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Pometia pinnata Leaf Extract As a Natural Larvicide For *aedes aegypti* Mosquitoes, A Vector Of Dengue Haemorrhagic Fever (DHF) Disease

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ABSTRACT: Dengue Haemorrhagic Fever (DHF) is a rapid-onset infection caused by the Dengue virus that can lead to severe shock and even death. *Pometia pinnata*, a plant found in the Maluku region, possesses untapped therapeutic potential despite the presence of secondary metabolite chemicals believed to have larvicidal properties. This study aims to evaluate the biolarvicidal efficacy of the leaf extract of *Pometia pinnata* against *Aedes aegypti's* larvae, a DHF carrier. The extraction process used the maceration technique employing ethanol as the solvent. A larvicidal experiment was performed to evaluate the bioactivity against *Aedes aegypti* larvae. The findings indicated that the leaf extract of *Pometia pinnata* possesses larvicidal properties against *Aedes aegypti* larvae, as evidenced by an LC50 value of 0.101%. The results offer insights into the possible utilisation of *Pometia pinnata* leaf extract as a viable source of active compounds for developing biolarvicides to control dengue vectors.

Keywords: *Pometia pinnata,* Dengue fever, *Aedes aegypti*

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INTRODUCTION

In the present, infectious diseases continue to pose a significant challenge to public health. Mosquitoes and other insects continue to be major factors in causing severe health issues. As a tropical nation, Indonesia is susceptible to mosquito-borne diseases (Syahrani et al., 2022; Wijayanti et al., 2016). *Aedes aegypti* is a mosquito species that serves as a carrier of severe diseases such as chikungunya, yellow fever, zika virus, and dengue virus(Kraemer et al., 2019). Dengue haemorrhagic fever (DHF) is a rapid-onset infection caused by the Dengue virus that has the risk of inducing shock and mortality(Wang et al., 2020).

The global incidence of dengue disease is consistently rising on an annual basis. The annual incidence of reported cases to the World Health Organisation (WHO) between 1996 and 2005 ranged from around 0.4 million to 1.3 million. In 2010, the number had increased to 2.2 million;

by 2015, it had risen to 3.2 million. The nations with the most significant average number of dengue cases reported to the World Health Organisation (WHO) in a single year between 2004 and 2010 were Brazil (447,446 cases), Indonesia (129,435 cases), Vietnam (91,321 cases), Mexico (75,353 cases), and Venezuela (61,612 cases) (Organization, 2020). The incidence of dengue in Indonesia has surged to 95,893 cases, distributed throughout 472 districts and cities in 34 provinces. Furthermore, fatalities have been reported in 219 districts and towns. The government promotes preventative and promotive measures to enhance public health. Moreover, the government exercises control over dengue vectors, employing insecticides. Using insecticides to eliminate *Aedes aegypti* mosquitoes has resulted in broader distribution and escalated mortality rates(Aldridge et al., 2024; Jaffal et al., 2023).

Abate, also known as temephos, is a commonly employed insecticide to manage or eliminate the larvae of *Aedes aegypti* mosquitoes. Excessive use of pesticides can lead to environmental contamination, the persistence of chemicals, and the development of resistance in the intended insects(Martini et al., 2019). Using abate as a larvicide can lead to adverse effects such as human poisoning, mainly due to the extensive application of abate, which can contaminate water sources, especially drinking water(Choi et al., 2019). To promote illness prevention and control, one of the measures taken is to harness the potential of natural substances derived from Indonesian plants, which are recognised to possess diverse qualities. Various plant species have been demonstrated to possess bioactive substances that efficiently decrease the population of *Aedes aegypti* larvae, including matoa leaves (*Pometia pinnata*)(Aravinth et al., 2023; Penilla-Navarro et al., 2024).

