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Producing Mosquito Larvicidal Product Using Papaya Leaves, Coconut Husk, and Citrus Peels

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Abstract

Household and agricultural waste is a huge problem in the country as it is also becoming the breeding ground for mosquito larvae, which are vectors of various diseases. This study aims to test the effectiveness and acceptability level of papaya leaves, coconut husk, and citrus peels as mosquito larvicidal product and as natural alternatives to commercially available ones as the latter contributes inset resistance. Employing a mixed method research design, the researchers used Design and Development Research to create and evaluate the product, while the experimental design to test its efficacy and identify its limitations. The expert criterion sampling was utilized to evaluate the developed larvicidal product in Lopez, Quezon. The ingredients were dried and powdered and macerated using three bases: water, alcohol, and oil, to extract their bioactive compounds. The efficacy of the larvicide was tested in three sets of water: dirty, semi clean, and clean. The mortality rate, amount of concoction applied, and the duration of exposure of concoction in the experimental testing were also recorded. Results showed that increasing the amount of concoction over time would increase the mortality rate of mosquito larvae. Specifically, 5 ml concoction in 50 ml dirty water resulted in 100% mortality rate (10 larvae) after exposure for five hours, making it the most effective treatment condition. The findings revealed that larvicidal products derived from papaya leaves, coconut husk, and citrus peels can serve as an effective and eco-friendly vector control.

Keywords: *Larvicidal, papaya leaves, coconut husk, citrus peels, extracts*

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I. INTRODUCTION

The Philippines generates a high amount of food waste every year, resulting in a waste problem and causing the spread of disease (Philippine Institute for Development Studies, 2022). Poor waste management contributes to the spread of illnesses caused by mosquitoes as wastes become their breeding ground (Abdullah et al, 2024). These wastes, when not properly disposed of, cause the mosquito population to thrive.

In the country, diseases carried by mosquitoes include malaria, dengue, and filariasis. *Aedes aegypti* is a type of mosquito that transmits and carries diseases in the Philippines (Labiros et al, 2022). The cases of malaria increased two times in 2023 with 6,248 cases reported by the Research Institute for Tropical Medicine (RITM), 90% higher than the 3,245 cases of the previous year (Montemayor, 2024). The local authorities in Quezon province reported four deaths caused by dengue and that cases of dengue are increasing (Mallari, 2025).

The life cycle of mosquitoes consists of four stages: egg, larva, pupa, and adult. The larval stage lasts over 4 to 14 days in total (Terminix, 2025). Mosquito larvae are commonly found on household water containers, specifically in dispensers and homes that have unclean environments (Panggeban et al, 2025). Anopheles mosquito larvae are commonly found in stagnant water including polluted ones serving as their breeding sites (Sattler et al, 2005). Removing the breeding area of mosquitoes affects the development of larvae. Strategies like draining could result in lower mosquito larvae population without high cost (Shaukat et al, 2019).

Consequently, larvicidal products are rapidly causing resistance, decreasing their effectiveness (Jobe et al, 2023). These products, though effective, have detrimental effects not only on human health, but also on animals and the environment, if used constantly. Traditional applications, such as DDT (dichlorodiphenyltrichloroethane), a synthetic organochlorine insecticide for mosquitoes, can cause significant wildlife decline (EPA, 2025). This issue highlights the need for safer and sustainable alternatives. On the contrary, natural larvicidal products for mosquitoes could offer sustainable and effective alternatives against the spread of diseases (Rahaman et al, 2024). This means that producing plant-based mosquito larvicides could decrease the harmful impact to the environment.

The researchers saw scattered papaya (*Carica papaya L.*) leaves which are left to rot and are no longer useful. The peel, together with the seed extract of Carica papaya, has larvicidal activities (Sharma, 2020). When the concentration of papaya leaves extract is higher, it is directly proportional to the mortality rate of the Aedes aegypti mosquito larvae (Komansilan & Taulu, 2022), making papaya leaves a natural larvicide. While harvesting coconuts (*Cocos nucifera L.*), only the coconut husks are left in the field as waste. Coconut husks charcoal can be effective and sustainable by utilizing agricultural waste. This shows that even the waste from coconut can be used in creating new products that can't damage or destroy the environment and help economic growth (Bitos et al, 2024). It produces a fraction that has an 80% mortality rate in E. sparsa insects in 10% concentration (Anong & Mamangkey, 2016). The disposal of citrus peels without proper treatment causes environmental pollution, especially in large amounts (Panwar et al, 2019). Citrus fruit peel is an accessible and affordable source of biomass that can be used again (Chavan et. al. 2018) as cited by (Singh et al, 2020). The peel and seed of some citrus has a

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potential to control *Anopheles* mosquitoes (Simon-Oke et al, 2019). In the same manner, the spread of disease-carrying mosquitoes remains a big problem in the community. However, studies on integrating these agricultural waste into an eco-friendly product are limited.

