



# LEMMOR: Lemongrass (*Cymbopogon citratus*) and Malunggay (*Moringa oleifera*) as an insecticide spray against yellow fever mosquito (*Aedes aegypti*)

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## Abstract

Dengue fever, transmitted by *Aedes aegypti* mosquitoes, poses significant health risks, particularly in tropical regions such as the Philippines, where more than 195,000 cases were reported as of December 2023. This study examines the effectiveness of natural insecticide formulations made from Lemongrass (*Cymbopogon citratus*) and Malunggay (*Moringa oleifera*) extracts, exploring their potential as safer alternatives to synthetic insecticides. The researchers aimed to investigate the optimal ratios of these extracts (50:50, 75:25, and 25:75) and the impact of different spray frequencies (once, twice, and thrice) on mosquito mortality rates. Using a Completely Randomized Design (CRD), the study applied three spray trials to assess the efficacy of the formulations. Results showed no statistically significant differences in effectiveness among the treatments ( $p > 0.05$ ); however, Treatment 3 (25:75 ratio) consistently yielded the fastest mortality rate, with an average of 44.33 seconds to eliminate mosquitoes. In contrast, Treatment 2 had the highest mean duration (66.66 seconds) and greater variability, indicating inconsistency in its effectiveness. This study highlights the potential of Lemongrass and Malunggay as natural insecticides, offering communities and households an eco-friendly alternative for dengue prevention while reducing reliance on harmful chemical-based products. Further research is recommended to explore the synergistic effects of these plant extracts and their practical applications in pest management strategies.

**Keywords:** lemongrass, malunggay, organic insecticide, *Aedes aegypti*

## Article History:

*Received:* March 15, 2025

*Accepted:* June 1, 2025

*Revised:* May 24, 2025

*Published online:* June 15, 2025

## Suggested Citation:

Olacao, R.N.J., Borcena, A.M.R., & Tayag, A.N.B. (2025). LEMMOR: Lemongrass (*Cymbopogon citratus*) and Malunggay (*Moringa oleifera*) as an insecticide spray against yellow fever mosquito (*Aedes aegypti*). *Journal of Allied Health Sciences & Medical Research*, 1(1), 42-64. <https://doi.org/10.53378/jahsmr.353224>

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## 1. Introduction

According to the latest World Health Organization (WHO) study, dengue is a virus transmitted to humans through the bites of infected mosquitoes. Nearly half of the global population is currently at risk of contracting the virus, with an estimated 100–400 million infections occurring each year. As of December 2023, the WHO reported 195,603 dengue cases in the Philippines. Dengue primarily affects tropical and subtropical regions, especially urban and semi-urban areas. Although most dengue infections are asymptomatic, some cases can lead to severe illness and even death (Hanafusa et al., 2024). While no specific cure exists for dengue, early detection and prevention significantly reduce mortality rates associated with severe cases (WHO, 2024). Using insecticides is a common preventive measure (Ayilara et al., 2023; Liberal, 2022), but synthetic insecticides can pose harmful effects, including high costs, soil contamination, health hazards, and environmental damage (Essiedu et al., 2020; Althoff & Huijben, 2022; Jensen et al., 2022; Luker, 2024).). As a result, the use of organic insecticides is recommended to mitigate the adverse effects of synthetic alternatives.

Lemongrass and Malunggay emerge as promising candidates due to their medicinal properties (De Oliveira et al., 2020; El-Sayed et al., 2020; Ojewumi et al., 2017; Telembanua et al., 2020; Zulfikar et al., 2019; Rabe et al., 2024) and abundance in the Philippines. Lemongrass is a non-toxic, safe, and biodegradable plant with insecticidal properties, notably due to the compound citronella. It is known to repel *Aedes aegypti* mosquitoes, the primary dengue vector in the Philippines (Rusnanda et al., 2021). Additionally, phytochemical screening of Malunggay extract has revealed the presence of alkaloids, tannins, flavonoids, and saponins, natural substances known for their insecticidal activity (Mgbemena, 2015). Given these properties, the researchers chose to explore the use of Malunggay and Lemongrass as the main ingredients in this study.