Pometia pinnata, a plant with untapped therapeutic potential, is underutilised in the Maluku region. The plant's fame primarily stems from its fruit, which possesses a particular flavour(Khu et al., 2021; Suedee et al., 2013). In the past, researchers only concentrated on studying the secondary metabolites of plants for their therapeutic properties. Matoa comprises saponins, triterpenoids, tannins, and flavonoids(Razoki, 2023). The presence of flavonoids and saponins in *Pometia pinnata* leaves is thought to possess the ability to harm the membranes of larvae, hinder endocrine function, initiate chemical reactions that disturb the metabolic processes of the larval body, and disturb the respiratory system in larvae. Consequently, this can diminish growth and lead to mortality in mosquito larvae(Ananda et al., 2023; Bodlah et al., 2023).

Based on phenomeme on, researcher take title about" *Pometia pinnata* leaf extract as a natural larvicide for *aedes aegypti* mosquitoes, a vector of Dengue Haemorrhagic Fever (DHF) Disease". This study aims to evaluate the biolarvicidal efficacy of the leaf extract of *Pometia pinnata* against the larvae of *Aedes aegypti* L, which is the carrier of dengue fever(Janatiningrum et al., 2024; Mohammad et al., 2012). The results of this research can also serve as a basis for further studies regarding the mechanism of action of *Pometia pinnata* leaf extract as a bio larvicide and its potential in field applications. Additionally, it can drive practical implementation efforts in disease vector control programs, whether through government or private initiatives(Asgari, 2023).

METHOD

Type of Research

This research is an experimental research with a post-test-only control group design.

Research Design

This study employed a Completely Randomised Design (CRD) using five treatments and three replications. The division of groups in this study is as follows.

a. Group I: ethanol extract of *Pometia pinnata* leaves with a concentration of 0 g/L.
b. Group II: ethanol extract of *Pometia pinnata* leaves with a concentration of 2.5 g/L.
c. Group III: *Pometia pinnata* leaf ethanol extract concentration of 5 g/L.
d. Group IV: *Pometia pinnata* leaf ethanol extract concentration of 10 g/L.
e. Group V: *Pometia pinnata* leaf ethanol extract concentration of 20 g/L.

Tools and Materials

The equipment utilised in this study comprised an analytical balance, pipette, 1000cc measuring cup, plastic tray, 15 plastic containers (as receptacles), glass jar, cloth (as a safeguard to prevent adult mosquitoes from escaping), blender or juicer, glass stirring rod, extractor (maceration apparatus), evaporator, label paper, and knife. The ingredients utilised comprise ethanol, leaves of *Pometia pinnata*, purified or distilled water, *Aedes aegypti* larvae, and fish food as nourishment for the larvae(Rao et al., 2023; Rodrigues dos Santos et al., 2023).

Working Procedure

Mosquito larvae preparation

The *Aedes aegypti* eggs were acquired from the Laboratory of Animal Sourced Disease Control (P2B2) of the Health Research and Development Agency (Balitbangkes) in Banjarnegara. The eggs were placed in plastic trays filled with approximately 1000cc of purified water. Following the hatching process, the larvae were provided with fish food daily. The larvae were cultivated until stage III, which took around six days, before being utilised in the research.

Test Material Preparation

The leaves of *Pometia pinnata* were collected and subjected to a drying process by aeration at ambient temperature. After drying, the leaves were pulverised using a blender, and the resulting powder was measured by weight. The powder was subsequently extracted using maceration utilising ethanol solvent to get a liquid extract. The ethanol solution of Pometia pinnate leaves was obtained by collecting and evaporating the liquid extract using a rotating evaporator (rotavapor) at 40oC. This process resulted in the concentrated ethanol extract from Pometia pinnate leaves. Subsequently, the ethanol extract, which had been concentrated, was measured and then mixed with distilled water to provide the required dosage for the study.

Removal of Larvae in Containers

1. Larvae in plastic trays are transferred to glass containers
2. Using a pipette, take ten larvae and place them into each container
3. After all larvae were transferred to the containers, each group of containers was covered with a cloth.
4. Larvae were fed fish food throughout the study.