The focus of this study is to produce a larvicidal product from agricultural waste using papaya leaves, coconut husk, and citrus peels, to determine its effectiveness and sustainability as an alternative for the commercial products mixed with chemicals sold in the market.

Research Questions

1. What are the ingredients in making larvicidal product?
2. What is the development process to produce larvicidal product?
3. What are the effectiveness and limitations of the developed larvicidal product?
4. Is there a significant relationship between the type of water and the mortality rate of mosquito larvae?
5. What is the acceptability level of the developed larvicidal product in terms of
    - packaging,
    - user-friendliness?

Hypotheses

- H_0: There is no significant relationship between the type of water and the mortality rate of mosquito larvae.
- H_1: There is a significant relationship between the type of water and the mortality rate of mosquito larvae.

II. METHODOLOGY

Research Design

The researchers used design and development research (DDR) and true experimental research to develop and test the papaya leaves, coconut husk, and citrus peels as larvicidal product. The research design is used to develop the target larvicidal product because it aligns with the objective of the researchers in the development and evaluation of a research product. DDR's objective is to create effective products and tools by studying their design, development, and evaluation processes (Richey & Klein, 2014), as cited in the Applied Doctoral Center. True experimental research is a type of experimental research that is considered as the most accurate way to test the hypothesis because it shows the cause and effect relationship between the variables. This type of experimental research is usually used in physical science (Zubair, 2023). The independent variables are the concentration level of the product in the three water bases used. The dependent variable is the mortality rate of the mosquito larvae. The test method was based

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on observation and the mortality of mosquito larvae. The researchers observed the larvae in different types of water after being treated with a larvicidal product for a specific period of time. The number of larvae was recorded to determine the effectiveness of the product. This combination will be helpful in the conceptualization, production, and evaluation of the product development as they will show the strengths and areas for improvement of this study.

To be guided with the production, proper procedures are followed. Figure 1 presents the flow chart of the preparation and testing of larvicidal product.

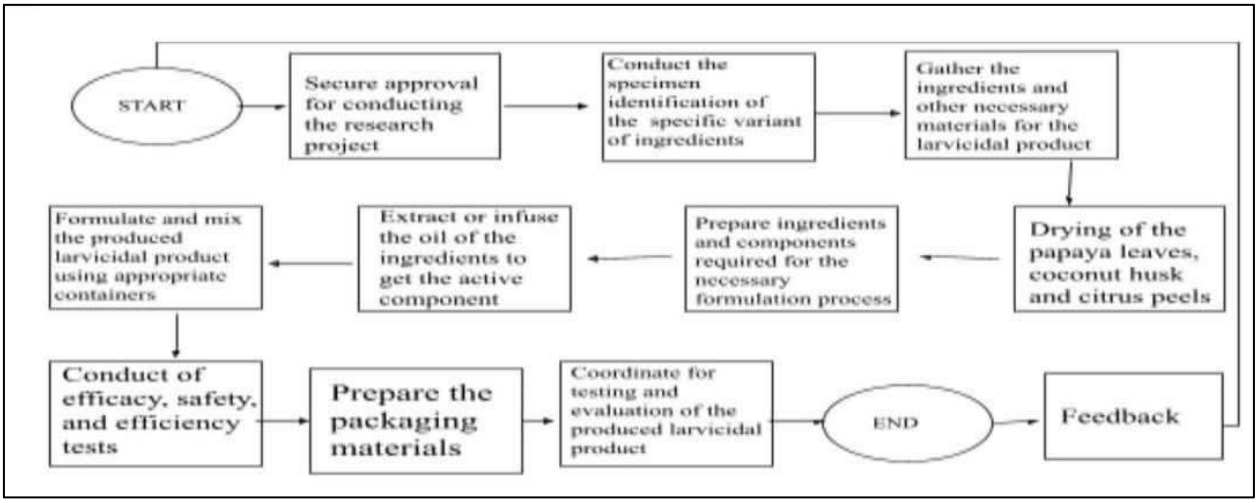

Figure 1. Flow chart of the preparation and testing of larvicidal product

The researchers secured the necessary approval to conduct the production. Then, the gathering of the ingredients, tools and equipment came next. The extraction of the ingredients and formulation of the product was the next step. The packaging, testing and evaluation came last.

Water-based formulations maintain efficacy over distance while oil-based ones may degrade, incorporating alcohol into other bases helps optimize solubility, dispersion, and overall larvicidal efficacy (Harburguer et al., 2011). The addition of an alcohol base is supported by the findings that papaya seed extracts showed the highest larvicidal potency against *Anopheles annularis* and *Culex quinquefasciatus* when prepared with 50% ethyl alcohol, indicating that the active compounds were well extracted (Nasiruddin et al., 2019). Thus, the three bases are combined to optimize their potential in killing mosquito larvae effectively.

