Bioedukasi
Jurnal Biologi dan Pembelajarannya
Vol. 24 No 1, February 2026, page 24 - 30
e-ISSN: 2580-0094; p-ISSN:1693-3931
DOI 10.19184/bioedu.v24i1.53697
bioedukasi.jurnal.unej.ac.id

Bioinsecticide Male Coconut Flower Extract Oil palm (*Elaeis guineensis* Jacq.) against Mortality of *Spodoptera litura F.* larvae .

Regi Sandy [1] , Sofia Ery Rahayu [2] , Frida Kunti Setiowati [3]
[1] Student Major Biology State University of Malang , Indonesia
[2] Majors Biology , State University of Malang , Indonesia
[3] Department of Biology , State University of Malang , Indonesia

Info Articles
Article history:
Received december 17, 2025
Revised february 27, 2026
Accepted february 28, 2026
Published february 28, 2026

Keywords: (AZ)
Bioinsecticide
Death
Toxicity

ABSTRACT (9)
Caterpillar grayak (*Spodoptera litura* F.) is a pest important thing that causes damage serious about various plant cultivation so that required alternative more control safe and friendly environment . This research aim For know effectiveness extract flower male coconut oil palm (*Elaeis) guineensis* Jacq.) as bioinsecticide to mortality of *Spodoptera litura* larvae . The study was conducted in a way experimental use method *non-choice feeding test* with Completely Randomized Design (CRD) consisting of on five treatments , namely control negative , control positive , and extracts at concentrations of 2%, 4%, and 8%, five replicates each with ten second-instar larvae per replicate (total 250 larvae). Extract obtained through method maceration use 70% ethanol and applied to the leaves spinach as test feed with method spraying . Mortality observed every 24 hours up to 120 hours. Data is analyzed using ANOVA and Tukey's follow-up test , as well as analysis probit For determine LC_{50} value . Research results show that mortality increase along increase concentration and time exposure . A concentration of 8% indicates effectiveness highest with mortality reached 100% at 120 hours, approaching control positive . Analysis probit show LC_{50} value decreases from 8.84% (24 hours) to 2.45% (120 hours), which indicates improvement toxicity extract against test larvae. Extract flower male coconut palm oil potential developed as bioinsecticide in control strategy pest sustainable .

Corresponding AAuthor :
Sofia Ery Rahayu, ,
Biology , State University of Malang
Semarang Road 05, Sumbersari , Malang , Indonesia
Email : sofia.ery.fmipa@um.ac.id

1. INTRODUCTION

Caterpillar grayak *Spodoptera litura* F is one of the pest main attacking various plant food and horticulture in Indonesia and other Asian countries [1]. This pest nature polyphagous and capable attack soybeans , corn , chilies , vegetables leaves , and commodities cultivation other so that cause loss significant economic if No controlled in a way right [2]. In Indonesia, control *Spodoptera litura* Still dominated by the use of pesticide synthetic Because considered effective and practical [3] . However , the use of pesticide synthetic in a way continously can cause various impact negative like resistance pests , pollution environment , residue on the results agriculture , as well as disturbance to non-target organisms [4], so that required alternative control more pests friendly environmental and sustainable .

One of increasingly alternative Lots developed is pesticide plant originating from from extract plants . Plants known contain various metabolit secondary like *alkaloids* , *flavonoids* , *terpenoids* , and *saponins* which have activity insecticide , antifeedant, inhibitor growth , as well as effect toxic to insects [4]. Some study report that extract leaf soursop and plants other effective in controlling *Spodoptera litura* larvae , indicated by an increase in mortality and damage midgut tissue of larvae [5] In addition , various extract other plants are also reported capable pressing population *Spodoptera litura* through mechanism physiological and disturbance system digestion [22]. Although thus , the source plants used in research the Enough diverse and not everything own similarities compound active and mechanism Work .

One of the potential but not widely studied plant materials is the male flower of the oil palm (*Elaeis guineensis*). This plant part is known to contain secondary metabolite compounds that have the potential to have biological activity against insects [6]. However, scientific studies on the effectiveness of male flower extract of oil palm against *S podoptera litura larvae* are still limited, especially in measuring the level of mortality based on variations in treatment concentration [7].

