitoes, making them effective repellents. Terpenes such as α-pinene and limonene also act as neurotoxins, disrupting the mosquito nervous system by interfering with neurotransmitters and ion channels in nerve cell membranes, leading to paralysis and death.

Moreover, because essential oils are derived from natural sources and are readily biodegradable, they are considered a safer and more environmentally friendly alternative to synthetic insecticides. As a result, they do not leave harmful long-term residues in the environment. Compared to synthetic insecticides, which often contain toxic chemicals, essential oils are generally safer for humans and pets. They may also help reduce resistance by disrupting the mosquito nervous system, inhibiting larval development, or acting as repellents. However, to date, there have been limited studies that systematically compare the effectiveness of various essential oils as bioinsecticides against *Aedes aegypti*. Therefore, more comprehensive studies are needed to further explore the potential of essential oils as natural bioinsecticides for mosquito control.

RESEARCH METHODS

In this review article, the Systematic Literature Review (SLR) method with a descriptive–narrative approach was employed to ensure that the literature selection process was conducted systematically and transparently. This process includes the identification, selection, evaluation, and analysis of the reviewed articles. The analyzed studies focus on the effectiveness of essential

oils, particularly those derived from clove (*Syzygium aromaticum*), young areca nut (*Areca catechu*), lime (*Citrus aurantifolia*), lemongrass (*Cymbopogon citratus*), and betel leaf (*Piper betle* Linn.), as natural bioinsecticides against *Aedes aegypti* mosquitoes.

This study utilized data sources obtained manually through electronic databases from various international and national journals, including Google Scholar, ScienceDirect, and ResearchGate. The keywords used in the literature search included "essential oils," "bioinsecticide," and "Aedes aegypti." The publication period considered ranged from 2010 to 2025 to ensure that the data obtained were relevant and up-to-date. A total of 4,916 articles were identified in the initial search. Subsequently, a refined search using additional keywords (*Syzygium aromaticum*, *Areca catechu*, *Citrus aurantifolia*, *Cymbopogon citratus*, and *Piper betle* Linn.) yielded 2,887 articles. Inclusion criteria were then applied to select relevant studies. These criteria included: articles published in indexed journals; studies employing experimental methods; studies in which the independent variable was plant-based insecticides; and studies in which the dependent variable was the mortality rate of *Aedes aegypti*. A total of 40 articles remained after this selection process.

The remaining articles were further evaluated using exclusion criteria. The exclusion criteria included: studies with significant limitations in research design; articles lacking complete data; studies that only discussed repellent effects without testing insecticidal effectiveness; paid articles that were not freely accessible; and studies on plant-based insecticides targeting insects other than *Aedes aegypti*. A total of 20 articles remained after applying the exclusion criteria. Finally, 5 articles that met both the inclusion and the more stringent exclusion criteria were selected for in-depth analysis.

The method used in this study is a descriptive–narrative approach based on a systematic literature review from various scientific databases. The article selection process considered topic relevance, experimental research design, and the availability of quantitative data such as LC_{50} and LT_{50} values. The selected articles were then analyzed comparatively to identify differences in effectiveness, variations in testing methods, and the active compounds responsible for insecticidal activity. This approach aims to provide a comprehensive overview of the potential of various essential oils as bioinsecticides against *Aedes aegypti*.