There is an existing gap in the literature regarding the combined effectiveness of Malunggay and Lemongrass extracts as a natural insecticide. Therefore, this study aims to examine their potential synergistic effects and efficacy when used together as an insecticide spray. Specifically, it aims to determine whether the combination of Lemongrass (*Cymbopogon citratus*) and Malunggay (*Moringa oleifera*) ethanolic extracts is effective as an insecticide against yellow fever mosquitoes (*Aedes aegypti*), a prominent species and the primary vector of dengue fever in the Philippines. The study seeks to test the following hypotheses:

For concentration ratios:

Ho: There is no effective concentration ratio of Lemongrass and Malunggay ethanolic extracts for developing an organic insecticide.

Ha: At least one concentration ratio of Lemongrass and Malunggay ethanolic extracts is effective in developing an organic insecticide.

For spray trials:

Ho: The application of Lemongrass and Malunggay ethanolic extracts does not affect the mortality and resistance of *Aedes aegypti* mosquitoes across different spray trials.

Ha: The application of Lemongrass and Malunggay ethanolic extracts affects the mortality and resistance of *Aedes aegypti* mosquitoes across different spray trials.

For treatment effectiveness:

Ho: Among the three treatments, only one exhibits the shortest mosquito-killing time, with no significant difference among the others.

Ha: More than one treatment demonstrates a significantly shorter mosquito-killing time, indicating differences in effectiveness.

This research holds importance for both communities and households by offering a sustainable solution to combat dengue while reducing reliance on harmful synthetic insecticides.

## **2. Literature Review**

### ***2.1 Lemongrass***

Plants have been extensively utilized in industrial and academic settings due to their ability to synthesize a vast array of organic compounds through metabolic processes. Secondary metabolites, in particular, are of significant interest as they are uniquely synthesized by different species and play critical roles in defense against chemical, physical, and biological challenges, despite not being directly involved in plant growth or development (Da Silva et al., 2023). One of the main plant prospects for these types of metabolites is lemongrass (*Cymbopogon citratus*).

According to a study conducted by Catelo and Jimenez (2017), lemongrass is among the most widely used plants in the Philippines for addressing various health conditions. Its versatility extends to applications such as tea, medicinal remedies, and insect repellents, owing to its potent antioxidant and antibacterial properties (Kim et al., 2019). Lemongrass is readily

available in the Philippines, particularly in local markets, where its accessibility supports its widespread use. Additionally, the rise of stalls and kiosks offering natural health and wellness products reflects a growing consumer inclination toward pharmaceutical and nutraceutical alternatives. This trend has significantly gained momentum over the past decade, emphasizing the increasing demand for natural and functional products.

Lemongrass (*Cymbopogon citratus*) is widely recognized for its high citral content, a key component contributing to its therapeutic and aromatic properties. The timing of harvest significantly influences the yield and composition of its essential oils, particularly citral concentration. Environmental and agronomic factors such as temperature, light intensity, soil moisture, fertilizer application, and plant maturity, also play critical roles in determining the quality and quantity of essential oils. The primary constituents of lemongrass oil include citral monoterpenes, an isomeric mixture of geranial and neral, and myrcene, both known for their potent antibacterial and medicinal properties (Wifek et al., 2016). Herbal preparations, including lemongrass tea, have traditionally been employed in folk medicine to manage various health conditions. While early studies on the efficacy of lemongrass extracts, such as tea, presented mixed results, renewed interest driven by traditional claims has led to deeper investigations. Recent findings reveal that lemongrass tea contains a rich profile of bioactive compounds found in its decoction, infusion, and essential oil extracts. These compounds demonstrate robust pharmacological activities, including antioxidant, anti-inflammatory, antibacterial, anti-obesity, antinociceptive, anxiolytic, and antihypertensive properties, providing scientific validation for its traditional therapeutic use (Olorunnisola et al., 2014).