Based on this description, this study aims to analyze the effectiveness of oil palm male flower extract on the mortality of *Spodoptera litura larvae* at several treatment concentrations. This research is expected to provide scientific information on the potential of oil palm male flowers as an environmentally friendly botanical pesticide and support sustainable agricultural systems.

2. RESEARCH METHODS

2.1 Location and Time

This research done from August to October 2025 in the Laboratory Physiology Plants , Faculty Mathematics and Science Knowledge Nature , State University of Malang. The main materials used is flower coconut palm oil collected males from plantation owned by farmers in Bukit Sejahtera Village, Musi Banyuasin Regency , South Sumatra.

The oil palms used are 8–10 years old and belong to the Tenera variety, commonly cultivated by local farmers. The plantations are located in lowland areas, 20–30 meters above sea level, and have ultisol soil type. The area generally has an average daily temperature of 26–32°C, with relatively high annual rainfall. These agroecosystem conditions reflect the environment for oil palm cultivation on a smallholder plantation scale in South Sumatra.

2.2 Preparation Sample Extraction and *Spodoptera litura Larvae*

Oil palm male flowers were obtained from smallholder plantations in Bukit Sejahtera Village, Musi Banyuasin Regency, South Sumatra. The flowers were collected after entering the production phase, then cleaned, washed, and air-dried for 2–3 days. The dried samples were ground into a homogeneous powder. Extraction was carried out using the maceration method using 70% ethanol as a solvent with a powder-to-solvent ratio of 1:10. The maceration was carried out in two stages (3 × 24 hours and 2 × 24 hours). The filtrates from both stages were combined and evaporated using a water bath to obtain a paste-like extract.

S podoptera litura instar 2 larvae were obtained from caterpillar sellers. Number of larvae used in the study This The maximum number of larvae is 250. The larvae first undergo a 24-hour acclimatization period to adjust to the room conditions. During acclimatization, the larvae are fed leaves. Fresh, untreated spinach at room temperature. Afterward, the caterpillars were fasted for 24 hours so that upon starting the treatment, they could immediately consume the treated feed.

2.3 Subjects and Research Design

This research is study experimental using method *non-choice feeding test* . This method chosen Because each test larva only given One type feed in the form of leaves that have applied treatment extract on each experimental unit without existence alternative feed others , so that oral effects and antifeedant activity can observed in a way directly on *Spodoptera litura* larvae . Experiment arranged use Completely Randomized Design (CRD) with five treatments and five replications .

Treatment used consists of on control negative (aquades), control positive (pesticide synthetic nurfarm cyclone), as well as extract flower male coconut oil palm (*Elaeis) guineensis*) at concentrations of 2%, 4%, and 8%. Each treatment repeated as many as five times, with every test consists of on ten larvae. Spinach leaves used as test feed and applied solution treatment use method spraying until surface leaf coated in a way evenly . The leaves then air-dried at room temperature room until No there is remainder dripping solution before given to the larvae accordingly with each treatment . Observation larval mortality was carried out every 24 hours sequentially until observation ends at 120 hours.

2.4 Data Observation and Analysis

Larval mortality rates were recorded. in a way Periodic monitoring . Data collected included the number of larvae that died at each treatment concentration and the observation time interval. Mortality was determined by touching the larvae with tweezers; larvae that did not move when touched were considered dead, while those that moved were considered alive. The percentage of larval mortality was calculated using the formula as following :

$$\text{Mortalitas (\%)} = \frac{\text{Jumlah larva mati}}{\text{Jumlah total larva}} X\ 100\%$$

Next data analyzed using One Way ANOVA followed by with Tukey's test if there is significant difference . Toxicity level extract counted through analysis probit For determine LC_{50} value . Initial data processing done using Microsoft Excel, whereas analysis statistics done using SPSS 2025.

