ANTI-MOSQUITO SPRAY BASED ON CARBON NANODOTS FROM DURIAN PEEL WASTE

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Article Info

Article history:
Received January 3th, 2025
Revised February 18th, 2025
Accepted March 6th, 2025

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ABSTRACT

The accumulation of organic waste can cause various diseases and environmental pollution. One of the diseases caused by this is Dengue Hemorrhagic Fever (DHF). Organic waste such as durian peel waste contains carbon, which can be processed into carbon nanodots (C-dots). The C-dots from durian peel waste can be used as a basic ingredient for mosquito repellent spray because durian peel contains essential oils, flavonoids, saponins, and tannins, which are toxic to mosquitoes. The synthesis of C-dots can also reduce environmental pollution due to durian peel waste. The purpose of this study was i) to prepare and characterize C-dots from durian peel waste using UV-Vis and PSA tests, and ii) to identify the effect of the C-dots solution in a mosquito repellent test in order to determine the ability of the anti-mosquito spray. This was an experimental study on the preparation of C-dots from durian peel waste using the two-steps low heating (TSLH) method. The anti-mosquito spray was made of 3 ratios of C-dots mass to distilled water volume, i.e.: (0.1 g : 200 ml); (0.2 g : 200 ml); and (0.3 g : 200 ml). Based on the results of the UV-Vis and PSA characterizations, it was found that the absorption peaks of the C-dots were at the wavelength interval of 288–332 nm and the sizes of the C-dots were 178.6 nm (69.3%) and 54.1 (20%). The mosquito repellent test showed that the anti-mosquito spray could repel and eradicate mosquitoes at the best ratio of (0.1 g C-dots : 200 ml of distilled water) with the highest mosquito's mortality of 11 mosquitoes in 17 minutes and 29 seconds. This proves that the C-dots from durian peel waste can be used as an anti-mosquito spray.

Keywords: C-dots, Durian peel waste, Anti-mosquito spray

Introduction

Dengue Hemorrhagic Fever (DHF) or dengue fever is a disease caused by acute infection of the dengue virus through mosquito bites. Dengue fever is caused by a dengue virus, which is transmitted through the bite of mosquitoes of the genus *Aedes*, especially species *Aedes aegypti* (Yulianti *et al*., 2020). Andriawan *et al.* (2022) revealed that the clinical symptoms of dengue fever include: sudden high fever without a clear cause and continues for 2-7 days, bleeding manifestations (petechiae, purpura, conjunctival hemorrhage, epistasis, ecchymosis, melena, and hematuria), and a positive Tourniquet test. Dengue fever cases are still a problem in Indonesia. According to data from the Ministry of Health, the number of dengue fever cases in Indonesia in 2023 continues to increase, especially during the rainy season. Data from dengue fever cases in Indonesia until the 19th week of 2023 reached 31,380 cases, with a death toll reaching 246 cases. Therefore, efforts are needed to overcome dengue fever.

Aedes aegypti is a mosquito that transmits or is the main vector of dengue fever. It also acts as a carrier of the yellow fever virus (*yellow fever*) and chikungunya. According to Baghowi *et al.* (2022), unsanitary environments have a major impact on the breeding of mosquitoes as carriers of dengue viruses. According to data from the National Waste Management Information System (SIPSN), the

amount of waste produced by 173 regencies/cities across Indonesia reaches 13,197,631 tons per year. This accumulation of waste can cause environmental pollution, such as producing unpleasant odors and becoming a breeding ground for *Aedes aegypti* mosquitoes, which carries the dengue virus. One way to break the chain of mosquito breeding and to control the vectors is by implementing vector control measures, including maintaining environmental cleanliness and implementing mosquito nest eradication (PSN) initiatives. PSN is implemented through i) draining water reservoirs, ii) closing water reservoirs, and iii) recycling used items that could potentially become mosquito breeding grounds, along with other dengue fever prevention measures (Rakhman & Wulandari, 2022).