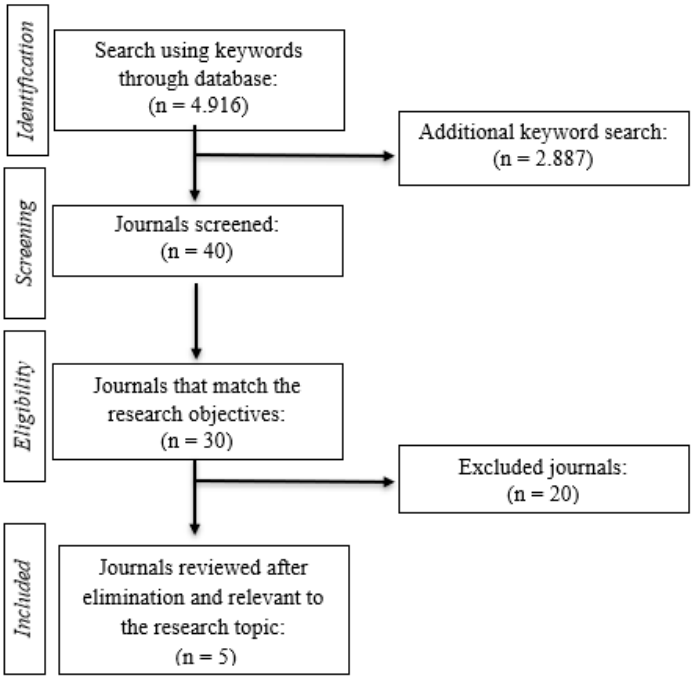

Figure 1. Article Search Flow

RESULTS AND DISCUSSION

Based on Table 1, there are five journals analyzed, consisting of two international journals and three national journals. These journals discuss the effectiveness of various essential oils used as bioinsecticides to control *Aedes aegypti* mosquitoes. Among the five journals, two are indexed in SINTA 5, one is indexed in SINTA 4, one is not indexed, and one is indexed in Scopus Q1. All five journals were published within the period from 2010 to 2025. The Q1 journal was published in 2019, the international SINTA 4 journal in 2021, the non-indexed journal in 2022, and the two national SINTA 5 journals in 2020 and 2021. All of these studies fall under the category of experimental research. The journals were obtained from databases such as Google Scholar, ResearchGate, and ScienceDirect. These articles employed experimental research methods. Experimental research is conducted to determine the effect of independent variables on dependent variables under strictly controlled conditions.

Table 1. Summary of article search results

First author (year), Article title	Journal name, volume, journal link, indexed	Research method
Ariwidhiani *et al* [5], Ekstrak bunga cengkeh sebagai insektisida terhadap mortalitas nyamuk *aedes aegypti* metode semprot	Jurnal Penelitian dan Kajian Ilmiah Kesehatan, Volume 7, No. 2 https://jurnal.politeknikmfh.ac.id/index.php/JPKIK/article/view/232 SINTA 5	Experimental Research
Riju Sarma *et al* [6], Insecticidal activities of *Citrus aurantifolia* essential oil against *Aedes aegypti* (Diptera: Culicidae)	Toxicology Reports, Volume 6, PP. 1091-1096 https://doi.org/10.1016/j.toxrep.2019.10.009 Scopus Q1	Experimental Research
Deki Gunawan *et al [7]*, Pemanfaatan Minyak Atsiri Daun Sirih (*Piper Betle Linn*) Sebagai Anti Nyamuk	Journal of Pharmaceutical and Health Research, Volume 2, No. 2, PP. 46-49 https://doi.org/10.47065/jharma.v2i2.862 SINTA 4	Experimental Research
Khoirul Anam [8], Pengaruh Konsentrasi dan Waktu Observasi Ekstrak Biji Pinang Muda (*Areca Cathecu*) dalam Bentuk Spray sebagai Bioinsektisida Nyamuk	Jurnal MID-Z (Midwifery Zigot) Jurnal Ilmiah Kebidanan, Volume 3, No. 1 https://doi.org/10.36835/jurnalmidz.v3i1.645	Experimental Research

	SINTA 5	
Winda Dwi Putri *et al* [9], Uji Efektivitas Sari Batang Serai Dapur *Cymbopogon Citratus* Sebagai Insektisida Alami Terhadap Mortalitas Nyamuk *Aedes aegypti*	**Jurnal:** KROMATIN: Jurnal Biologi dan Pendidikan Biologi Vol. 3, No. 1, Year 2022 https://journal.unismuh.ac.id/index.php/kromatin/article/view/8915/5106 Not indexed	Experimental Research