2.5 Research Ethics

Extract flower male coconut palm oil applied to larval feed using method spraying (*spray method*). Solution extract sprayed in a way evenly on the surface leaf feed using a hand sprayer with a volume of 1 mL per sheet leaf until all over surface covered thinly and homogeneously . After spraying , the leaves air-dried at room temperature room for 3 minutes until surface leaf No Again wet and solution absorbed in a way evenly . Leaves that have been dry Then quick given to the test larvae according to with treatment . Treatment negative control was performed with spray aquades on leaves larval feed . Control positive done with spray pesticide synthetic to surface leaf feed larvae with dose in accordance instructions on the packaging bottle . During treatment the larvae were placed at a temperature room .

3 RESULTS AND DISCUSSION

3.1 Mortality of *Spodoptera litura* Larvae

Mortality is size base For evaluate effectiveness something agent insecticide . Observations on the mortality of *Spodoptera litura larvae* were carried out for 24–120 hours after treatment application with 24-hour intervals to determine the toxic response pattern and the effective time of the oil palm male flower extract. The mortality percentage was calculated at each observation time. The results of the One-Way ANOVA analysis and Tukey's follow-up test ($\alpha = 0.05$) showed a significance value <0.05, which means that the extract concentration had a significant effect on larval mortality. Complete data are presented in Table 3.1 and Figure 3.1 .

Table 3.1 Percentage of Mortality of *Spodoptera litura Larvae* (%) During 120 hours

Treatment	Percentage Larval mortality (%) ±SE hour to -				
	24	**48**	**72**	**96**	**120**
K-	4 ± 4.00 ^{b}	4 ± 4.00 ^{ab}	12 ± 4.90 ^{d}	12 ± 4.90 ^{d}	12 ± 4.90 ^{d}
K+	62 ± 0.73 ^{c}	72 ± 0.73 ^{c}	82 ± 0.73 ^{c}	94 ± 0.40 ^{c}	100 ± 0.00 ^{c}
2%	20 ± 0.45 ^{a}	30 ± 0.32 ^{a}	32 ± 0.37 ^{a}	36 ± 0.24 ^{a}	40 ± 0.45 ^{a}
4%	26 ± 0.93 ^{ab}	34 ± 0.93 ^{a}	46 ± 0.93 ^{b}	58 ± 0.49 ^{b}	66 ± 0.51 ^{b}
8%	32 ± 0.58 ^{b}	52 ± 0.58 ^{b}	74 ± 0.75 ^{c}	96 ± 0.20 ^{c}	100 ± 0.00 ^{c}

Information:
Numbers in the columns followed by the same letter indicate no significant difference at the 95% confidence level ($\alpha = 0.05$) based on the results of Tukey's further test.

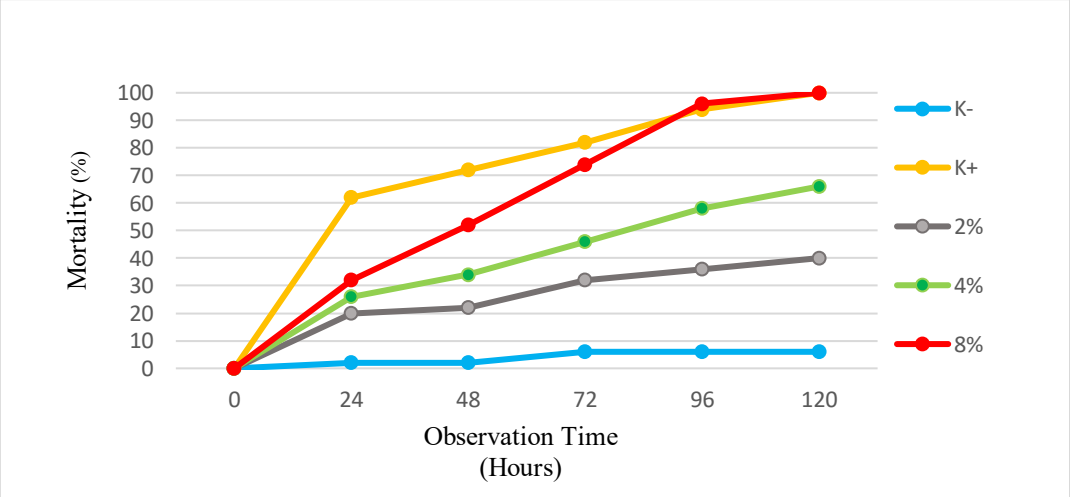

Figure 3.1. Graph mortality *Spodoptera litura* (%) in various concentration extract flower coconut palm oil male and control for 24 to 120 hours of observation .