Indonesian public awareness of environmental sanitary is still very low. Therefore, additional efforts are needed to combat the virus-carrying deque mosquitoes, e.g.: by developing mosquito repellent. Various types of mosquito repellent include sprays, burner, and electric ones. The mosquito repellent products offer many advantages, such as 10-hour effectiveness in repelling mosquitoes without explaining the long-term effects if used incorrectly by the public (Permatasari *et al.*, 2022). Therefore, eco-friendly mosquito repellent with minimum or no side effects t[1]o humans are needed. This mosquito repellent can be made by utilizing organic waste sources to reduce waste accumulation, e.g.: durian skin waste.

Indonesian durian is one of the largest fruit commodities in the world (Harahap *et al.*, 2017). Based on data obtained from Central Bureau of Statistics (*Badan Pusat Statistik* - BPS), the number of durians produced in 2021 reached 1,353,037 fruits. As much as 69.16% of the durian fruit consists of skin (Agustina *et al.*, 2021). Durian skin is considered useless, so it becomes a waste that is rarely managed and can cause environmental pollution that needs to be addressed immediately. However, durian skin contains essential oils, flavonoids, saponins, cellulose, lignin, and starch, which cause a pungent odor and are disliked by mosquitoes because they can affect the nervous system, causing instability and ultimately death (Syaharini, 2018). According to research by Sari *et al.* (2022), essential oil compounds contained in durian peel, e.g.: flavonoids, saponins, and tannins have a toxic effect on mosquito larvae so that they can poison, cause nervous disorders, and damage the respiratory and digestive systems of the larvae.

The problem of dengue fever caused by waste has prompted researchers to conduct research on processing durian peel waste into mosquito repellent to address this issue. The mosquito repellent uses carbon nanodots (C-dots) from durian peel waste, which are safe to use because they are non-toxic and have good biocompatibility, making them widely used for *bio-imaging*, *drug delivery*, and antibacterial agents (Sari *et al*., 2020). The biocompatible and non-toxic properties of C-dots and the compounds contained in durian peel are considered an effective combination to be the components of the mosquito repellent. Therefore, this is an innovation in the application of nanotechnology in the production of mosquito repellent in Indonesia. Thus, this study aims i) to prepare and characterize C-dots from durian peel waste using UV-Vis and PSA tests, and ii) to identify the effect of the C-dots solution in a mosquito repellent test to determine the ability of the anti-mosquito spray. It is hoped that the anti-mosquito spray can be used as an environmentally friendly alternative to conventional mosquito repellents.

Methods

This was experimental research, which involved creating a mosquito repellent spray from durian peel waste in the form of C-dots. The characterizations of the C-dots consisted of UV-Vis spectrophotometer and PSA. Another observation was conducted for the mosquito repellent test. This study was conducted for three months in three locations. Sample preparation was carried out at the Physics Laboratory of the Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta (UNY). UV-Vis and PSA tests were conducted at the IDB Laboratory of the Faculty of Mathematics and Natural Sciences, UNY. The mosquito repellent test was conducted at the Biology Garden Laboratory of the Faculty of Mathematics and Natural Sciences, UNY. The data generated from

this study were quantitative data in the form of the numbers of mosquito died and qualitative data in the form of descriptive sentences and images. In this study, the independent variable was the concentration of the C-dots. The dependent variable is the effectiveness and efficiency of environmentally friendly C-dots technology mosquito repellent spray as an alternative to conventional mosquito repellent. The control variables were the volume of distilled water and the mass of the durian peel waste powder that has been oven dried.

Preparation of the C-dots used the two-steps low heating (TSLH) method. The TSLH method can be given as follows. Durian peel waste was washed thoroughly, then cut into small pieces, and then dried. Once dry, the waste was wrapped in aluminum foil, then placed in a baking pan and placed in an oven at 250 °C for 3 hours until it was blackish-dry. Next, the waste was ground into powder using a mortar and the powder was refined using a blender. The fine powder was filtered using a sieve and placed into a container. The fine powder from the filtering process was weighed using a digital scale as much as 15 g to be made into a solution using 450 ml of distilled water in a beaker glass. The solution was sonicated for 1 hour then filtered using filter paper and put into a microwave with temperature indicator of medium high until it becomes caramel.