Larvicidal Activity Testing

Ten larvae of *Aedes aegypti* mosquitoes were moved from the container to a glass cup holding the correct extract concentration. During 24 hours, observations were conducted, commencing the time count after the larvae were introduced into the goblets.

Data Collection

The data acquired entailed quantifying the mortality rate of larvae in each container throughout the observation period. The counts were documented in a table, with larvae being classified as deceased if they sank to the bottom of the container, displayed no movement, were visibly separated from other mobile larvae, and did not react to any stimuli.

Subsequently, the death rate of mosquito larvae was determined by applying the formulated equation to the prepared concentration.

$$\text{Mortality} = \frac{Number\ of\ animals\ that\ died}{Total\ number\ of\ test\ animals} \text{ x } 100\%$$

Data Analysis

The observation data will undergo analysis utilising Analysis of Variance (ANOVA) through the SPSS 24.00 software. If a statistically significant difference is observed, additional tests will be conducted using the Least Significant Difference Test (BNT) with a confidence level of 0.05%.

RESULT AND DISCUSSION

Mortality of *Aedes aegypti* Mosquito Larvae

The results of observations on the average mortality of *Aedes aegypti* mosquito larvae during 24 hours of observation can be seen in Table 1.

Table 1. Average mortality of *Aedes aegypti* mosquito larvae

Concentration	Repeat			Total	Average number of mortalities	Mortality (%)
	1	2	3			
0%	3	4	3	10	3,33[a]	33,3
2,5%	10	10	10	30	10[b]	100
5%	10	10	10	30	10[b]	100
10%	10	10	10	30	10[b]	100
20%	10	10	10	30	10[b]	100

Table 1 reveals that the average mortality rate of *Aedes aegypti* mosquito larvae is 3.33 individuals (33.3%) at a concentration of 0%. At concentrations of 2.5%, 5%, 10%, and 20%, the mortality rate of mosquito larvae is ten individuals (100%).

The Analysis of Variance (ANOVA) findings indicated the F value > F table value. This implies that the *Pometia pinnata* leaf extract significantly impacts the mortality of *Aedes aegypti* mosquito larvae(Finetti et al., 2023; Thambi et al., 2024). The subsequent tests utilising the Least substantial Difference (BNT) test revealed a significant difference in the average mortality rate of *Aedes aegypti* mosquito larvae when exposed to *Pometia pinnata* leaf extract at a concentration of 0% compared to doses of 2.5%, 5%, 10%, and 20%. However, there was no significant difference in the average

mortality of *Aedes aegypti* mosquito larvae when exposed to *Pometia pinnata* leaf extract concentrations of 0.75%, 1%, 2%, and 2%(Krokovsky et al., 2023).

The mean death rate of *Aedes aegypti* mosquito larvae in Table 1 can be observed with greater clarity in Figure 1.

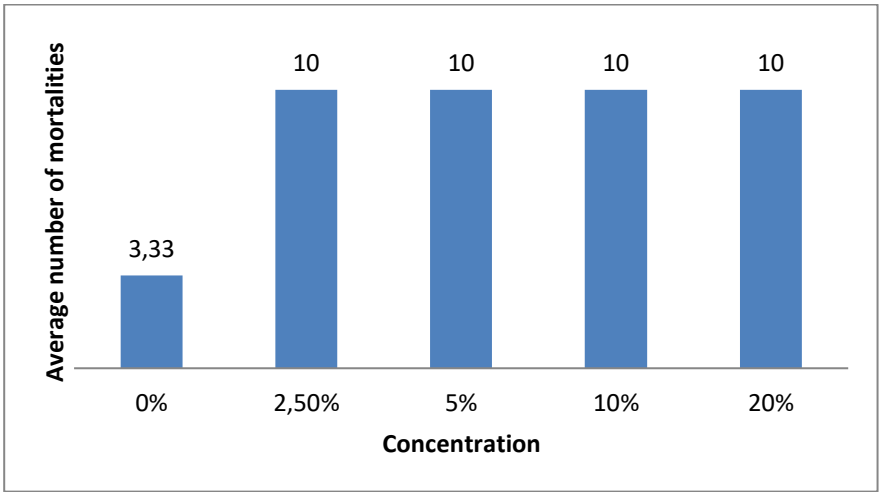

Figure 1: Mortality graph of *Aedes aegypti* mosquito larvae after being treated with *Pometia pinnata* leaf extract.