Based on Table 3.1 shows that larval mortality increased with increasing concentration and observation time. The highest concentration treatment had a greater effect than the other concentrations, while the negative control showed the lowest mortality. Tukey's test showed a significant difference between treatments at each observation time ($p < 0.05$) . Figure 3.1 shows results consistent with the data in Table 3.1 , indicating that the positive control and highest concentration treatments had the highest mortality rates compared to the other treatments. The increase in mortality at high concentrations was consistent with increasing observation time, reaching levels equivalent to those of the positive control at the end of the observation period. This matter show that 8% concentration is most effective treatment in cause death of larvae and have approaching effectiveness control positive at the end time observation . Research results This consistent with characteristics insecticide modern chemistry , which is generally Work fast and have toxicity high [8].

Treatment use extract flower male coconut palm oil show that Its effectiveness is highly influenced by concentration . At the highest concentration (8%), larval mortality showed values close to those of the positive control. Based on the results of the *One Way ANOVA test* followed by the Tukey test, mortality at a concentration of 8% at several observation times was not significantly different ($p > 0.05$) compared to the positive control. This indicates that under these conditions, the effectiveness of oil palm male flower extract is relatively comparable to the synthetic pesticide used as a comparison. Phenomenon This in line with findings a number of study previously shown that extract plant generally dose- dependent , where the increase concentration compared straight with improvement mortality pests [9].

This result consistent with report that metabolit secondary in plants , such as *flavonoids* , *saponins* , and *terpenoids* , can bother system digestive and nervous system of *Spodoptera litura* larvae , which causes improvement death along with exposure and concentration [10], with thus extract flower coconut palm oil male can categorized as insecticide effective botanicals , especially at concentrations high . Findings This strengthen that use pesticide botany potential become alternative friendly environment For reduce dependence on pesticides synthetic [11].

In a way physiological , increased mortality along time and concentration can explained by the content metabolit secondary in extracts , such as *flavonoids* , *phenolics* , *tannins* , and *terpenoids* , which are known cause disturbance eating , dysfunction digestion , and disorders metabolism in insects herbivores , so that effect mortality often appear after period delay [12]. Some study similar also found that extract plant show effect No directly , such as reduce activity eating and inhibiting growth before Finally cause death [13]. Comparison with research that uses other parts of coconut palm oil or plant local show that effectiveness extract is very dependent on the part plants , methods extraction , and concentration . This research show that flower male in concentration tall approach effectiveness pesticide synthetic , which confirms potential part This as source viable bioinsecticide developed [14].

This research support findings study previously that improvement concentration extract will increase mortality of *Spodoptera litura* larvae . In practical , results This open opportunity For formulation bioinsecticide based flower coconut palm oil male , even though a number of problem Still need clarified before application field , including identification and quantification compound active through analysis phytochemicals more carry on For in a way direct connect composition chemistry and mechanisms work [15]. In addition , the evaluation residue and assessment security For non-target organisms , as well as studies formulation , required For utilise in a way practical slow effectiveness However cumulative . This research No only confirm potential flower coconut palm oil male as bioinsecticide but also highlights a number of direction For study more further necessary For change findings laboratory become solution control safe and effective pest control in the field .

3.2 Concentration Value Effective (LC_{50}) Coconut Male Flower Extract Oil palm (*Elaeis guineensis* Jacq.)

The LC_{50} (lethal concentration 50%) value of male oil palm flower extract against *Spodoptera litura larvae* was calculated at five observation time intervals: 24, 48, 72, 96, and 120 hours. This value indicates the concentration of extract required to cause 50% mortality of the larval population at each time point. observation . The following table presents the LC_{50} values during the observation period.