The mosquito repellent spray was produced by diluting the C-dots caramel into distilled water. The variations in the concentration of the C-dots caramel with distilled water were given as follows: 0.1 g : 200 ml; 0.2 g : 200 ml; and 0.3 g : 200 ml. The best concentration for the mosquito repellent will be given *fragrance* as much as 0.1 ml. This study used quantitative and qualitative data analysis techniques. The C-dots characterization tests conducted were UV-Vis spectroscopy and PSA. The performance test was conducted in the form of mosquito repellent test. The data obtained were then processed using data processing software to present the data in graphical and tabular forms. The UV-Vis spectrophotometer test used a wavelength range of 190 – 800 nm, which was presented in the form of a graph between absorbance and wavelength. The result obtained was matched with the reference results of UV-Vis tests from previous studies to determine the suitability of the spectrum of the C-dots absorbance graph that appears on the graph. The PSA test was used to determine the particle size distribution of C-dots. The particle size distribution of the C-dots was presented in a graph that depicts %passing and %channel, which appears on the graph. Mosquito repellent testing was conducted by analyzing the time and the number of mosquitoes killed in each tube sprayed with each sample of C-dots concentration variation. This test was used to determine the best C-dots concentration to be applied in the preparation of a ready-to-use mosquito repellent spray solution.

Results and Discussion

C-dots synthesis was carried out using the TSLH method. The synthesis of the C-dots from durian peel waste was carried out by making a solution with a ratio of durian peel carbon powder mass and distilled water volume, namely 15 g : 450 ml. Then, the solution was heated using a microwave in small amounts starting from 100 ml until crusts in the form of blackish brown caramel solids were formed, as shown in Figure 1.

Figure 1. C-dots in the form of caramel solids from durian peel waste.

The synthases result of the C-dots from durian peel waste are in the form of a brownish-yellow solution, as shown in Figure 2. This solution is a dilution of C-dots with distilled water. The dilution of C-dots was carried out by varying the mass of the C-dots caramel, namely 0.1 grams, 0.2 grams, and 0.3 gram with the same amount of distilled water of 200 ml. Then, the solution was tested simply by UV/violet laser irradiation to determine the presence of C-dots in the solution. The results of the UV/violet laser irradiation test show the presence of green fluorescence, which is a characteristic of C-dots (Putro *et al.*, 2018). Based on Figure 2, the more C-dots mass used in the solution, the more concentrated the green-colored solution will be and the lower the ability to transmit UV/violet laser light.

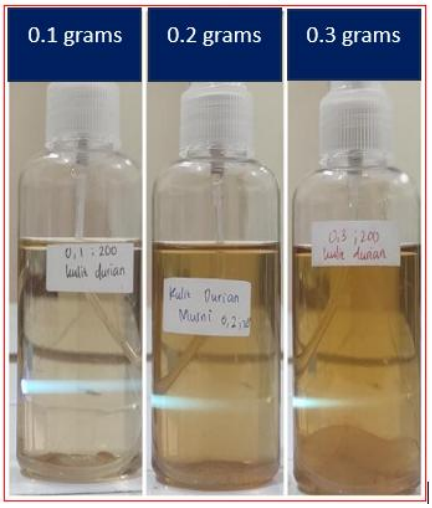

Figure 2. C-dots luminescence with variations of 0.1 grams; 0.2 grams; and 0.3 grams (from left to right).

The prepared C-dots from durian peel waste were characterized using a UV-Vis spectrophotometer to determine the absorbance peak at a specific wavelength. The UV-Vis characterization produces a graph in the form of a relationship between absorbance and wavelength (nm). The testing was carried out at a wavelength interval of 190 nm to 800 nm. The graph of the UV-Vis test result is shown in Figure 3. Based on Figure 3, the peaks of the C-dots from durian peel waste are in the wavelength interval of 288 – 332 nm. This is in accordance with a previous study that C-dots have absorbance peaks between 260 – 550 nm (A'yun *et al.*, 2018). Another study shows C-dots having two absorbance peaks with a UV wavelength interval of 260 – 360 nm and a spectrum tail extending up to the visible light (Widyani & Dwandaru, 2021). Generally. C-dots show strong absorption in the UV region between 230 – 320 nm with a tail extending into the visible region of the spectrum (Oyohwose *et al.*, 2023).