Table 1 demonstrates that the ethanol extract derived from *Pometia pinnata* leaves can induce mortality in *Aedes aegypti* mosquito larvae, which are the carriers of the dengue disease. Overall death of mosquito larvae was seen at doses of 2.5%, 5%, 10%, and 20%. The findings indicated that during the initial 2-hour period of observation, the mean mortality rate of *Aedes aegypti* mosquito larvae was eight individuals (80%) at 2.5% and 5% concentrations, 8.67 individuals (86.7%) at 10% concentration, and 8.33 individuals (83.3%) at 20% concentration. As per Kusumawati et al. (2018), an increase in the concentration of the extract leads to a corresponding increase in the number of active chemicals present in the extract, which in turn affects the mortality rate of mosquito larvae.

The ANOVA test reveals a significant impact of administering *Pometia pinnata* extract on the death rate of *Aedes aegypti* mosquito larvae. Following the observed effect, the LSD statistical test is employed to ascertain the disparity in impact among the treatments. According to the LSD test, it has been determined that the average death rate of *Aedes aegypti* mosquito larvae in *Pometia pinnata* leaf extract at a concentration of 0% is substantially distinct from the concentrations of 2.5%, 5%, 10%, and 20%. However, there was no significant difference in the average mortality rate of *Aedes aegypti* mosquito larvae when exposed to *Pometia pinnata* leaf extract concentrations of 0.75%, 1%, 2%, and 2%.

The mortality of *Aedes aegypti* larvae in this study was caused by the presence of secondary metabolite chemicals in the extract of *Pometia pinnata*. Each of these secondary metabolite molecules plays a distinct role in facilitating the effectiveness of natural larvicides(Lim et al., 2023; Souza Wuillda et al., 2019). The presence of flavonoids in *Pometia pinnata* acts as a receptor antagonist in the oral region of the larvae, impairing their ability to perceive taste stimuli. Consequently, the larvae cannot perceive the food in their vicinity, impeding their ability to attain

the optimal weight necessary for advancing to the subsequent phase. Furthermore, secondary metabolite chemicals, including saponins and tannins, function as gastric toxins, leading to decreased growth rates and nutritional problems in larvae (Divekar *et al.*, 2023).

Saponins exert their effects through two primary pathways. Saponins initially activate the mucous membranes of the digestive tract, inducing a bitter sensation that diminishes the larval appetite and ultimately results in mortality(Francis et al., 2002; Mikołajczyk-Bator, 2022). Furthermore, saponins can harm the protective layer of wax that covers the insect's body, causing substantial loss of fluids and ultimately causing the death of the larvae. Consequently, as the concentration increases, the larvae ingest a more significant number of secondary metabolite chemicals, resulting in an elevated death rate of the larvae(Cui et al., 2019).

Tannin molecules are crucial in suppressing enzyme activity and eliminating substrates, particularly proteins(Divekar et al., 2022; Huang et al., 2018). Tannins hinder the regular functioning of enzymes by attaching to them, causing disruptions in cellular metabolic processes and leading to nutritional deficits in larvae. Stunted larval growth is the outcome, and if this progression persists, it might result in larval mortality(Delimont et al., 2017).