Table 3.2 LC_{50} Value of Oil Palm Male Flower Extract against Spodoptera *litura Larvae*

Observation Time (hours)	LC_{50} (%)	95% CI	Slope ± SE
24	8.84	7.50–10.40	1.23 ± 0.15

Observation Time (hours)	LC_{50} (%)	95% CI	Slope ± SE
48	6.78	5.50–9.20	1.50 ± 0.18
72	4.54	2.80–5.10	1.65 ± 0.20
96	3.65	1.90–4.00	1.72 ± 0.22
120	2.45	1.20–2.00	1.80 ± 0.25

Description: LC_{50} (%) indicates the concentration of extract capable of causing the death of 50% of *Spodoptera litura larvae* , while 95% CI (%) is the lower and upper limits of the 95% confidence interval of LC_{50}. Slope ± SE indicates the slope of the probit regression line and its standard error.

Concentration value effective 50% (LC_{50}) is indicator important For determine potential toxic something extract on the test organism . LC_{50} is defined as capable concentration causing 50% of deaths in the target population in period time certain , and generally analyzed use approach probit so that connection between concentration and response biological can transformed linearly [16]. In the study this , the LC_{50} value of the extract flower male coconut palm oil against *Spodoptera litura* larvae counted based on mortality data . Mortality in each treatment moreover formerly corrected use Abbott's formula for remove influence mortality natural in controls . Mortality values that have been corrected Then changed become form probit and regressed to $\log_{10}$ concentration for get equality dose-response [17].

Based on Table 3.2, the LC_{50} value of oil palm male flower extract on *Spodoptera litura larvae* shows a decreasing trend as the observation time increases. This indicates that exposure time influences the toxicity of the extract; the longer the exposure time, the lower the concentration required to cause 50% mortality. Therefore, the effectiveness of the extract tends to increase with increasing exposure time to the larvae.

The decrease in LC_{50} values in plant extracts indicates an increase in toxicity with increasing exposure time, because secondary metabolite compounds require time to disrupt the physiological systems of larvae, such as the nervous and digestive systems [10]. In plants of the Arecaceae family, the lower the LC_{50} value, the higher the effectiveness of the extract as a botanical insecticide. The decrease in LC_{50} over time also indicates a cumulative toxicity effect on test larvae [18]. Extract from family Arecaceae known contain compound active like toxic phytosterols and triterpenoids for insect herbivores [19], so that LC_{50} results in study This relevant with characteristics phytochemicals plant the original .

When compared with study previously , the LC_{50} value obtained is at in same range with a number of extract plants used For oppose *Spodoptera litura* . For example , the leaves of Moonflower (*Tithonia diversifolia* A. Gray) [1] , while extract leaf bitter other show effectiveness with LC_{50} between 8,000–14,000 ppm depending on the part plants and methods extraction [20]. Higher LC_{50} values low from extract flower palm male show that part flower male own composition compound more active strong compared to with a number of extract other plants that have tested . In addition , the response dose- response formation in study This show consistent results , where the increase concentration extract followed by an increase larval mortality , which supports validity calculation probit and the suitability of the regression model used .

In a way Overall , the results of this LC_{50} confirm that extract flower male coconut palm oil potential as pesticide vegetable For control *Spodoptera litura* . Relative LC_{50} value low and pattern increased mortality in a way significant along with improvement concentration can become base For study more further , especially related with characterization compound active , mechanism toxicity , and formulation practical in the field .

4 CONCLUSION

This study show that extract flower male coconut palm oil own effect significant in increase *Spodoptera litura* larval mortality . Larval mortality increased along with time exposure and concentration extract , with response toxic strongest at a concentration of 8%, which is close to effectiveness insecticide synthetic . Symptoms emerging poisoning , such as decline activity eating , change color body , and weakening movement , strengthening indication that metabolit secondary in extract play a role active in bother larval physiology . The LC_{50} value of 6.78% at 48 hours indicates that . The extract had a moderate toxic effect on the test larvae. The decrease in the $LC50_{value}$ on every time treatment showed that the longer the exposure time, the higher the effectiveness of the extract in inducing larval mortality . This explain extract flower male coconut palm oil own good potential as insecticide vegetable , so that flower male coconut palm oil can considered as source alternative bioinsecticide with potential For developed use support control more pests safe and friendly environment . Further research carry on required For identify compound active and testing security as well as its application on a large scale field .