Based on Table 2, it is shown that all five journals employed the same independent and dependent variables. The independent variable was the concentration of essential oils, while the dependent variable was the mortality of *Aedes aegypti* mosquitoes. In the studies conducted by Riju Sarma et al. [6] and Deki Gunawan et al. [7], testing was carried out using the filter paper method impregnated with essential oils. Meanwhile, the other three studies used a similar method, namely by directly spraying the essential oils onto *Aedes aegypti* mosquitoes. In general, the objective of these five studies was to determine the effectiveness of essential oils in killing *Aedes aegypti* mosquitoes and to analyze the effect of concentration and exposure time of each essential oil on mosquito mortality. All five journals employed probit analysis as the statistical testing method. Probit analysis is used to estimate the effective dose by determining the concentration that causes mortality in a population of *Aedes aegypti* mosquitoes.

Table 2. Results of the research

First Author (Year)	Population, Sample, Variables	Research Methods and Objectives	Statistical Tests
Ariwidhiani *et al* [5]	**Population and Sample** Clove flower extract (*Syzygium aromaticum*) and 70 *Aedes aegypti* mosquitoes **Independent Variable** Concentration of clove flower extract (*Syzygium aromaticum*) **Dependent Variable** Mortality of *Aedes aegypti* mosquitoes	**Method** Mosquitoes were placed into 3 different containers, each containing 10 mosquitoes. Observations were made by recording the time when mosquitoes landed and left. Testing was conducted for 60 minutes. The same procedure was applied to the control using 70% alcohol. The preparation was tested for 7 days (day 1, 3, 5, and 7), while effectiveness testing was conducted only on day 1 and day 7. **Objective** To analyze the potential of clove flower extract (*Syzygium aromaticum*) as an insecticide	Chi-Square Test and Probit Analysis

		against *Aedes aegypti* using a spray method	
Riju Sarma *et al* [6]	**Population and Sample** Essential oils from leaves and peel of lime (*Citrus aurantifolia*) and 10 *Aedes aegypti* mosquitoes per concentration **Independent Variable** Concentration of essential oil from leaves and peel of *Citrus aurantifolia* **Dependent Variable** Mosquito mortality	**Method** Two concentrations (100 ppm and 1000 ppm) were prepared using acetone as a solvent. A total of 2 ml of each solution was applied to Whatman No.1 filter paper (12 × 15 cm) and dried for 10 minutes. The impregnated paper was placed in a cylindrical tube (10 cm depth), and 10 mosquitoes were introduced into each tube. Mortality was recorded at 1, 2, 3, 4, 5, 6, 24, 48, and 72 hours. LC_{50} values were determined using probit analysis. **Objective** To evaluate the toxicity of essential oils from lime leaves and peel against different life stages of *Aedes aegypti* (egg, larva, adult) under laboratory conditions	Probit Analysis, Abbott's Correction, and Descriptive Statistics
Deki Gunawan *et al* [7]	**Population and Sample** Essential oil from betel leaves (*Piper betle Linn*) and 10 mosquitoes per concentration **Independent Variable** Concentration of betel leaf essential oil (*Piper betle Linn*) **Dependent Variable** Mosquito mortality	**Method** Essential oil concentrations of 13%, 15%, and 17% were sprayed onto cloth and placed in testing boxes (40 × 50 cm). Ten mosquitoes were released into each box. Observations were conducted for 60 minutes, recording landing and leaving time. The control used 70% alcohol. **Objective** To utilize betel leaf essential oil and determine the effective concentration as a mosquito repellent.	Probit Analysis
Khoirul Anam [8],	**Population and Sample** Essential oil of young areca nut (*Areca catechu*) and 25 *Aedes aegypti*	**Method** Spray application at concentrations of 1000 ppm, 5000 ppm, and 10,000 ppm into containers with mosquitoes. Observations were conducted at 15, 30, 60, 120, and 240 minutes.	Probit Analysis and Repeated Measure GLM (*General Linear Model*)