Lethal Concentration 50 (LC_{50}) *value*

The efficacy of the ethanol extract derived from *Pometia pinnata* leaves in causing the death of *Aedes aegypti* mosquito larvae is assessed by determining the LC_{50} value. The LC_{50} value represents the concentration required to kill 50% of the *Aedes aegypti* mosquito larvae. This determination is made using Probit analysis. Table 2 displays the outcomes of the probit analysis.

Table 2. LC_{50} value of ethanol extract of *Pometia pinnata* leaves

Probability	Estimate	95% Confidence Interval for Treatment	
		Lower Bound	Upper Bound
50	0,101	0,007	0,382

The data presented in Table 2 indicates that the LC_{50} value of the ethanol extract derived from *Pometia pinnata* leaves is 0.101%, with a lower confidence limit of 0.007 and an upper confidence limit of 0.382. A concentration of 0.101% ethanol extract derived from *Pometia pinnata* leaves can cause mortality in 50% of *Aedes aegypti* mosquito larvae. According to Tanamatayarat's (2016) toxicity categorisation, the *Pometia pinnata* leaf extract is poisonous based on its LC_{50} value below ten ppm(Tanamatayarat, 2016). Furthermore, according to Clarkson, LC_{50} values exceeding 1000 ppm are classified as non-toxic based on the toxicity classification. LC^{50} levels ranging from 0 to 100 ppm are highly hazardous. Based on the LC_{50} value of 0.101% for the *Pometia pinnata* leaf extract, it may be inferred that the extract falls into the very hazardous classification according to the criteria established by Clarkson(Meena et al., 2020).

The findings of this study suggest that the leaf extract of *Pometia pinnata* has significant promise as a larvicide for effectively managing the larval population of *Aedes aegypti* mosquitoes, which are responsible for transmitting dengue fever. The positive meaning of this capability can be harnessed in the development of bio-larvicides as a substitute in *Aedes aegypti* mosquito control programmes and endeavours to mitigate the proliferation of dengue disease. However, additional study is necessary to identify the active chemicals, comprehend the mechanism of action, and ensure safety

issues. This is crucial to fully maximise this approach's potential before implementing it on a larger scale.

CONCLUSION

Based on the findings and analysis, the leaf extract of *Pometia pinnata* demonstrated promise as a biolarvicide against the larvae of *Aedes aegypti*, the carrier of Dengue Fever (DHF). The larvicidal activity exhibited a notable efficacy in suppressing the development of mosquito larvae, as evidenced by the considerable LC_{50} value of 0.101%. The results suggest that the leaf extract of *Pometia pinnata* contains secondary metabolite chemicals that possess larvicidal capabilities, which can be effectively used in efforts to control dengue vectors(Khoo et al., 2023; Sujatmiko et al., 2021).

The implications of this research drive the development of bio larvicide products based on the extract of *Pometia pinnata* leaves to control the population of *Aedes aegypti* mosquito larvae. These products can be considered environmentally friendly alternatives and safe for humans in efforts to prevent the transmission of Dengue Hemorrhagic Fever (DHF).

REFERENCE

Aldridge, R. L., Gibson, S., & Linthicum, K. J. (2024). AEDES AEGYPTI CONTROLS AE. AEGYPTI: SIT AND IIT-AN OVERVIEW. *Journal of the American Mosquito Control Association*, *40*(1), 32–49. https://doi.org/10.2987/23-7154

Ananda, N. D., Rachmawati, K., Lastuti, N. D. R., Suwanti, L. T., Hidajanti, N., & Meles, D. K. (2023). The Effectiveness of Ethanol Extract of Ketapang Leaves (Terminalia catappa L.) as a Larvicidal Against Aedes aegypti Mosquito Larvae. *Journal of Basic Medical Veterinary*, *12*(1), 1–7. https://doi.org/10.20473/jbmv.v12i1.42248