The lemongrass plant (*Cymbopogon citratus* (DC.) Stapf.), a member of the Poaceae family, is a well-known aromatic plant valued for its essential oil production. Although native to Southwest Asia, it is now cultivated and grows naturally in tropical and subtropical regions worldwide. In traditional medicine, lemongrass has been extensively used for its therapeutic properties, including applications in treating gastrointestinal and nervous system disorders, as well as its anti-inflammatory, analgesic, sedative, and antipyretic effects (Shah et al., 2011; Kusuma et al., 2024). The essential oil is typically extracted from the dried leaves of the plant, yielding between 0.5% and 2.0%, with citral being the predominant component, accounting for at least 60% of the oil. Citral consists of two isomers, neral (Z-isomer) and geranial (E-isomer), which serve as chemical markers of lemongrass essential oil. Notably, citral content

is influenced by geographical and environmental factors, with higher concentrations observed in tropical regions (Valková et al., 2022).

Lemongrass is highly regarded for its insecticidal properties, particularly its ability to repel insects and mosquitoes through natural insecticides (Peach et al., 2019). In recent years, there has been increasing interest in plant-based insecticides due to their biodegradability, affordability, and potential safety benefits for human health (Soonwera & Phasomkusolsil, 2016). Research on natural alternatives to synthetic chemical larvicides has revealed that essential oils from plants such as basil, cinnamon, citronella, lemongrass, and thyme exhibit significant larvicidal activity.

In a study conducted by Soonwera and Phasomkusolsil (2016), the efficacy of lemongrass and clove essential oils as larvicides for *Aedes aegypti*, a mosquito species known to transmit dengue, was investigated. The oils were tested in mixtures with soybean oil at concentrations of 1%, 5%, and 10%, with effectiveness monitored over a 10-day period. The study found that higher concentrations of lemongrass and clove oils had significant impacts on the immature stages of *Ae. aegypti* and *Anopheles dirus*. These findings highlight the potential of lemongrass and clove essential oils as sustainable and effective natural larvicides, offering an environmentally friendly alternative to synthetic options.

In another research study, Enad (2023) evaluated the effectiveness of oregano and lemongrass as organic insect repellents for household use. The research highlighted their potential as sustainable solutions for preventing insect infestations, particularly from houseflies, which pose significant health risks. Houseflies are known vectors of various diseases, including typhoid fever, diarrhea, dysentery, cholera, trachoma, African sleeping sickness, and onchocerciasis. To assess the efficacy of the repellents, the study employed three treatments with nine replications each, measuring both the flies' resistance rates and the products' effectiveness. The findings revealed that Treatments 1 and 2 were notably effective in repelling insects and exhibited higher resistance rates compared to Treatment 3. Based on these results, the study concluded that extracts from oregano leaves and lemongrass show significant potential as organic household insect repellents, offering a safer and environmentally friendly alternative to chemical-based products.

## 2.2 *Malunggay*

Plants are globally valuable in protecting people from hematophagous insects, with numerous studies highlighting the repellent effectiveness of plant oils. These oils are biodegradable, eco-friendly, widely available, and generally exhibit low toxicity to mammals. Moreover, plants are often easily accessible and inexpensive in many endemic regions. Plant oils possess several beneficial properties: they can easily penetrate insect cuticles, enhancing their bioavailability and potentially reducing insect lifespan on treated surfaces. Additionally, the active compounds in plant oils may act through specific mechanisms, making them a promising alternative to pyrethroids. Among the plants used for insect protection are Moringa and bitter melon. Moringa, the sole genus in the Moringaceae family, is also known as the drumstick tree (Patil et al., 2022).

Moringa is a fast-growing, drought-resistant plant native to the southern Himalayas in northern India, and it is widely cultivated in tropical and subtropical regions. It is used for water purification and in herbal medicine. Moringa oleifera leaf powder is also used as a soap substitute for hand washing (Torondel et al., 2014). This plant is considered a functional food and has various industrial food applications. Moringa provides essential nutrients beneficial for health, making it an important food source for enhancing food security in economically disadvantaged areas (Islam et al., 2021; Tafesse et al., 2020; Mahaveerchand & Abdul Salam, 2024). Incorporating Moringa oleifera seed flour improves the sensory qualities of different breads and biscuits (Koriyama et al., 2025; Agrawal et al., 2022; Govender & Siwela, 2020).