	mosquitoes per concentration **Independent Variable** Concentration of areca nut essential oil (*Areca catechu*) **Dependent Variable** Mortality of *Aedes aegypti* mosquitoes	A control without extract was used for comparison. **Objective** To analyze the effect of concentration and observation time of areca nut extract as a natural bioinsecticide	
Winda Dwi Putri *et al [9]*	**Population and Sample** Essential oil of lemongrass stem (*Cymbopogon citratus*) and 25 mosquitoes per test variation **Independent Variable** Concentration of lemongrass stem essential oil (*Cymbopogon citratus*) **Dependent Variable** Mortality of *Aedes aegypti* mosquitoes	**Method** Essential oil concentrations (10%–80%), positive control (Baygon), and negative control (aquadest) were sprayed twice into containers with 25 mosquitoes. Observations were conducted for 3 hours at 60-minute intervals. **Objective** To determine the effect of lemongrass stem essential oil concentration as a bioinsecticide	One-way ANOVA and Probit Analysis

Based on Table 3, it can be observed that all analyzed journals report toxicity values in the form of Lethal Concentration (LC). Lethal Concentration refers to the concentration of a chemical substance in water that can cause death in a test organism population under specific conditions. The LC values used in these studies include LC_{20}, LC_{50}, and LC_{80}, which represent the concentrations required to cause mortality in 20%, 50%, and 80% of the *Aedes aegypti* mosquito samples, respectively.

It should be noted that comparisons of LC_{50} values across studies have limitations due to differences in concentration units (ppm and %) as well as variations in experimental design. Based on the analysis of the five experimental studies, it is evident that the effectiveness of each material in killing *Aedes aegypti* mosquitoes varies, both in terms of concentration and exposure time.

The most effective essential oil based on the lowest LC_{50} value is clove (*Syzygium aromaticum*), with an LC_{50} of 3.434%, indicating that only a relatively low concentration is

required to kill 50% of the mosquito population. Meanwhile, in terms of the speed of action, as indicated by the LT_{50} value, the most rapidly acting material is young areca nut (*Areca catechu*), with an LT_{50} of 56.967 minutes after treatment.

Table 3. Research Analysis Results

First Author (Year)	Research Object	Research Findings
Ariwidhiani et al. [5]	Clove	Significance value = 0.000 ($p < 0.05$); LC50 value = 3.434%
Riju Sarma et al. [6]	Lime	LC50 value = 103.88 ppm; LT50 = 24 hours
Deki Gunawan et al. [7]	Betel leaf	LC20 = 13% (6.5 mL); LC50 = 15% (7.5 mL); LC80 = 17% (8.5 mL)
Khoirul Anam [8]	Young areca nut	LC50 value = 7.602 ppm; LT50 = 56.967 minutes after intervention
Winda Dwi Putri et al. [9]	Lemongrass	LC50 value = 40.886%; LT50 = 1.003 hours

In this study, a descriptive comparative analysis was conducted by comparing the LC_{50} and LT_{50} values reported in each study. However, it is important to note that each study employed different experimental designs. These variations include differences in larval stages tested, application methods (direct contact, impregnation, or fumigation), exposure duration, and types of solvents used. The obtained toxicity values may be influenced by these methodological differences. Consequently, comparisons of relative effectiveness among essential oils cannot be considered fully equivalent quantitative comparisons. Therefore, the results of this analysis are primarily descriptive-comparative in nature and aim to provide a general overview of the potential of bioinsecticides against *Aedes aegypti*.