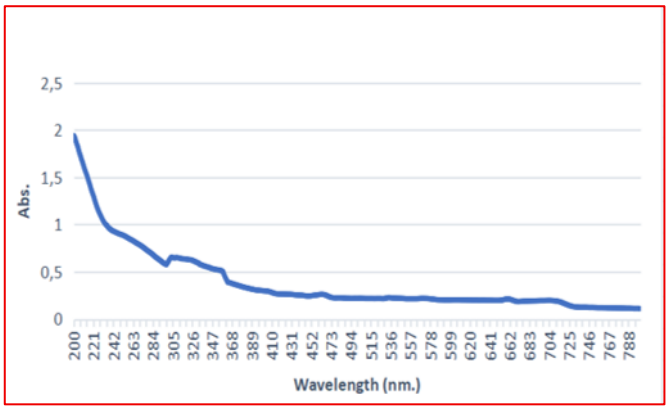

Figure 3. Absorption spectrum of C-dots from durian peel waste.

The particle size distribution of the C-dots can be obtained from the PSA characterization. The PSA test results are shown in Figure 4. It may be observed from Figure 4 that as many as 69.3% of the particles (in the sample) have sizes less than 178.6 nm. Moreover, as many as 20% of the particles have sizes less than 54.1 nm, whereas as many as 1.9% and 8.6% of the particles have sizes less than 5760 nm and 1053 nm, respectively, which are outside the range of nanomaterial sizes (i.e.: less than 100 nm). This means that the particle size distributions are not homogeneous in the sample. Regarding their particle size distribution, C-dots are one of the nanomaterials made of carbon with sizes less than 10 nm (Sari *et al.*, 2020). However, the results of this study show that the particle sizes obtained are less than 178.6 nm and 54.1 nm. These latter size distributions are in the range of nanomaterials, although not yet in the range of C-dots. This may be caused by the PSA characterization that may not detect particles with sizes less than 10 nm. Hence, the detected particle size distributions from the PSA might be aggregates or clumps of C-dots.

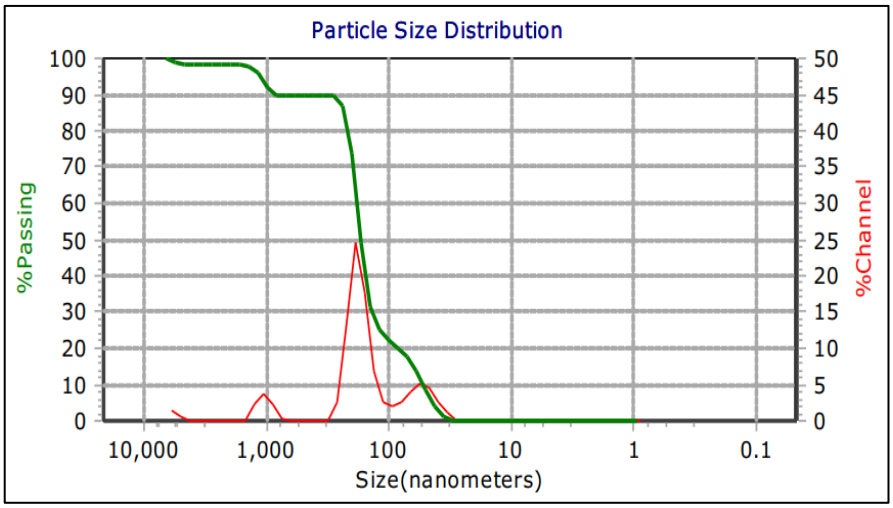

Figure 4. Particle size distributions of the C-dots from durian peel waste.