Aravinth, A., Dhanasundaram, S., Perumal, P., Vengateshwaran, T. D., Thavamurugan, S., & Rajaram, R. (2023). Biological activities of the brown seaweed Dictyota ciliolata with special reference to the human diseases transmitting Aedes aegypti's larvae. *Biomass Conversion and Biorefinery*. https://doi.org/10.1007/s13399-023-03928-0

Asgari, S. (2023). Cross-kingdom RNAi to enhance the efficacy of insect pathogens. *Trends in Parasitology*, *39*(1), 4–6. https://doi.org/10.1016/j.pt.2022.11.001

Bodlah, M. A., Iqbal, J., Ashiq, A., Bodlah, I., Jiang, S., Mudassir, M. A., & Fareen, A. G. E. (2023). Insect behavioral restraint and adaptation strategies under heat stress: An inclusive review. *Journal of the Saudi Society of Agricultural Sciences*. https://doi.org/10.1016/j.jssas.2023.02.004

Choi, L., Majambere, S., & Wilson, A. L. (2019). Larviciding to prevent malaria transmission. *The Cochrane Database of Systematic Reviews*, *8*. https://doi.org/10.1002/14651858.CD012736.pub2

Cui, C., Yang, Y., Zhao, T., Zou, K., Peng, C., Cai, H., & Hou, R. (2019). Insecticidal activity and insecticidal mechanism of total saponins from Camellia oleifera. *Molecules*, *24*(24), 4518. https://doi.org/10.3390/molecules24244518

Delimont, N. M., Haub, M. D., & Lindshield, B. L. (2017). The impact of tannin consumption on iron bioavailability and status: A narrative review. *Current Developments in Nutrition*, *1*(2), 1–12. https://doi.org/10.3945/cdn.116.000042

Divekar, P. A., Narayana, S., Divekar, B. A., Kumar, R., Gadratagi, B. G., Ray, A., & Behera, T. K. (2022). Plant secondary metabolites as defense tools against herbivores for sustainable crop protection. *International Journal of Molecular Sciences*, *23*(5), 2690. https://doi.org/10.3390/ijms23052690

Finetti, L., Paluzzi, J.-P., Orchard, I., & Lange, A. B. (2023). Octopamine and tyramine signalling in Aedes aegypti: Molecular characterization and insight into potential physiological roles. *PLoS ONE*, *18*(2 February). https://doi.org/10.1371/journal.pone.0281917

Francis, G., Kerem, Z., Makkar, H. P., & Becker, K. (2002). The biological action of saponins in animal systems: a review. *British Journal of Nutrition*, *88*(6), 587–605. https://doi.org/10.1079/BJN2002725

Huang, Q., Liu, X., Zhao, G., Hu, T., & Wang, Y. (2018). Potential and challenges of tannins as an alternative to in-feed antibiotics for farm animal production. *Animal Nutrition*, *4*(2), 137–150. https://doi.org/10.1016/j.aninu.2017.09.004

Jaffal, A., Fite, J., Baldet, T., Delaunay, P., Jourdain, F., Mora-Castillo, R., Olive, M.-M., & Roiz, D. (2023). Current evidences of the efficacy of mosquito mass-trapping interventions to reduce Aedes aegypti and Aedes albopictus populations and Aedes-borne virus transmission. *PLoS Neglected Tropical Diseases*, *17*(3). https://doi.org/10.1371/journal.pntd.0011153

Janatiningrum, I., Zahra, A., & Anggia, V. (2024). Rhizosphere actinobacteria isolated from Pometia pinnata and its antimicrobial activity. *Biodiversitas*, *25*(3), 1007–1014. https://doi.org/10.13057/biodiv/d250313

Khoo, Y. W., Khaw, Y. S., Tan, H. T., Li, S.-F., & Chong, K. P. (2023). First Report of Macrophomina phaseolina Causing Leaf Blight on Pometia pinnata in Malaysia. *Plant Disease*, *107*(1), 230. https://doi.org/10.1094/PDIS-11-21-2478-PDN