In these essential oils, most contain similar groups of secondary metabolites, such as terpenes, alkaloids, and phenylpropanoids. Various studies have shown that secondary metabolites possess strong potential as natural bioinsecticides due to their toxic properties toward insects. In addition to secondary metabolites, essential oils also contain aliphatic compounds and benzene derivatives. Based on the study by Aliah [10], clove flower extract contains saponins, alkaloids, glycosides, and flavonoids. The main constituents of clove extract are eugenol, eugenol acetate, and caryophyllene. Eugenol exhibits neurotoxic effects on mosquitoes, as it can affect sensory nerves, the peripheral nervous system, and the central nervous system of insects. It has the ability to poison nerve axons by inhibiting octopamine receptors—a type of sympathomimetic receptor that regulates sympathetic activity—leading to physiological disruption.

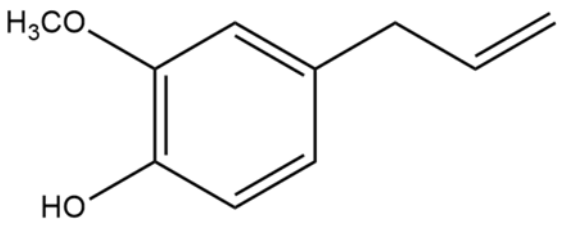

Figure 2. Structure of eugenol

The secondary metabolite content in young areca nut (*Areca catechu*) includes tannins, which act as major bioactive compounds. Tannins play a role in inhibiting the activity of the α-

amylase enzyme in *Aedes aegypti* mosquitoes. As a result, mosquito muscles experience energy deficiency and encounter difficulty in contraction and relaxation. This condition forces muscle cells to utilize alternative energy sources to maintain cellular metabolism [8]. Based on research conducted by Corel Moctezuma and colleagues [11], tannins also function as insecticides by forming protein–tannin complexes, which act as inhibitors of α-amylase. Consequently, insects experience reduced feeding activity (anti-feeding effect) and damage to the insect cuticle [11].

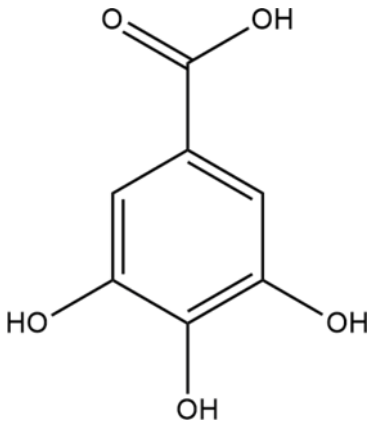

Figure 3. Structure of tannin

CONCLUSION

Based on the analysis of five articles examining the effectiveness of various essential oils as bioinsecticides against *Aedes aegypti* mosquitoes, it can be concluded that all studies employed an experimental research approach, with the independent variable being the concentration of essential oils and the dependent variable being the mortality rate of *Aedes aegypti*. The testing methods used included spray application and filter paper impregnation.

In general, all tested essential oils demonstrated effectiveness in killing mosquitoes, although their effectiveness varied depending on plant type, concentration, and exposure time. The most commonly used statistical analysis was probit analysis, which was applied to determine LC_{50} values (the lethal concentration required to kill 50% of the population). The following conclusions can be drawn from the comparative analysis: Clove essential oil (*Syzygium aromaticum*) exhibited the lowest LC_{50} value (3.434%), indicating that it is the most effective in killing mosquitoes at low concentrations. Meanwhile, essential oil from young areca nut (*Areca catechu*) showed the fastest action (LT_{50} = 56.967 minutes), making it the most rapid in causing mosquito mortality after application. All essential oils contain secondary metabolites such as terpenes, alkaloids, and flavonoids, which are toxic to insects. Active compounds such as eugenol in clove and tannins in young areca nut play important roles in the mechanism of toxicity against mosquitoes.

However, the heterogeneity of testing methods and variations in experimental design among the analyzed studies indicate the need for methodological standardization and more comprehensive future research, including field-scale evaluations and safety assessments for non-target organisms. Overall, essential oils show promising potential as natural bioinsecticides for controlling *Aedes aegypti*, but further scientific validation is required to ensure their effective and sustainable implementation in vector control programs.