Research Locale and Population

The research study is set in Lopez, Quezon. The papaya leaves, coconut husk, and citrus peels are harvested or bought at Brgy. Magallanes, Brgy. Manguisian and Lopez supermarket. For the evaluation of the developed larvicidal product, the researchers used expert criterion sampling. Criterion sampling allows the researchers to set a specific criterion that the research participants need to follow to be part of the research study. It means choosing the people who

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meet specific requirements set by the researchers so that the findings of the research can be more reliable. The criterion was based on the research questions (Nyimbili, F. & Nyimbili, L., 2024). This group of validators are composed of subject-matter experts, future researchers or students of BTLE-AFA of PNU South Luzon and consumers. There are a total of fifty (50) research participants coming from the identified evaluators.

Conforming with the purpose of the study, the researcher developed a product evaluation tool to evaluate the larvicidal product. It is the research tool developed from reviewed literature. Content validation using 4Rs techniques was conducted to ensure the validity of the developed tool. The validators of the research tool involved three (3) research experts and subject matter experts. They were requested to evaluate the developed research tool. The indicators are researchers-made to ensure that they are fully aligned with the research.

Scope and Limitations

The treated larvae are limited to mosquito larvae found in Lopez, Quezon. Due to time and financial constraints, the taxonomy of mosquito larvae was not identified. Additionally the concoction was not tested on non-target organisms (NTOs), its safety to other organisms remains undetermined. Moreover, the potential of reusing the tested water was not evaluated as its potential of hydrogen (pH) of the water was not identified. Such constraints may influence the study's findings and scope.

Statistical Treatment

The data analysis involved the use of qualitative and quantitative data. Hence, the researcher used descriptive analysis for the first, second questions, and third questions. The fourth and fifth questions used quantitative data analysis, the researchers used G-test for the fourth question. G-Test is used in different research studies to determine if there is a significant difference and relationship between the variables (Ziliak, 2014). Mean and Analysis of Variance (ANOVA) for the fifth one. Likewise, data were tallied using MS Excel.

Research Ethics

The researchers used informed consent and confidentiality and anonymity as the main research ethics. Informed consent is secured before the evaluation process. Likewise, confidentiality and anonymity are applied all throughout the evaluation process. Confidentiality and anonymity impacts the overall critical appraisal of the research outcomes because if it is poorly made, it can weaken the credibility of the development (Kang, 2023). Informed consent and confidentiality and anonymity agreement conforms to the various literatures concerned with the same purpose.

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III. RESULTS and DISCUSSION

Papaya leaves, citrus peels, and coconut husk are often not utilized and their larvicidal potential are overlooked. This study aims to produce a larvicidal product using papaya leaves, coconut husk, and citrus peels. It tries to determine its effectiveness and sustainability as an alternative for the commercial products mixed with chemicals sold in the market. Three sets of water are used for the testing. Figure 2 presents the type of water used in the sets.

Figure 2. Water Conditions Used in Testing. A. Dirty; B. Semi clean; C. Clean

The researchers used the same size of container (2 ounces) where the 50 ml of water will be added, numbers of larvae, amount of concoction, and number of hours that is being tested for the first test. In the second test, 500 ml of water with the same variables are used. There are three (3) sets of water tested, this is adopted from Akpodiente et al (2019), stating that using different types of water showed variation in the testing. The first set used is dirty water which is the water the larvae were found in, it is characterized by having observable dirt and sometimes mosses. The second one is semi clean water composed of mixed dirty and clean water. Lastly, the clean water comes from the well. The sample size of ten (10) larvae tested in each set is adopted from Rahman et al (2024). The researchers also used formula and concentration of Pallavi et al (2023), as basis before formulating their own concoction. The tests were facilitated through observation. The researchers observed the before and after of the treatment to get the results of the tests.

Ingredients in Making Larvicidal Product

To develop the larvicidal product, the researchers determined the ingredients in producing the larvicidal product. Table 1 shows the ingredients and corresponding measurement used in preparation of larvicidal product to produce 500 ml concoction.

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Table 1. *Ingredients in making larvicidal product*

Ingredients	Measurement
Papaya leaves powder	143ml
Coconut husk powder	143ml
Lukban (pomelo) peels powder	71ml
Orange peels powder	71ml
35% ethanol alcohol	715ml
Distilled water	715ml
Coconut oil	857ml

The researchers developed a larvicidal product made from papaya leaves, coconut husk, and citrus peels. The measurements are based on Pallavi et al., (2023), the bases are 50-60 ml to cater the size of a 50 ml container for the testing, as well as the powders. The yield from that container is 35 ml. To fill a 500 ml bottle, the measurements were scaled up and multiplied by 14.29 and rounded off (Fig. 3). The original measurements of ingredients were 5 ml orange, 5 ml lukban, 10 ml coconut husk, and 10 ml papaya leaves. Figure 3 presents the formula used to scale up the measurements.