Khu, A., Syahputra, R. A., Lie, S., Nugraha, S. E., & Situmorang, P. C. (2021). Amelioration of cisplatin-induced kidney injury by pometia pinnata. *Pharmacognosy Journal*, *13*(5), 1257–1268. https://doi.org/10.5530/pj.2021.13.159

Kraemer, M. U. G., Reiner, R. C., Brady, O. J., Messina, J. P., Gilbert, M., Pigott, D. M., Yi, D., Johnson, K., Earl, L., Marczak, L. B., Shirude, S., Davis Weaver, N., Bisanzio, D., Perkins, T. A., Lai, S., Lu, X., Jones, P., Coelho, G. E., Carvalho, R. G., & Golding, N. (2019). Past and future spread of the arbovirus vectors Aedes aegypti and Aedes albopictus. *Nature Microbiology*, *4*(5), 854–863. https://doi.org/10.1038/s41564-019-0376-y

Krokovsky, L., Lins, C. R. B., Guedes, D. R. D., Wallau, G. D. L., Ayres, C. F. J., & Paiva, M. H. S. (2023). Dynamic of Mayaro Virus Transmission in Aedes aegypti, Culex quinquefasciatus Mosquitoes, and a Mice Model. *Viruses*, *15*(3). https://doi.org/10.3390/v15030799

Lim, H., Lee, S. Y., Ho, L. Y., & Sit, N. W. (2023). Mosquito Larvicidal Activity and Cytotoxicity of the Extracts of Aromatic Plants from Malaysia. *Insects*, *14*(6), 512. https://doi.org/10.3390/insects14060512

Martini, M., Hestiningsih, R., Widjanarko, B., & Purwantisari, S. (2019). Resistance of Aedes as a Vectors Potential for Dengue Hemorrhagic Fever (DHF) in Semarang City, Indonesia. *J Trop Life Sci*, *9*(1), 89–94. https://doi.org/10.11594/jtls.09.01.12

Meena, D. K., Sahoo, A. K., Swain, H. S., Borah, S., Srivastava, P. P., Sahu, N. P., & Das, B. K. (2020). Prospects and Perspectives of Virtual In-vitro Toxicity Studies on Herbal Extracts of Terminalia Arjuna with Enhanced Stratagem in Artemia salina model: A Panacea to Explicit the Credence of the Solvent System in Brine Shrimp Lethality Bioassay. *Emirates Journal of Food and Agriculture*, *32*(1), 25–37. https://doi.org/10.9755/ejfa.2020.v32.i1.2055

Mikołajczyk-Bator, K. (2022). The significance of saponins in shaping the quality of food products from red beet. *Acta Scientiarum Polonorum Technologia Alimentaria*, *21*(1), 81–90. https://doi.org/10.17306/J.AFS.1012

Mohammad, F. V, Noorwala, M., Ahmad, V. U., Zahoor, A., & Lajis, N. H. J. (2012). A new monodesmosidic triterpenoid saponin from the leaves of Pometia pinnata. *Natural Product Communications*, *7*(11), 1423–1426. https://doi.org/10.1177/1934578x1200701105

Organization, W. H. (2020). *Dengue. Guidline for Diagnosis, Treatment, Prevention and Control* (New).

Penilla-Navarro, P., Solis-Santoyo, F., Lopez-Solis, A., Rodriguez, A. D., Vera-Maloof, F., Lozano, S., Contreras-Mejıa, E., Vazquez-Samayoa, G., Torreblanca-Lopez, R., Perera, R., Black, W. C., & Saavedra-Rodriguez, K. (2024). Pyrethroid susceptibility reversal in Aedes aegypti: A longitudinal study in Tapachula, Mexico. *PLoS Neglected Tropical Diseases*, *18*(1). https://doi.org/10.1371/journal.pntd.0011369

Rao, P., Ninama, J., Dudhat, M., Goswami, D., & Rawal, R. M. (2023). Curcumin interferes with chitin synthesis in Aedes aegypti: a computational and experimental investigation. *Molecular Diversity*. https://doi.org/10.1007/s11030-023-10672-0