5 CONFESSION

Writer want to say accept love to Faculty Mathematics and Science Knowledge Nature , State University of Malang, above provision facility laboratory during the research process . Appreciation was also expressed to the farmers Musi Banyuasin Regency which has help provide material research . Author want to say accept love to Mrs. Sofia Ery Rahayu, S.Pd , M.Si and Dr. Frida Kunti Setiowati , ST, M.Si as mentor on guidance , direction and correction they during compilation manuscript this . Greeting accept love is also given to colleagues laboratory on help technical and support they during study .

6 REFERENCES

[1] Wahyuni, M., Saleh, C., and Kartika, R. Toxicity Test (*Brine Shrimp Lethality Test)* and Antibacterial Activity Test of Moon Flower Leaves (*Tithonia diversifolia* A. Gray) against *Staphylococcus aureus* and *Escherichia coli Bacteria* . *Mulawarman Chemistry Journal* , *12* . 2015

[2] Bragard, C., Dehnen-Schmutz, K., Di Serio, F., Gonthier, P., Jacques, MA, Jaques Miret, JA, Justesen, AF, Magnusson, CS, Milonas, P., Navas-Cortes, JA, Parnell, S., Potting, R., Reignault, PL, Thulke, HH, Van der Werf, W., Vicent Civera, A., Yuen, J., Zappalà, L., Malumphy, C., … MacLeod, A. (2019). Spodoptera litura pest categorization. *EFSA Journal* , *17* (7). https://doi.org/10.2903/j.efsa.2019.5765. 2019

[3] Akram, AH, Sudarmawan, AAK, & Sudantha, IM. Effectiveness of Various Plant Insecticides for Controlling Liriomyza sp. Pests. *Journal of Tropical Biology* , *24* (2b), 397–405. https://doi.org/10.29303/jbt.v24i2b.8161. 2025

[4] Rengarajan, M., Kumar, V., and Balasubramanian, kaleeswaran. (2024). Bioefficacy of *Solanum torvum* (Sw.) against agricultural pest Spodoptera litura (Fab.) (Lepidoptera: Noctuidae). *Discover Agriculture* , *2* (1). https://doi.org/10.1007/s44279-024-00035-0. 2024

[5] Roensis Sinambela, B. (2024). The Impact of Pesticide Use in Agricultural Activities on the Environment and. In *the Journal of Agrotech Health* (Vol.8, Issue 2). 2024

[6] Septiono, E., Biology, YJ, Mathematics, F., Knowledge, I., University, A., & Surabaya, N. (2020). *The Effectiveness of Babandotan (Ageratum conyzoides L.) for Controlling Spodoptera litura and Plutella xylostella Larvae The Effectiveness of Babandotan (Ageratum conyzoides L.) in Controlling Spodoptera litura and Plutella xylostella Larvae* . *9* , 233–238. https://journal.unesa.ac.id/index.php/lenterabio/index233.2020

[7] Sari, DP, & Nugroho, LH (2018). Phytochemical screening and bioactive compound analysis of oil palm (*Elaeis guineensis*) male flowers. *Journal of Applied Agricultural Research* , 10(2), 85–92. 2018

[8] Hidayati, N., Rahardjo, BT, & Prasetyo, E. (2020). Botanical insecticides for controlling *Spodoptera litura* : A review of efficacy and mode of action. *Biodiversitas* , 21(7), 3171–3178. 2020

[9] Sukma, A., Program, P., Health, SS-1, Stikes, L., and Husada , W. (nd). The Use of Chemical Pesticides on Enzyme Levels *cholinesterase* use of chemical pesticides on the levels of cholinesterase enzymes and pesticide residues in the soil.