Almost every part of the Moringa plant, root, bark, gum, leaves, fruit (pods), flowers, seeds, and seed oil, has been used in traditional medicine to treat a variety of ailments, including skin infections, swelling, anemia, asthma, bronchitis, diarrhea, headaches, joint pain, rheumatism, gout, heart problems, fevers, digestive issues, wounds, diabetes, conjunctivitis, hemorrhoids, goiter, earaches, measles, and smallpox (Patil et al., 2022). Afolabi (2022) conducted a study demonstrating Moringa oleifera's strong larvicidal and adulticidal properties, suggesting its potential for controlling mosquito larvae and adults to reduce malaria prevalence in endemic regions. Phytochemical analysis indicated that Moringa plants are safe, affordable, and widely accessible. Furthermore, research by Mgbemena (2015) showed that Moringa oleifera leaf extract exhibited varying repellency at different concentrations, with higher concentrations resulting in stronger repellency.

### ***2.3 Yellow Fever Mosquitoes***

*Aedes aegypti*, often referred to as the yellow fever mosquito, is a small, dark insect distinguished by white spots on its legs and a lyre-shaped pattern on its thorax (Matthews, 2019). Unlike most mosquitoes, it is active during the day and aggressively seeks human blood, which is essential for female reproduction. These mosquitoes thrive in urban environments, laying eggs in stagnant water near human dwellings. Over the past thirty years, the global distribution of *A. aegypti* has significantly expanded due to increased trade, travel, and urbanization. It has adapted to diverse habitats and climates and is now found across several continents, including parts of North America and Europe. Its ability to survive and proliferate in densely populated areas makes it a highly efficient vector for arboviral diseases such as Zika, dengue, yellow fever, and chikungunya, posing serious public health concerns (Mohapatra et al., 2024).

Environmental factors, particularly temperature, play a vital role in the survival and behavior of *A. aegypti*. As ectothermic organisms, their physiology, behavior, and reproductive processes are influenced by external environmental conditions. To adapt to temperature fluctuations, they exhibit behavioral changes and produce heat shock proteins that help maintain cellular integrity and improve overall fitness. These adaptations contribute to their resilience and ability to thrive in a wide range of environments. Risk mapping studies have shown strong correlations between the presence of *A. aegypti* and the outbreaks of arboviral diseases, providing valuable data for public health interventions.

Despite these insights, controlling this mosquito remains a challenge due to its adaptability. In the absence of vaccines for many of the diseases it transmits, integrated vector management, comprising habitat control, public awareness campaigns, and chemical control methods such as fogging, remains essential. Continued research and innovation are crucial for developing effective strategies to manage this globally significant vector and mitigate its impact on human health.

## **3. Methodology**

### ***3.1 Research Design***

This study primarily employs an experimental and descriptive research design, allowing the researchers to manipulate variables and observe their effects throughout the experiment. A combination of quantitative and qualitative research methods is utilized to

provide a comprehensive understanding of the research question and problem, as well as to examine the effects of a specific phenomenon. The quantitative approach involves collecting numerical data during the experimental phase, while the qualitative method is used for observational purposes.

### ***3.2 Data Preparation***

**Materials.** Before collecting fresh Malunggay leaves, the researchers first conducted an ocular inspection in a specific area of San Jose del Monte City, Bulacan, using visual observation with the naked eye. They assessed whether the location had a sufficient number of healthy plants. After confirming this, they gathered the required amount of plants along with other materials used in the study. As for the Lemongrass, the researchers purchased it from a local market in San Jose del Monte City, Bulacan.

#### Ethanolic Extraction

35 grams of pulverized Lemongrass leaves

35 grams of Moringa leaf powder

700 ml of 95% Ethanol ( $C_2H_6O$ )

**Figure 1**

*Pretreatment of Lemongrass*



***Pretreatment of Lemongrass.*** After thorough sun drying, the collected lemongrass leaves were ground into a fine powder using a blender. Then, 35 grams of powdered lemongrass leaves were weighed and placed into a maceration vessel. The extraction process was carried out in a container using 95% ethanol as the solvent, maintaining a 1:10 ratio of lemongrass powder to ethanol. The mixture was left to stand for three days to allow the

compounds in the lemongrass to dissolve into the solvent. Afterward, the solution was separated from the solid residue using a cotton wool filter. The filtered extract was then transferred to a tightly sealed glass jar.