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Target yield ÷ Original Yield = Measurement

500 ml ÷ 35 ml = 14.29 ml

5 ml orange × 14.29 ml = 71.45 ml

5 ml lukban × 14.29 ml = 71.45 ml

10 ml coconut husk × 14.29 ml = 142.9 ml

10 ml papaya leaves × 14.29 ml = 142.9 ml

50 ml 35% ethanol alcohol × 14.29 = 714.5 ml

50 ml distilled water × 14.29 = 714.5 ml

60 ml coconut oil × 14.29 = 857.4 ml

Figure 3. Formula for Scaling

The original 35 ml formulation is scaled up to 500 ml using a factor of 14.29 to keep the proportions consistent. Each ingredient is multiplied by this factor so the final mixture maintains the same composition as the original to achieve a 500 ml product.

The product is a mixture of extracts from water-based, alcohol-based, and oil-based maceration, 190 ml, 190 ml, and 120 ml respectively. Oil is nonpolar and can dissolve other nonpolar (hydrophobic) substances, following the principle of "like dissolves like" (Lajoie et al., 2022). Thus, the oil-based base has few extractions and is not equal to the other two bases. Aside from the main ingredients, distilled water, 35% ethanol alcohol, and coconut oil are also used by the researchers. Distilled water serves as a reliable base for larvicidal formulations, indicating strong effectiveness through high mortality rates (Mariños et al , 2013). Table 2 summarizes existing study of effectiveness of papaya leaves, coconut husk, and citrus peel.

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Table 2. *Existing study of effectiveness of papaya leaves, coconut husk, and citrus peel*

Ingredient	Target insect	Effect on insect	Other property	Reference
Citrus maxima Pomelo (essential oil)	Mosquito		Protects NTO (fish)	Visakh et al, 2022
Cocos nucifera Coconut (oil)	*Anopheles* larvae	Interrupts siphonal respiration		Aizoun et al, 2021
Carica papaya seeds (extracts)	*Anopheles annularis* Vander Wulp and *Culex quinquefasciatus* larvae			Nasiruddin et al, 2019

Papaya leaves and citrus peels are considered as wastes from citrus processing industries and papaya leaves and seeds are often thrown away (Zema et al, 2018). Sudhakar et al (2025) used citrus peels as a mosquito larvicidal as alternatives to chemically made ones. Coconut wastes can be used as beneficial products that are gentle to the environment (Bitos et al, 2024).

Development Process for Larvicidal Product using Papaya Leaves, Coconut Husk, and Citrus Peels

The developed larvicidal product aims to eliminate the presence of mosquito larvae in standing water as an alternative to commercially made ones that contain harmful chemicals. The procedures conducted are the dehydration of ingredients and crushing them to be powdered, maceration of powdered ingredients in three (3) bases, and storing it in a cool and dry place. Figure 4 shows the development process for larvicidal product using papaya leaves, coconut husk, and citrus peels.

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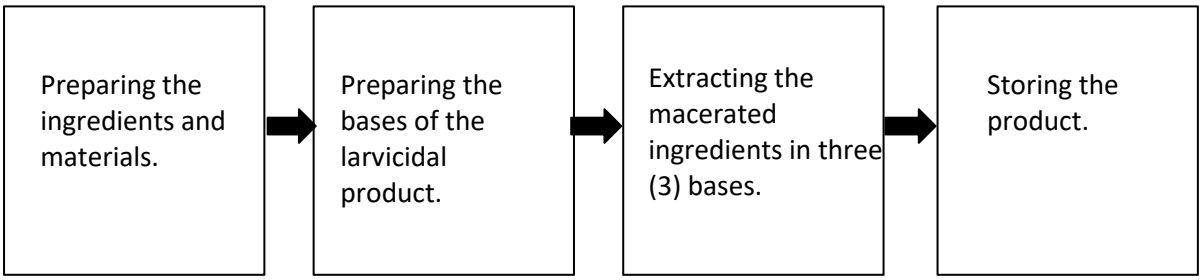

Figure 4. Development Process for Larvicidal Product using Papaya Leaves, Coconut Husk, and Citrus Peels

In developing the larvicidal product, the researchers identified four (4) major phases. These include (1) Preparing the ingredients, tools and equipment, (2) preparing the bases of the larvicidal product, (3) extracting the macerated ingredients in three (3) bases, and (4) storing the product.

The researchers conducted the first phase by preparing the ingredients, tools and equipment. Starting by gathering the papaya leaves using a knife, removing the peels of the citrus and getting the coconut husk. This is done by wearing personal protective equipment (PPEs). It is followed by washing papaya leaves and citrus peels, drying them then chop ingredients into approximately 0.5 inches.

For the second phase, the researchers prepare the bases of the larvicidal product. Place the chopped citrus peels and papaya leaves in a food dehydration machine. Figure 5 shows the set up of the food dehydrator with the main ingredients inside it.