[10] Celia Permatasari, S., Tri Asri Department of Biology, M., & Mathematics and Natural Sciences, State University of Surabaya, F. (2021). *Effectiveness of Ethanol Extract of Kirinyuh Leaves (Eupatorium odoratum) on Mortality of Spodoptera litura Larvae Effectiveness of Ethanol Extract of Siam Weed Leaves (Eupatorium odoratum) on Mortality of Spodoptera litura* . *10* (1), 17–24. https://journal.unesa.ac.id/index.php/lenterabio/index. 2021

[11] Jamin, FS, Mustofa, D., Restu, K., Rusli, M., & Adhi, S. (2024). *Pesticide Use in Agriculture: Health Risks and Environmentally Friendly Alternatives* . *7* (11), 4151–4159. https://doi.org/10.56338/jks.v7i11.6342. 2024

[12] Nuraeni, Y., and Darwiati, W. (2021). Utilization of secondary plant metabolites as botanical pesticides against forest plant pests. *Galam Journal* , *2* (1), 1–15. https://doi.org/10.20886/glm.2021.2.1.1-15. 2021

[13] Kartina, K., Shulkipli, S., Mardhiana, M., & Egra, S. (2019). Potential of Karamunting Extract (Melastoma malabathricum L.) as a Botanical Insecticide to Control Armyworms (Spodoptera litura F.). *Agrotekma: Journal of Agrotechnology and Agricultural Sciences* , *4* (1), 28. https://doi.org/10.31289/agr.v4i1.2806. 2019

[14] Fentia, L., & Rullen, BN (2020). Identification of Antioxidants in Male Flower Extracts of Oil Palm (Elaeis Guineensis Jacq). *Journal Encyclopedia* , *2* (2), 53–57. https://jurnal.ensiklopediaku.org/ojs-2.4.8-3/index.php/ensiklopedia/article/view/407. 2020

[15] Sandy, FF, Susilawati, Y., and Ramadhania, ZM (2020). Review: Qualitative and Quantitative Analysis of Chemical Compound Content of Sasaladaan Herb (Peperomia pellucida (L) HBK). *Journal of Science and Health* , *2* (4), 505–518. https://doi.org/10.25026/jsk.v2i4.199. 2020

[16] Lubis, F., Suriani, M., Lisdayanti, E., Arif Nasution, M., Aquatic Resources, P., Fisheries and Marine Sciences, F., Teuku Umar, U., Marine Sciences Faculty of Fisheries and Marine Sciences, P., Teuku Umar Jl Alue Peunyareng, U., & Barat, A. (nd). *Analysis of the Toxicity Level of Soaking Mangrove Leaves (Rhizopora apiculata) on the Survival of Poecilia sp. Fish. Analysis of the Toxicity Level of Soaking Mangrove Leaves (Rhizopora apiculata) on the Survival of Poecilia sp. fish* . https://doi.org/10.21776/ub.jsal.2024.011.03.6

[17] Hotimah, H. (2015). Testing the effectiveness of Javanese chili fruit and leaf extract (Piper retrofractum Vahl.) against Culex sp. mosquito larvae. *Sepuluh Nopember Institute of Technology* , 1–73. 2015

[18] Isman, MB (2017). Progress in pest management using botanical insecticides. *Crop Protection*. 2017

[19] Dedi, Kurniawan and Candra Irfan Aulia. *Analysis of Secondary Metabolite Content of Sugar Palm (Arenga Pinnata L.) Peel Using the GC-MS Method* . Medan Area University Warehouse.

[20] Yati, Muhammad Sarjan, and Hery Haryanto. (2025). The Effect of Various Concentrations of Botanical Pesticides from Paitan Leaves (Tithonia diversifolia) on Controlling Armyworm Pests (Spodoptera litura F.) on Edamame Plants (Glycine max (L.) Merril). *Agrocomplex Student Scientific Journal* , *4* (2), 554–565. https://doi.org/10.29303/jima.v4i2.7160. 2025