***Pretreatment of Malunggay.*** The collected moringa leaves were sun-dried until completely dry and then pulverized using a blender to produce a fine powder. Next, 35 grams of moringa leaf powder were measured and placed into a maceration vessel. The extraction process was carried out in a container using 95% ethanol as the solvent, with a moringa-to-ethanol ratio of 1:10 (Hasanah & Khumaidi, 2017). For maceration, the mixture was left for three consecutive 24-hour periods in a dark place with the lid tightly closed, stirring occasionally. The solution was then separated from the solid using a cotton wool filter. The filtered extract was subsequently transferred into a tightly sealed glass jar.

**Figure 2**

*Pretreatment of Malunggay*



**Figure 3**

*Formulation of spray*



**Formulation of Spray.** The study employed a Completely Randomized Design (CRD) with three treatment groups containing varying proportions of active ingredients: Treatment 1 (20 ml Malunggay extract + 20 ml Lemongrass extract), Treatment 2 (25 ml Malunggay extract + 15 ml Lemongrass extract), and Treatment 3 (15 ml Malunggay extract + 25 ml Lemongrass extract). After combining the active ingredients, each of the three treatments was transferred into a separate spray bottle with appropriate labels (Bhatti et al., 2023).

**Preparation of Yellow Fever Mosquitoes.** A mosquito found in the area was immediately covered with a cup that had a small hole to allow oxygen to enter once the mosquito was inside. A piece of paper was then carefully slid between the cup and the surface on which the mosquito was resting, effectively trapping it (Onyianta, 2023). Once a total of eighteen mosquitoes had been gathered—two mosquitoes per bottle—they were examined to determine if they were *Aedes aegypti* by checking for a white line on their legs and matching their physical characteristics with that of the species. Nine bottles were prepared, each containing two mosquitoes, corresponding to the number of extract ratio treatments used in the study. The mosquito experiment was conducted in a carefully monitored setting (Bhatti et al., 2023).

#### Figure 4

*Preparation of the Yellow Fever Mosquitoes*



**Methods and Techniques.** A combination of quantitative and qualitative methods was employed to gather data for this study, which aimed to determine the effectiveness of Lemongrass and Malunggay as insecticides. Additionally, an experimental research design was applied.

### ***3.3 Research Instrument***

Technologically and statistically based methodologies were used in the quantitative aspect of this study to gather data on the efficacy of Lemongrass and Malunggay as insecticides. For the qualitative component, data were collected through observations and existing literature.

### ***3.4 Data Gathering Process***

Experiments and observations were conducted to collect data. Samples with varying proportions of ingredients were prepared to determine the ideal ratio. A data table was also created to effectively organize and manage the findings. The following tests were conducted to obtain specific data:

1. Assess the insecticidal properties of lemongrass and malunggay by applying each of the three treatments with one, two, and three sprays.
2. Determine the number of sprays required to kill mosquitoes within a specific time period.
3. Identify the duration needed for each treatment concentration and spray frequency to eliminate mosquitoes.

In this phase of the experiment, the formulated sprays with different ratios of active ingredients, 50:50, 75:25, and 25:75, were tested using varying numbers of sprays. Three spray bottles were prepared, each corresponding to one of the treatment ratios, with five mosquitoes placed in each. For the first bottle, Treatment 1 was sprayed, and the number of sprays needed to kill the mosquitoes was recorded. The procedure was repeated for the second bottle using Treatment 2, and for the third bottle using Treatment 3.

Treatment 1 (20 ml Malunggay Extract + 20 ml Lemongrass Extract) - 50:50 ratio

Sprayed once

Sprayed twice

Sprayed thrice

Treatment 2 (25 ml Malunggay Extract + 15 ml Lemongrass Extract) - 75:25 ratio

Sprayed once

Sprayed twice

Sprayed thrice

Treatment 3 (15 ml Malunggay Extract + 25 ml Lemongrass Extract) - 25:75 ratio

Sprayed once

Sprayed twice

Sprayed thrice

After conducting the procedure, the most effective extract ratio and corresponding number of sprays were determined by analyzing the percentage of mosquito deaths (mortality) and the time it took to eliminate *Aedes aegypti* mosquitoes (resistance), using appropriate statistical tools.