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Figure 5. Set up of food dehydrator

The preferable hours to dry papaya leaves is 4-6 hours (Raja et al., 2019) and around 8-12 hours for citrus peels (Venema, 2017), in a 55°C temperature, as drying of plant materials at moderate temperatures (around 50–60 °C) is commonly applied to achieve sufficient moisture removal while preserving bioactive compounds before grinding and storage (Yap et al., 2020; Parmar, 2022). The ingredients are crushed using a mortar and pestle. The coconut husk is sun dried for eight (8) days (Tamil Nadu Agricultural University, n.d.). Next, use a strainer to filter the powder. The powder from coconut husk is gathered through sifting its small parts. Lastly, place the powders in a separate clean container.

In phase three, the researchers macerated the ingredients in the three bases. The water-based solution consists of 71ml of orange and lukban (pomelo) peels, 143ml of papaya leaves, 143ml of coconut husk and 715ml of water. For the alcohol-based solution, 71ml of orange and lucban (pomelo) peels, 143ml of papaya leaves, coconut husk 143ml and 715ml alcohol were used. Lastly, oil-based solution consists of 71ml of orange and lukban (pomelo) peels, 143ml of papaya leaves, coconut husk 143ml and 857ml coconut oil. After 24 hours, extract the juice of the ingredients and transfer to a clean container. To ensure fully releasing all bioactive compounds from plants that are responsible for killing the mosquito larvae, soak the plants for 24 hours (Lambert et al., 2021). For water-based, alcohol-based and oil-based, the yield is 380ml, 380 ml, 240ml, respectively. Two 500 ml bottles can be filled by the yield.

The last phase involves carefully transferring to clean, dry amber glass containers to protect it from light and contamination. Each container is tightly sealed and properly labeled with the product name, ingredients, production date, expiration date, precautionary statement and direction for use.

Figure 5 shows the development process from the preparing ingredients and bases, extracting and storing natural ingredients to produce a plant-based larvicidal product. The process of drying, grinding, and maceration help to release bioactive compounds from the ingredients, which has a contribution to the death of mosquito larvae. Papaya leaf extract has alkaloids and flavonoids, compounds that are effective in killing *Aedes aegypti* larvae (Ilham et al, 2019). Plant extracts prepared by solvent extraction method are considered effective and can cause mortality to mosquito larvae and are better for the soil than using chemical larvicide

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(Komansilan & Taulu, 2022). These studies support the process used to develop the larvicidal product shown in the figure.

Effectiveness and Limitations of the Developed Mosquito Larvicidal Product

The purpose of the testing is to determine the effective concentration in eliminating mosquito larvae in different water conditions: dirty, semi-clean, and clean. Table 3 presents the dates of production and testing.

Table 3. *Testing of the concoction in different batches*

Batch number	Date of production	Date of testing	Place
First batch	February 01, 2026	February 03, 2026	Brgy. Manguisian Lopez, Quezon
Second batch	February 03, 2026	March 01, 2026	Brgy. Manguisian Lopez, Quezon

The product underwent two (2) tests to determine its effectiveness and validity when freshly produced and to compare the results and check if the product is still effective after almost four (4) weeks, respectively. These testing phases helped evaluate the product's effectiveness and reliability for community use. Figure 6 shows the result of the first testing for the first batch of developed product. Figure 7 shows the result of the second testing for the second batch of developed product.

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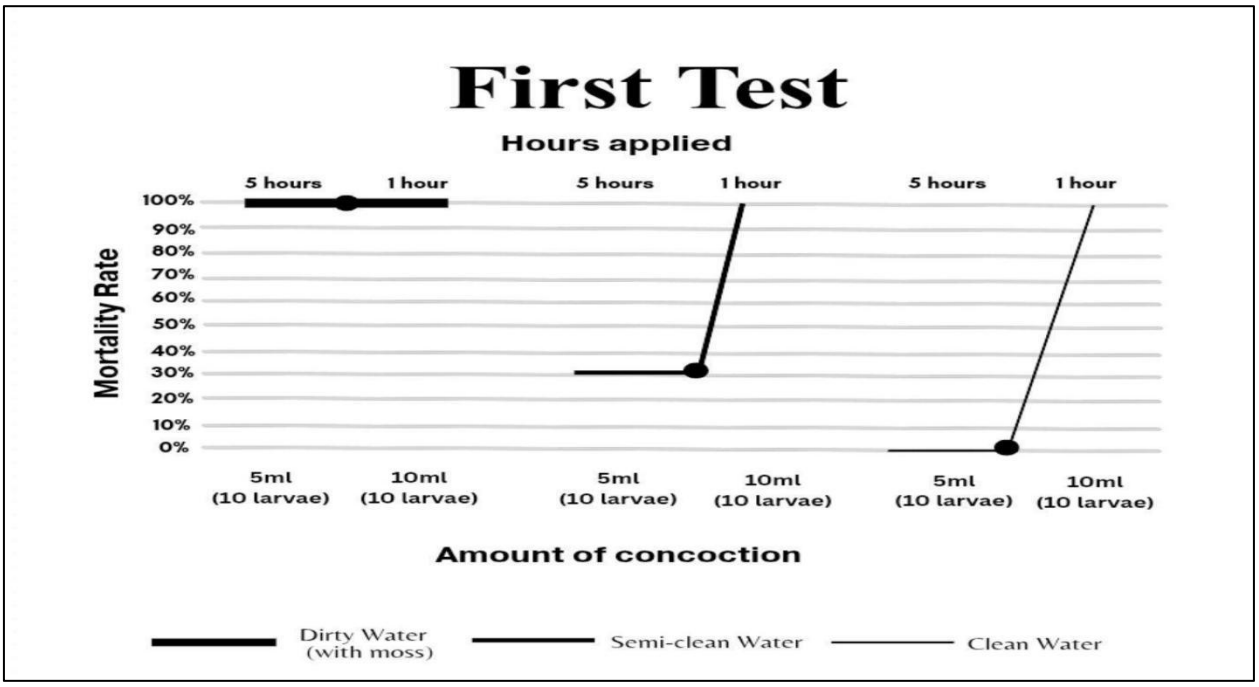