Mosquito repellent test was conducted by comparing several concentrations of the C-dots solution. Several concentrations of C-dots used for this mosquito repellent testing are 0.1 g of C-dots with 200 ml of distilled water; 0.2 g of C-dots with 200 ml of distilled water; and 0.3 g of C-dots with 200 ml of distilled water. Each concentration of the C-dots solution is sprayed into a tube containing mosquitoes and mosquito larvae to observe the effect and condition of the mosquitoes before, during, and after spraying. Based on the research results with 4 tubes containing 15 mosquitoes and mosquito larvae, each sprayed with different C-dots solution concentrations, the solution concentration of 0.1 grams of C-dots with 200 ml of distilled water is the concentration that provided the best effect for mosquito repellent and could kill mosquitoes. The results of mosquito repellent test using the C-dots solutions with different C-dots mass and distilled water volume ratio are shown in Figure 5 and 6.

The results of this study indicate that the C-dots solution from durian peel waste is effective for repelling and even killing mosquitoes. This can be seen from the mortality of the mosquitoes caused by the spraying of C-dots solutions into the tubes. The C-dots solution with a ratio of (0.1 g C-dots : 200 ml distilled water) causes 11 mosquitoes' mortality within 17 minutes and 29 seconds. Likewise, C-dots solutions with ratios of (0.2 g C-dots : 200 ml distilled water) and (0.3 g C-dots : 200 ml distilled water) cause 8 and 3 mosquitoes' mortalities in each tube within the same time. Essential oil is one of the components contained in the durian peel, which is useful as a compound to kill mosquitoes by acting as a poison that can disrupt the mosquito's digestive tract, so that mosquitoes starve to death, as well as the mosquito larvae (Nusu, 2020). This makes the C-dots solution from durian peel waste able to repel and even kill mosquitoes.

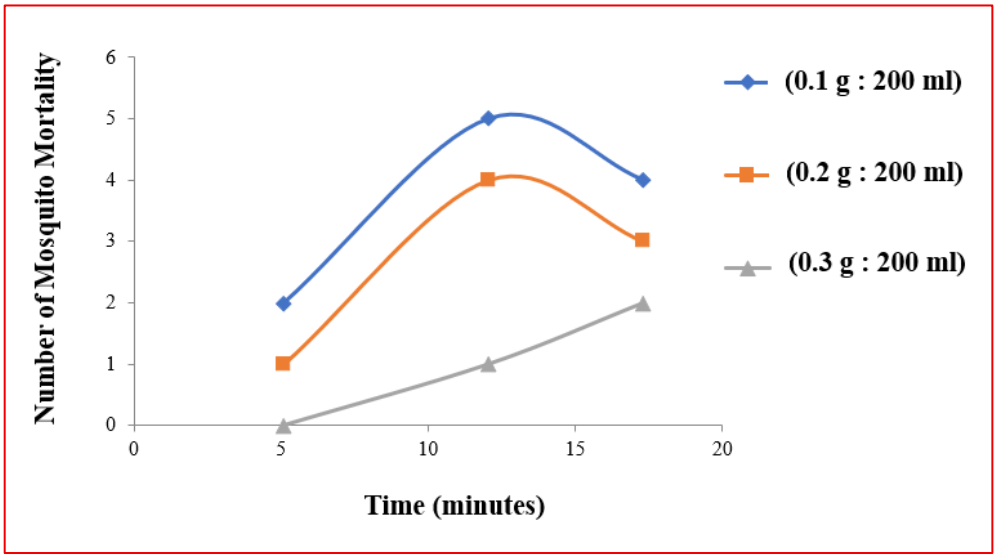

Figure 5. Mosquito repellent test results using C-dots solutions from durian peel waste.