REFERENCES

[1] Gunawan, D., & Kurniaty, R. (2021). Pemanfaatan Minyak Atsiri Daun Sirih (Piper Betle Linn) Sebagai Anti Nyamuk. *Journal of Pharmaceutical and Health Research*, *2*(2), 46–49. https://doi.org/10.47065/jharma.v2i2.862

[2] Sari, V., Gafur, A., Sari, D. R., Biologi, P., Hayati, I., Pahlawan, U., Tambusai, T., Mesin, J. T., Bengkalis, N., & Pertanian, P. P. (2023). Efektivitas Minyak Serai Sebagai Bioinsektisida Nyamuk. In *Journal of Engineering Science and Technology Management* (Vol. 3, Issue 1). https://jestm.org/index.php/jestm/index

[3] Kementerian Kesehatan Republik Indonesia. (2024). *Waspada DBD di Musim Kemarau*. Sehat Negeriku. https://sehatnegeriku.kemkes.go.id/baca/rilis-media/20240616/0045767/waspada-dbd-di-musim-kemarau/

[4] Lolo, W. A., & Wiyono, W. I. (2023). Peningkatan Kapasitas Masyarakat Dalam Upaya Pencegahan Demam Berdarah Dengue (DBD) Melalui Pelatihan Pembuatan Bio Spray Anti Nyamuk Di Kelurahan Mapanget Kecamatan Talawaan Kabupaten Minahasa Utara. *The Studies of Social Sciences*, *5*(2), 41–51. https://doi.org/10.35801/tsss.v5i2.51692

[5] Ariwidiani, N. N., Getas, W., & Kristinawati, E. (2021). Ekstrak Bunga Cengkeh Sebagai Insektisida Terhadap Mortalitas Nyamuk *Aedes aegypti* Metode Semprot. *7*(2), 2021. www.lppm-mfh.com

[6] Sarma, R., Adhikari, K., Mahanta, S., & Khanikor, B. (2019). Insecticidal activities of Citrus aurantifolia essential oil against *Aedes aegypti* (Diptera: Culicidae). *Toxicology Reports*, *6*, 1091–1096. https://doi.org/10.1016/j.toxrep.2019.10.009

[7] Gunawan, D., & Kurniaty, R. (2021). Pemanfaatan Minyak Atsiri Daun Sirih (Piper Betle Linn) Sebagai Anti Nyamuk. *Journal of Pharmaceutical and Health Research*, *2*(2), 46–49. https://doi.org/10.47065/jharma.v2i2.862

[8] Anam, K. (2020). Pengaruh Konsentrasi dan Waktu Observasi Ekstrak Biji Pinang Muda (*Areca cathecu*) dalam Bentuk Spray sebagai Bioinsektisida Nyamuk Aedes Aegypti. *Jurnal MID-Z (Midwifery Zigot) Jurnal Ilmiah Kebidanan*, *3*(1).

[9] Putri, W. D., Khaerah, A., & Akbar, F. (2022). Uji efektivitas sari batang serai dapur *Cymbopogon citratus* sebagai insektisida alami terhadap mortalitas nyamuk *Aedes aegypti*. *Kromatin: Jurnal Biologi dan Pendidikan Biologi*, 3(1), 1–8. https://journal.unismuh.ac.id/index.php/kromatin/article/view/8915/5106

[10] Aliah, N. (2016). Uji Efektivitas Ekstrak Daun Cengkeh (Syzigium aromaticum) sebagai Repellent Semprot Terhadap Lalat Rumah (Musca domestica). Universitas Islam Negeri Alauddin Makassar.

[11] Moctezuma,Correl& Hammerbacker,A. (2014). Specific Polyphenols and Tannins are Associated with Defense Againts Insects Herbivores in the Tropical Oak Quercus oleoides. J Chem Ecol. New York : Springer Science and Busines Media.