### ***3.5 Data Analysis***

To analyze the significant differences between the values obtained from the tests, statistical analysis was conducted primarily using a one-way Analysis of Variance (ANOVA) and the computation of mean times required to repel or kill the mosquitoes. These statistical tools addressed the three main statements of the problem. Specifically, one-way ANOVA was applied to determine whether there were significant differences in effectiveness among the different extract ratios. This analysis helped assess whether the mean effectiveness of insecticides formulated with varying ratios of Lemongrass and Malunggay extracts differed significantly. If the ANOVA test revealed significant differences, post-hoc testing, particularly Tukey's Honestly Significant Difference (HSD) test, was used to identify which specific ratios differed significantly from one another.

In addition, ANOVA was also applied to examine the effectiveness of different application methods, sprayed once, twice, or thrice, of Lemongrass and Malunggay extracts. It helped determine whether there were statistically significant differences in mosquito mortality and resistance across the various spray applications, and which treatment exhibited the highest level of significance. This statistical analysis aimed to evaluate the following hypotheses: There is at least one effective concentration ratio of lemongrass and malunggay ethanolic extracts for developing an organic insecticide; The application of lemongrass and malunggay ethanolic extracts as an insecticide affects the mortality and resistance of *Aedes aegypti* mosquitoes through varying spray frequencies; and more than one of the three treatments formulated with lemongrass and malunggay ethanolic extracts shows a significantly shorter mosquito-killing time, indicating higher efficacy.

Using the Data Analysis Toolpak in Microsoft Excel 2021, data from the testing trials were calculated and interpreted to determine the mortality and resistance rates of mosquitoes subjected to the different extract ratios. This analysis served as a constructive evaluation of the effectiveness of combining these two plants in developing an organic insecticide capable of increasing mosquito mortality within a given period.

### **3.6 Risk Assessment**

This research involved handling biological materials and conducting experiments in a laboratory setting, which posed certain risks. Working with live mosquitoes for mortality testing carried the potential danger of insect bites or exposure to vector-borne diseases. To mitigate these risks, safety protocols were strictly followed, including the use of appropriate personal protective equipment (PPE), training on proper equipment usage, and ensuring sufficient laboratory ventilation. The entire experimental process was supervised by qualified laboratory technicians and research advisers to minimize potential hazards.

## **4. Results and Discussions**

This study aims to evaluate the results of experiments on the use of Lemongrass and Malunggay leaf extracts as an insecticidal spray against yellow fever mosquitoes.

**Table 1**

*Number of mosquitoes eliminated*

<b>Treatment</b>	<b>T1</b>	<b>T2</b>	<b>T3</b>
Number of time the mixture has been sprayed	3	3	3
Several mosquitoes died	2	2	2

Table 1 shows the number of times each treatment was sprayed on the mosquitoes and the average number of mosquitoes eliminated. Each of the three treatments, Treatment 1, Treatment 2, and Treatment 3, was sprayed three times, successfully eliminating 2 mosquitoes with every spray.

**Table 2***Testing results of treatment*

	<b>Treatment 1</b>	<b>Treatment 2</b>	<b>Treatment 3</b>
Once	1 minute and 12 seconds (72 seconds)	1 minute and 32 seconds (92 seconds)	58 seconds
Twice	55 seconds	1 minute (60 seconds)	40 seconds
Thrice	42 seconds	48 seconds	35 seconds

Table 2 displays the number of times each treatment was sprayed on the mosquitoes in a controlled setting. For Treatment 1, spraying once took 1 minute and 12 seconds to eliminate the mosquitoes, spraying twice took 55 seconds, and spraying thrice took 42 seconds. In Treatment 2, it took 1 minute and 32 seconds with one spray, 1 minute with two sprays, and 48 seconds with three sprays to eradicate the mosquitoes. Finally, Treatment 3 took 58 seconds to eliminate mosquitoes with one spray, 40 seconds with two sprays, and 35 seconds with three sprays. Additionally, the table shows that Mixture 3 required the shortest time to eliminate mosquitoes across all three spray applications, while Mixture 2, with three sprays and a minimum of 48 seconds, had the longest extermination time.