It can be observed that the more the C-dots mass is dissolved, the ability of repelling and killing mosquitoes decreases. This is likely because the addition of C-dots mass can cause C-dots particles to clump or aggregate, so that the particle size increases and when sprayed cannot enter the mosquito's body. The C-dots solution with the smallest ratio of (0.1 g : 200 ml distilled water) has the best ability in repelling and killing mosquitoes. It may be observed in Figure 6 that the tube sprayed with 0.1 gram of C-dots solution with ratio of (0.1 g : 200 ml distilled water) has the opaquest tube base, which indicates the highest mosquito mortality. Finally, the C-dots solution with the best concentration, namely (0.1 g : 200 ml distilled water) is added with 0.2 ml lavender fragrance to become a product sample that can be used as an anti-mosquito spray.

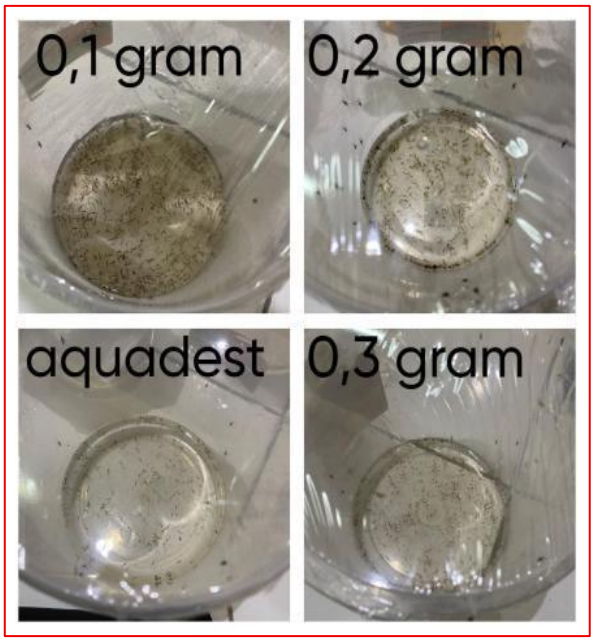

Figure 6. Mosquito repellent test on 4 tubes with variation of C-dots solution concentration.

Conclusion

The research concludes that the preparation and characterizations of C-dots from durian peel waste are successful. Moreover, the C-dots from durian peel waste have been implemented as an anti-mosquito spray. The characterization of the C-dots solution from durian peel waste using UV-Vis spectrophotometer shows absorbance peaks in the wavelength interval of 288 – 332 nm. The characterization using the PSA shows that the C-dots solution has particle size distribution of 178.6 nm (69.3%) and 54.1 nm (20%). Finally, the mosquito repellent test shows that the best ratio of the C-dots solution in repelling and eradicating mosquitoes is (0.1 g C-dots : 200 ml distilled water). The C-dots solution at that ratio can kill 11 mosquitoes out of 15 mosquitoes in 17 minutes and 29 seconds.

References

A'yun, A. Q., Isnaeni, I., Tahir, D., Ramlan, N. M., & Putri, R. H. 2018. Perbandingnan Sifat Optis Carbon Dots (C-Dots) dari Daun Mangga Kering dan Segar. *Quantum: Seminar Nasional Fisika, dan Pendidikan Fisika*, 626–631.

Agustina, S., Rahmat, D., & Hernaman, I. 2021. Potensi Kulit Durian (*Durio zibethinus*) sebagai Bahan Pakan Ruminansia. *Jurnal Nutrisi Ternak Tropis dan Ilmu Pakan*, *3*(1), 1–9.

Andriawan, F. R., Kardin, L., & Rustam HN, M. 2022. Hubungan Antara Status Gizi dengan Derajat Infeksi Dengue pada Pasien Demam Berdarah Dengue. *Nursing Care and Health Technology Journal (NCHAT)*, *2*(1), 8–15. https://doi.org/10.56742/nchat.v2i1.33

Badan Pusat Statistik. 2021. *Produksi Tanaman Buah-buahan 2021*. Diakses pada 24 Februari 2023, dari https://www.bps.go.id/indicator/55/62/1/produksi-tanaman-buah-buahan.html.