Razoki, R. (2023). Antioxidant and Antibacterial Activities of Ethanol Extract of Matoa (Pometia pinnata) Leaves. *Journal of Pharmaceutical and Sciences*, *6*(2), 351–357. https://doi.org/10.36490/journal-jps.com.v6i2.97

Rodrigues dos Santos, D., Lopes Chaves, L., Couto Pires, V., Soares Rodrigues, J., Alves Siqueira de Assunção, M., Bezerra Faierstein, G., Gomes Barbosa Neto, A., de Souza Rebouças, J., Christine de Magalhães Cabral Albuquerque, E., Alexandre Beisl Vieira de Melo, S., Costa Gaspar, M., Maria Rodrigues Barbosa, R., Elga Medeiros Braga, M., Cipriano de Sousa, H., & Rocha Formiga, F. (2023). New weapons against the disease vector Aedes aegypti: From natural products to nanoparticles. *International Journal of Pharmaceutics*, *643*. https://doi.org/10.1016/j.ijpharm.2023.123221

Souza Wuillda, A. C. J., Campos Martins, R. C., & Costa, F. D. N. (2019). Larvicidal activity of secondary plant metabolites in Aedes aegypti control: An overview of the previous 6 years. *Natural Product Communications*, *14*(7), 1934578 19862893. https://doi.org/10.1177/1934578X19862893

Suedee, A., Tewtrakul, S., & Panichayupakaranant, P. (2013). Anti-HIV-1 integrase compound from Pometia pinnata leaves. *Pharmaceutical Biology*, *51*(10), 1256–1261. https://doi.org/10.3109/13880209.2013.786098

Sujatmiko, F., Sahroni, I., Fadillah, G., & Fatimah, I. (2021). Visible light-responsive photocatalyst of SnO2/rGO prepared using Pometia pinnata leaf extract. *Open Chemistry*, *19*(1), 174–183. https://doi.org/10.1515/chem-2020-0117

Syahrani, L., Permana, D. H., Syafruddin, D., Zubaidah, S., Asih, P. B., Rozi, I. E., & Lobo, N. F. (2022). An inventory of human night-biting mosquitoes and their bionomics in Sumba, Indonesia. *PLoS Neglected Tropical Diseases*, *16*(3), 10316. https://doi.org/10.1371/journal.pntd.0010316

Tanamatayarat, P. (2016). Antityrosinase, Antioxidative Activities, and Brine Shrimp Lethality of Ethanolic Extracts from Protium serratum (Wall. ex Colebr.) Engl. *Asian Pacific Journal of Tropical Biomedicine*, *6*(12), 1050–1055. https://doi.org/10.1016/j.apjtb.2016.10.001

Thambi, P. J., Modahl, C. M., & Kini, R. M. (2024). Niemann–Pick Type C2 Proteins in Aedes aegypti: Molecular Modelling and Prediction of Their Structure–Function Relationships. *International Journal of Molecular Sciences*, *25*(3). https://doi.org/10.3390/ijms25031684

Wang, W. H., Urbina, A. N., Chang, M. R., Assavalapsakul, W., Lu, P. L., Chen, Y. H., & Wang, S. F. (2020). Dengue hemorrhagic fever–A systemic literature review of current perspectives on pathogenesis, prevention and control. *Journal of Microbiology, Immunology and Infection*, *53*(6), 963–978. https://doi.org/10.1016/j.jmii.2020.03.007

Wijayanti, S. P., Sunaryo, S., Suprihatin, S., McFarlane, M., Rainey, S. M., Dietrich, I., & Kohl, A. (2016). Dengue in Java, Indonesia: relevance of mosquito indices as risk predictors. *PLoS Neglected Tropical Diseases*, *10*(3), 4500. https://doi.org/10.1371/journal.pntd.0004500