**Table 3***Summary of testing results*

	<b>Treatment 1</b>			<b>Treatment 2</b>			<b>Treatment 3</b>		
	<b>Times sprayed</b>	<b>Number of seconds</b>	<b>Number of mosquito died</b>	<b>Times sprayed</b>	<b>Number of seconds</b>	<b>Number of mosquito died</b>	<b>Times sprayed</b>	<b>Number of seconds</b>	<b>Number of mosquito died</b>
1	72	2	1	92	2	1	58	2	
2	55	2	2	60	2	2	40	2	
3	42	2	3	48	2	3	35	2	
<b>AVE</b>	<b>56.33</b>	<b>2</b>		<b>66.66</b>	<b>2</b>		<b>44.33</b>	<b>2</b>	

Table 3 summarizes the testing of three mixtures of Lemongrass and Malunggay at different concentrations sprayed against Yellow Fever mosquitoes in a controlled environment. For Treatment 1, the average time to exterminate the mosquitoes was 56.33 seconds, regardless of the number of sprays. Two mosquitoes were killed with one to three sprays of the mixture. In Treatment 2, the average extermination time was 66.66 seconds, with two mosquitoes killed

across the different spray applications. Lastly, Treatment 3 had an average extermination time of 44.33 seconds, consistently killing two mosquitoes at each number of sprays.

**Table 4**

*Summary result of the three (3) mixtures*

Groups	Count	Sum	Average	Variance
Treatment 1	3	169	56.33	226.33
Treatment 2	3	200	66.66	517.33
Treatment 3	3	133	44.33	146.33

Table 4 presents a summarized analysis of three different treatment concentrations, each evaluated across three observations. The table highlights key metrics: count, sum, average, and variance. Treatment 1 was applied three times (count = 3), resulting in a total sum of 169. This translates to an average of 56.33, indicating a moderate level of effectiveness. The variance of 226.33 suggests a moderate spread of results, meaning that the outcomes were neither highly consistent nor extremely varied. Treatment 2 was also applied three times (count = 3), yielding a total sum of 200. This resulted in the highest average of 66.66, suggesting that this treatment consistently produced the largest outcomes compared to the other treatments. It also has the highest variance (517.33), indicating that the results were more scattered and less consistent than those of the other treatments. Treatment 3 was applied three times (count = 3) and resulted in a total sum of 133. This led to the lowest average of 44.33, implying that this treatment generally produced the smallest outcomes. It also has the smallest variance (146.33), suggesting more consistent results.

**Table 5**

*Result of one-way ANOVA*

Source of variation	SS	Df	MS	F	p-value	F-crit
Between Groups	749.56	2	374.78	1.26	0.35	5.14
Within Groups	1789	6	296.67			
Total	2529.56	8				

\* Non-significant difference among groups ( $P$ -value  $>0.05$ )

The outcome of the one-way analysis of variance (ANOVA) is displayed in Table 5. Microsoft Excel 2021's statistical tools, specifically the Single Factor ANOVA, were used to obtain the necessary data. The degrees of freedom (df) are shown as 2 for between-group variation and 6 for within-group variation. The computed F value of 1.263295 is lower than the critical value (F-crit) of 5.143, and the P-value of 0.3484394 is much greater than the significance level of 0.05. This indicates that the differences in the means among the three treatments are not statistically significant. In other words, the observed differences in the treatments are likely due to random variation rather than the actual effects of the treatments. The ANOVA results, mainly the high P-value and the F value being lower than the critical value, suggest that the differences observed between the three treatments are not large enough to conclude that they are caused by the treatments. Instead, it is likely that these differences occurred by chance, which explains why the results are not statistically significant.

The summary result of the three (3) mixtures, each treatment underwent three trials, each successfully repelling two mosquitoes within different time periods. Treatment 3 (15 ml Malunggay, 25 ml Lemongrass) clearly repelled mosquitoes fastest compared to the other treatments, with spraying thrice being the most effective, killing mosquitoes within 35 seconds. Treatment 1 (20 ml Malunggay, 20 ml Lemongrass) was the second most effective, also showing spraying thrice as the most effective method, killing mosquitoes in 42 seconds. Lastly, Treatment 2 (25 ml Malunggay, 15 ml Lemongrass) was the least effective, with the longest extermination time, spraying thrice took 48 seconds. After conducting the ANOVA to analyze the data, it was found that the P-value is 0.3484394, which is higher than the 0.05 threshold used to determine whether to accept the null hypothesis. Consequently, based on the statistical analysis results, the null hypothesis is accepted.