Baghowi, M. & Busahdiar, B., 2022, October. Upaya Pemberantasan Nyamuk Aedes Aegypti dengan Pengasapan (*Fogging*) Dalam Rangka Mencegah Peningkatan Kasus Demam Berdarah. In Prosiding Seminar Nasional Pengabdian Masyarakat LPPM UMJ, *1*(1).

Harahap, H. M., Munir, A. P., & Rohanah, A. 2017. Rancang Bangun Alat Pengupas Buah Durian Sistem Press Manual. *Rekayasa Pangan dan Pert*, *5*(2), 364–369.

Kementerian Kesehatan Republik Indonesia. 2022. *Kasus DBD Meningkat, Kemenkes Galakkan Gerakan 1 Rumah 1 Jumantik (G1R1J)*. Diakses pada 24 Februari 2023, dari https://www.kemkes.go.id/article/view/22061600001/kasus-dbd-meningkat-kemenkes-galakkan-gerakan-1-rumah-1-jumantik-g1r1j-.html.

Nusu, M. I. 2020. Implementasi Ekstrak Kulit Durian (*Durio zibethinus*) terhadap Kematian Larva Nyamuk Aedes Aegypti. *Jurnal Ilmiah Manusia dan Kesehatan*, *1*(1), 143–154.

Oyohwose, U. A., Omoko, V. I., Emmanuel, E., & Bello, A. P. 2023. Synthesis, Characterization, and Applications of Carbon Dots: A Review. *International Journal of Engineering Research and Reviews, 11*(2), 1–13.

Permatasari, S., Frethernety, A., & Shinta, H., E. 2022. Pengaruh Obat Nyamuk Bakar dan Semprot terhadap Motilitas Sperma Tikus (*Rattus norvegicus*). *Jurnal Kedokteran Universitas Palangka Raya*, *8*(1), 946–951. https://doi.org/10.37304/jkupr.v8i1.1499.

Putro, P. A., Roza, L., Isnaeni. 2018. Karakterisasi Sifat Optik C-Dots dari Kulit Luar Singkong Menggunakan Teknik Microwave. *Jurnal Teknologi Technoscientia*, 128-136.

Rakhman, A. & Wulandari, M., A. 2022. Edukasi 3M Plus dan Mediaovitrap untuk Pencegahan Demam Berdarah Dengue di Desa Kebandingan Kecamatan Kedungbanteng Kabupaten Tegal. *Jurnal Abdimas Bhakti Indonesia*, *3*(1), 64–70.

Sari, E. K., Sekartaji, D., Rahmah, A. N. A., & Dwandaru, W. S. B. 2020. Nanomaterial Carbon-Dots dari Daun Sirih (*Piper Betle L.*) sebagai Antibakteri terhadap Bakteri *S. Mutans* dan *E. Coli*. *Positron*, *10*(2), 26. https://doi.org/10.26418/positron.v10i2.41731.

Sari, T. K. & Winahyu, D. A. 2022. Potensial Test of Durian (*Durio zibethinus Murr.*) as Larvacides Againts Aedes aegypti Mosqoito Larves. *Jurnal Analis Farmasi*. *7*(1), 91–101.

SIPSN. 2022. *Capaian Kinerja Pengelolaan Sampah*. Diakses pada 24 Februari 2023, dari https://sipsn.menlhk.go.id/sipsn/.

Syaharani, G. 2018. Pemanfaatan Kulit Durian sebagai Obat Nyamuk dan Krim Pengobatan Infeksi Jamur. *Institut Teknologi Sepuluh Nopember*, *May*, 2–5.

Widyani, K. A., & Dwandaru, W. S. B. 2021. Preparasi dan Karakterisasi Nanomaterial C-Dots Berbahan Limbah Cair Budidaya Lele dengan Metode Pemanasan Oven. *Jurnal Ilmu Fisika dan Terapannya, 8*(2).

Yulianti, E., Juherah, Abdurrivai, A. 2020. Perilaku Bertelur dan Siklus Hidup Nyamuk Aedes Aegypti pada Berbagai Media Air (Studi Literatur). *Sulolipu: Media Komunikasi Sivitas Akademika dan Masyarakat*, *20*(2), 227-239.