Figure 6. First testing of the larvicidal product from batch one (1)

For the first testing, for the dirty water, 5ml of concentration in 50ml of water, the number of larvae tested was ten (10). The mortality rate is computed by dividing the number of dead mosquito larvae by the number of total mosquito larvae, then multiplied by 100, as adopted from Rahman et al (2024). Ten (10) larvae died after 5 hours; the mortality rate is 100%. The researchers put the second pour of the concoction to follow the same process for the other set of waters. For semi clean, 5ml of concentration was applied to the same concentration of water and number of larvae tested. The main difference is that the number of larvae that died after 5 hours was three (3); the mortality rate is 30%. For the second pour, 10 ml of concentration was added to the same water and number of larvae, and after 1 hour, ten (10) larvae died; the mortality rate is 100%. For clean water, a 5 ml concentration was added to the 50 ml concentration of water of the same number of larvae. The number of larvae that died after 5 hours is zero (0); the mortality rate is 0%. For the second pour, 10 ml of concentration was added to the same water. The number of larvae tested and the number of larvae that died after 1 hour is ten (10); the mortality rate is 100%.

The first test showed that the higher concentration which is 15 ml of the larvicidal solution was the most effective in killing the larvae, as it achieved a 100% mortality rate in just one (1) hour in all water types. While the lower concentration which is 5 ml has an effect depending on the type of water. The set with the dirty water with 5 ml of concentration of the larvicidal product in a 50 ml of water tested came out as the fastest for the concentration to take effect. The mortality rate is 100% after five (5) hours. The set of clean water where 15 ml was poured in a 50 ml of water tested took the longest time for the concentration to take effect, with a total of six (6) hours duration. It can be observed here that the type of water and the amount of

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concentration have a significant effect when it comes to the longevity and effectiveness of the larvicidal solution.

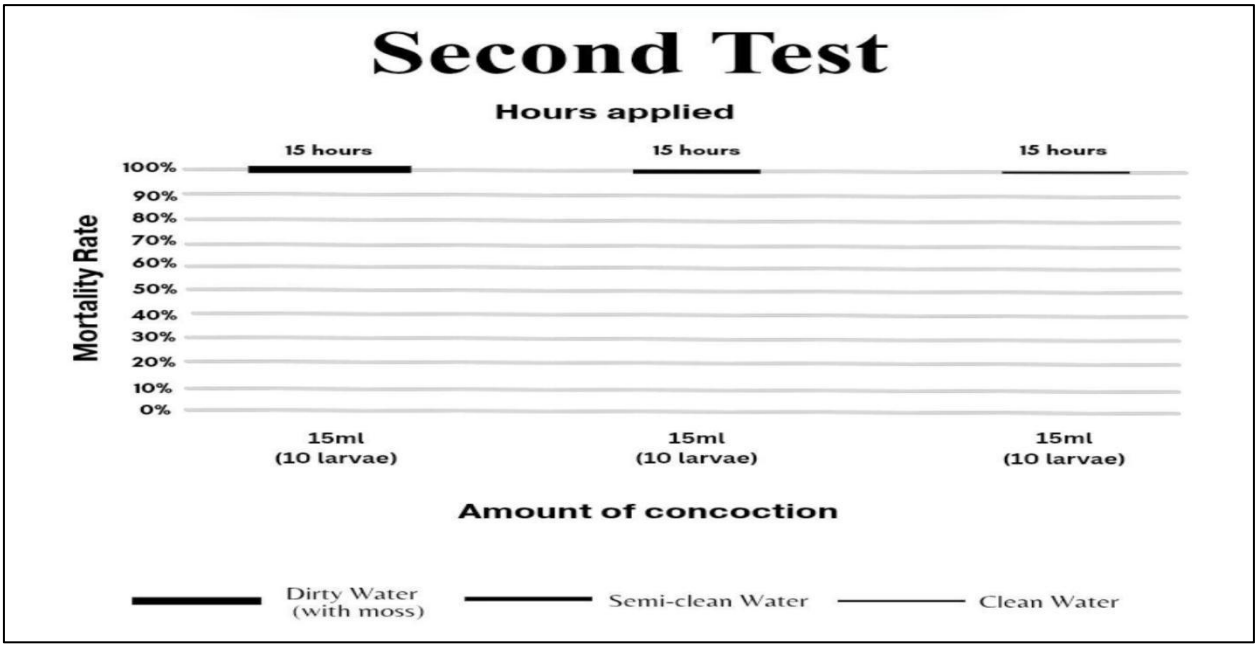

Figure 7. Second testing of the larvicidal product from batch one (1) after three (3) weeks of production in a larger container of water