This study demonstrated that the mixture of Lemongrass and Malunggay extracts is effective as an insecticide, based on both physical observations and statistical analysis. Statistically, Treatment 3 was found to have the most effective concentration, as it eradicated Yellow Fever mosquitoes in just 35 seconds, compared to 42 seconds for Treatment 1 and 48 seconds for Treatment 2. Although all treatments were effective in killing mosquitoes, Treatment 2 was the slowest, followed by Treatment 1. Therefore, Treatment 3 proved to be the fastest and most effective option for mosquito extermination.

As presented in Table 5, the results of the one-way ANOVA revealed a p-value of 0.348, which exceeds the 0.05 threshold used to determine the acceptance or rejection of the hypothesis. Consequently, the null hypothesis is accepted, indicating that the differences observed between the treatments are not statistically significant. Based on this analysis, the following hypotheses are accepted:

Ha: There is at least one effective ratio of concentrations for the combination of Lemongrass and Malunggay ethanolic extracts in order to develop an organic insecticide.

The first alternative hypothesis is accepted based on the testing results. The combination of Lemongrass and Malunggay ethanolic extracts in different concentrations was able to eradicate mosquitoes in varying amounts of time, confirming that at least one ratio is effective.

Ha: The application of Lemongrass and Malunggay ethanolic extracts as an insecticide affects the mortality and resistance of *Aedes aegypti* mosquitoes through different spray trials of the three treatments.

This second alternative hypothesis is also supported by the testing results. All treatments effectively reduced mosquito mortality and influenced the time required to terminate them. This demonstrates that the different spray trials had an impact on the mortality and resistance of *Aedes aegypti* mosquitoes, thereby justifying the acceptance of this hypothesis.

Ho: Among the three treatments formulated with Lemongrass and Malunggay ethanolic extracts, only one treatment exhibits the shortest mosquito-killing time, with no significant differences among the other treatments.

The third null hypothesis is considered most consistent with the findings. It suggests that while one treatment may exhibit the shortest mosquito-killing time, the differences among treatments are not statistically significant. Considering that all treatments demonstrated effectiveness, it was hypothesized that only one treatment would show the shortest extermination time, with the others varying slightly. Despite these differences, statistical analysis indicates that the variation is likely due to random chance, supporting the conclusion that there is no significant difference in effectiveness among the treatments.

## 5. Conclusion

The conducted experimentation demonstrated the ability of LEMMOR to repel Yellow Fever mosquitoes, with all samples proving to be effective. However, Treatment 3 (15 ml Malunggay, 25 ml Lemongrass) was found to have the most effective concentration, eliminating mosquitoes with three sprays within a span of 35 seconds. The results of one-way ANOVA indicated a case of random variation. The differences observed among the three treatments were not significant enough to conclude that they were caused by the treatments themselves, thus leading to the acceptance of the null hypothesis.

Based on the data collected and presented, the following recommendations may help future researchers conduct the procedures more efficiently and conveniently:

Use high-standard food processing equipment when pulverizing both plants, particularly Lemongrass, to achieve a more powder-like consistency.

Consider utilizing the most recommended equipment for essential oil extraction, such as a rotary evaporator or a hydrodistillation toolset, instead of relying solely on ethanolic extraction.

Contact testing centers in advance, ideally one to two months prior, to schedule product testing.

Collect as many *Aedes aegypti* mosquitoes as possible to better evaluate the spray's accuracy, resistance, and mortality rates.

Eliminate other variables that could affect the experimentation process to maintain consistency and reliability.

Conduct additional tests to further evaluate the product's effectiveness and accuracy across various environments and conditions.

### Disclosure statement

No potential conflict of interest was reported by the author(s).

### Funding

This work was not supported by any funding.

### Institutional Review Board Statement

This study was conducted in accordance with the ethical guidelines set by City of San Jose Del Monte National Science High School. The conduct of this study has been approved and given relative clearance(s) by City of San Jose Del Monte National Science High School.

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