For the second testing, a new setup of testing was conducted. The concentration of larvicidal; 15 ml in 500 ml of water, since it was established to effectively kill the larvae in under six (6) hours in the first testing for all sets. The container was also changed into a bigger one, scaling up the water tested to 10× to test its efficacy on a larger amount of water. The duration of treatment ended when all the larvae in all sets died.

All sets with 15 ml of concentration of the larvicidal product in a 500 ml of water tested came out as effective as the first test. The mortality rate is 100% after fifteen (15) hours and compared to the first test, it took longer. The second test proved that the larvicidal product killed larvae well in different water conditions. Even though the water tested was scaled up and only had one pour of concoction, the product still showed potential effectiveness as mosquito larvicide in different controlled water conditions such as dirty water, semi-clean water and clean water.

The result of the first test aligns with the findings of Nolia et al., (2025), in terms of effectiveness, when the concentration is higher, the mortality rate of the larvae is high as well. In terms of hours applied, this study needs six (6) hours to take effect, which is significantly lower than the

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conducted study which covered twelve (12) hours. The second test, in terms of effectiveness of plant extracts, aligns with the findings of Irshad et al (2024), having a high mortality rate, but the duration to take effect of this study is significantly lower than twenty-four (24) hours. In terms of stability, the second test aligns with the findings of Stewart et al (2023), as the shipped larvicide tested in their study showed effectiveness even after one week of production. Water sources significantly affect mosquito development and characteristics as water conditions influence larval response, which is supported by Akpodiete et al. (2019).

The limitations of the developed product is that it is tested only up to 500 mL of water. Its pH level is not identified as well. Further studies should focus on evaluating the larvicidal product in an actual environment, particularly in mosquito breeding sites. The results indicate that the product demonstrates greater efficacy in dirty water, suggesting its suitability for large-scale application rather than household use. The expiration date of the product was not determined.

Relationship Between the Type of Water and the Mortality Rate of Mosquito Larvae

To assess the relationship between the type of water and the mortality rate of mosquito larvae, G-test of independence was used. Table 4 and 5 show the result for the first batch and second batch, respectively.

Table 4. *G-test result of first batch*

Type of water	Dead (*O*)	Alive (*O*)	Expected Dead (*E*)	Expected Alive (*E*)	Sum of Terms	*G*-statistic	df	Critical Value	p-value
Dirty water	10	0	4.33	5.67	14.418	28.836	2	5.99	0.000000547
Semi-clean water	3	7	4.33	5.67					
Clean water	10	0	4.33	5.67					

The calculated value (G= 28.84) is larger than the critical value (5.99) and the p-value is less than 0.05 (0.000000547), therefore, the null hypothesis (H_0) is rejected and the alternative

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hypothesis (H_1) is accepted. This suggests that there is a statistically significant relationship between type of water and the mortality rate of mosquito larvae. Nevertheless, some expected frequencies are below the recommended value of 5. This violates the assumptions of the G-test and may compromise the reliability of the results.

Table 5. *G-test result of second batch*

Type of water	Dead (*O*)	Alive (*O*)	Expected Dead (*E*)	Expected Alive (*E*)	Sum of Terms	*G*-statistic	df	Critical Value	p-value
Dirty water	10	0	10	0	25.11	50.22	**2**	5.99	0.000000000124
Semi-clean water	10	0	10	0					
Clean water	10	0	10	0					

The calculated value ($G = 50.22$) is much larger than the critical value (5.99) and p-value is less than 0.05 (0.000000000124). Nonetheless, there is no variation in the data, as all larvae died across the different water types. This indicates that the G-test is not applicable for the second batch, and no valid conclusion regarding the relationship between the type of water and the mortality rate of mosquito larvae can be drawn.

Acceptability Level of the Developed Larvicidal Product

To evaluate the acceptability level of the developed larvicidal product, an evaluation was conducted. The groups identified as evaluators are (1) subject-matter experts (SMEs) or professors, (2) future researchers or students, and (3) consumers. The evaluation was held on February 14, 2026 and to complete the SMEs, an individual evaluation was done on March 05 and 06, 2026. Figure 8 shows the packaging material of the developed larvicidal product, which is an amber glass bottle.

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Figure 8. Packaging Material of the Developed Larvicidal Product

The larvicidal product was stored in an amber glass bottle to protect it from direct sunlight and contamination. Amber glass is very effective in preventing foreign objects from entering the product. Amber glass is widely recognized as a packaging material for protecting sensitive products from UV radiation that can affect its effectiveness (Johnson, 2025). Amber blocks UV rays, it can also enhance the shelf life of the product, it is also eco-friendly and recyclable unlike other plastic containers that can cause waste to the environment (Davis, 2025). Therefore, the use of amber glass containers in this study helps maintain good quality and efficacy of the larvicidal product during storage.

Using the validated evaluation tool, a total of fifty (50) evaluators assessed the product. Table 6 presents the acceptability evaluation results.

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Table 6. *Results of the Acceptability Level Evaluation of Producing Mosquito Larvicidal*

Criteria	Evaluators			MS	QD	R
	SME	FR	CON			
Packaging	3.667	3.863	3.864	**3.799**	SA	1
User-Friendliness	3.667	3.737	3.853	**3.752**	SA	2
Total	**3.667**	**3.799**	**3.861**	**3.776**	SA	—

Legend:

SME-Subject Matter Experts/Course Professors

FR-Future Researchers/BTLE Students

Con-Consumers.

MS-Mean Score

QD-Qualitative Descriptio

1.00 to 1.75- Strongly Disagree (SD)

1.76 to 2.50- Disagree (D)

2.51 to 3.25- Agree (A)

3.26 to 4.00- Strongly Agree (SA)

"Strongly agree" is included in the Agree-disagree (AD) or Likert questions, which are commonly used response formats to measure attitudes and opinions in the social and medical sciences (Dykema et al, 2021).

The criteria used are packaging and user-friendliness. There are three stages in DDR, analysis, design and development, and evaluation based on (Parthiban et al, 2023). This states that packaging and user friendliness are considered the key factors under the evaluation of the product. The criterion for packaging received the highest evaluation rating of 3.799, interpreted as strongly agreed. User-friendliness came second with the rating of 3.752, interpreted as strongly agreed. All the criteria are evaluated strongly, with a total product evaluation score of 3.776. The high evaluation scores indicate that the product is well-designed and practical for use, showing its potential as an effective and acceptable alternative for controlling mosquito larvae.

Packaging is an important factor in a product since it attracts and communicates with the consumers (Shekhar & Raveendran, 2016). The product can sell itself through a properly made packaging. The importance of user-friendliness for products is to improve consumers' satisfaction and product success (Roudbaraki, 2022). This means that if a product is easy to use and handle and the packaging is suitable for the product, this will help increase consumers' satisfaction that can lead to the success of the product.

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The researchers also conducted significant difference analysis using ANOVA aside from the acceptability evaluation. Table 7 and 8 shows the results of ANOVA from the responses of the evaluators.

Table 7. *Significant Difference Among the Acceptability Rating Given by the Evaluators*

Source	DF	Sum of Square	Mean Square	F Statistics	p-value
Between Groups	2	0.1838	0.09188	1.8405	0.17
Within Groups	47	2.3462	0.04992		
Total	49	2.53	0.05163		

The test statistic F equals **1.840535**, which is in the 95% region of acceptance: [0 : 3.1951]. The difference between the sample averages of all groups is not big enough to be statistically significant. The evaluation scores by the set of evaluators shows no significant difference.

Table 8. *Significant Among the Criteria of the Acceptability Rating*

Source	DF	Sum of Square	Mean Square	F Statistics	p-value
Between Groups	1	0.01174	0.01174	2.9315	0.1377
Within Groups	6	0.02403	0.004005		
Total	7	0.03577	0. 00511		

The test statistic F equals **2.931483**, which is in the 95% region of acceptance: [0: 5.9874]. In other words, the difference between the sample averages of all groups is not big enough to be statistically significant. The evaluation scores by the set of evaluators shows no significant difference.

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IV. CONCLUSION and RECOMMENDATION

Conclusion

The research findings reveal that agricultural waste such as papaya leaves, coconut husk, and citrus peels has potential as an eco-friendly alternative larvicidal product that can help to reduce mosquito-borne disease. The study found that extracts from papaya leaves, coconut husk, and citrus peels were as effective as a larvicidal product having a 100% mortality rate. With 5 ml concoction with ten (10) larvae in a fifty (50) ml of dirty water being the most effective concentration in the mentioned set. Also, increasing the product's concentration increases the mortality rate of all sets. The product was evaluated in terms of user-friendliness and packaging. The evaluation revealed that the developed product was acceptable with a total mean score of 3.776 which is Strongly Agreed, from the Subject Matter Experts (SME), students or future researchers, and consumers.

Recommendations

Future studies should also not just focus on the mosquito larvae found in the locale of this study. The taxonomy of mosquito larvae should be included in future study. The concoction was not tested on non-target organisms (NTOs) to ensure its safety to other organisms that are not intended to be killed by the formulation. The potential of reusing the tested water was not evaluated as its potential of hydrogen (pH) of the were not identified.

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