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Testing the Effectiveness of Basil Leaf Essential Oil (Ocimum basilicum L) against Aedes Aegypti Mosquitoes in Aromatherapy Candles

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ABSTRACT

Purpose: This study aims to formulate basil leaf essential oil (Ocimum basilicum L.) as an active ingredient against Aedes aegypti mosquitoes in the form of aromatherapy wax that can be applied by inhalation.

Research Method: This study is a laboratory experimental study. Essential oil from basil leaves was obtained through steam distillation, while the wax preparation was made using the melting method. The aromatherapy wax formulation consisted of five groups, namely positive control, negative control, formulation I (2%), formulation II (4%), and formulation III (6%). Each formulation was tested through a series of physical property tests, including organoleptic tests (color, odor, and shape), burning time test, melting point test, and effectiveness test as an insect repellent against Aedes aegypti. Data analysis was performed using a one-way ANOVA statistical test and followed by a Tukey Post Hoc test.

Results and Discussion: The results showed that aromatherapy candles containing basil essential oil had varying effectiveness against mosquito mortality. Formulations with higher concentrations (4% and 6%) provided the best results in physical testing and biological effectiveness compared to other formulations and controls.

Implications: This study supports the development of natural-based aromatherapy candles as a safe, effective, and environmentally friendly alternative insecticide for controlling Aedes aegypti mosquitoes in domestic environments.

Keywords: aromatherapy candles; basil leaves; aedes aegypti mosquitoes; essential oil; ocimum basilicum l.

Introduction

Medicinal plants have long been an important alternative in the world of health and traditional medicine, particularly in Indonesia, which boasts an extremely high level of biodiversity. One plant with significant potential for development is basil leaves (Ocimum basilicum L), which are widely known not only as a food ingredient but also for their active compounds with pharmacological benefits. Basil leaves contain secondary metabolites such as alkaloids, flavonoids, steroids, and saponins, which act as natural antibacterial agents (Supadmi, 2020). Additionally, the essential oil in basil leaves contains primary active compounds such as linalool (56.7%–60%) and eugenol (40%–71%), which are known for their strong antibacterial and mosquito-repellent properties. This essential oil provides a distinctive and sharp aroma that is unpleasant to mosquitoes and functions as a natural antiseptic that is safe for humans (Putri et al., 2021). The main problem underlying this study is the increasing number of cases of Dengue Hemorrhagic Fever (DHF) caused by the Aedes aegypti mosquito. These mosquitoes reproduce rapidly, especially in humid environments with standing water, posing a significant threat to public health. Data from Gustian et al. (2024) indicates that by November 2024, the number of DBD cases in Central Java had surged dramatically to 14,000 cases, a 125% increase compared to the previous year, which recorded only 6,500 cases. This surge is closely linked to climate change and exceptionally prolonged rainy seasons. This situation demands safer, more effective, and easier-to-apply mosquito control alternatives, especially in residential environments. One promising alternative is aromatherapy candles made with active ingredients from basil leaf essential oil as a natural insecticide that is environmentally friendly and does not cause side effects like chemical insecticides.

Essential oils, which are extracted from aromatic plant parts, including basil leaves, have characteristics such as being volatile, lipophilic, and having a distinctive aroma (Siswantito et al., 2023). Aromatherapy, as a medium for relaxation and room freshening, is now developing in various forms such as candles, massage oils, and soaps, where essential oils serve as the main active ingredient. Research by Putri et al. (2021) has tested the use of basil leaf essential oil in the form of aromatherapy candles as a natural insecticide, showing promising results. Additionally, the compounds linalool and eugenol found in basil demonstrate biological activity that can repel or even kill mosquitoes due to their pungent aroma and bitter taste, which are unpleasant to mosquitoes (Salsabila, 2023). Furthermore, the study by Dewi & Arianti (2023) states that the use of aromatherapy candles is gentler on the skin compared to mosquito repellent lotions, which carry a risk of irritation. In terms of formulation, the study by Murniningsih et al. (2022) showed that using essential oil concentrations of 2%, 4%, and 6% produced white-colored candles with a distinctive aroma, where the 4% and 6% formulations provided the best stress-relieving effects with a significance value of 0.00 ($P < 0.05$). Herawaty et al. (2021) further noted that the combination of lemongrass and citronella essential oils also affects the melting point and burning time of the candles, with formulation III (1%:5%) showing stable physical performance and formulation I (3%:20%) being the most preferred by respondents due to its strong aroma. These studies confirm that aromatherapy candle formulations containing lemongrass essential oil have great potential as an effective and practical natural mosquito repellent.

Previous studies have demonstrated the potential of basil leaves as an active ingredient in the production of aromatherapy candles with antibacterial and mosquito-repellent properties. However, significant gaps remain in both empirical and theoretical aspects that require further clarification. For example, the study conducted by Murniningsih et al. (2022) focused more on the effect of basil leaf essential oil concentration on the antistress properties and organoleptic characteristics of candles, without directly testing its effectiveness in repelling or killing Aedes aegypti mosquitoes. Similarly, the study by Herawaty et al. (2021) evaluated the physical properties of aromatherapy candles, such as melting point, burning time, and user preference. However, it did not address the numerical testing of the insecticide's effectiveness against mosquitoes directly. On the other hand, although Putri et al. (2021) attempted to develop aromatherapy candles made from basil leaves as a natural insecticide, the study did not provide quantitative data on the effect of various essential oil concentrations on the number of mosquitoes successfully repelled or killed. Therefore, to date, there is insufficient empirical evidence based on data to explain the causal relationship between the concentration of basil leaf essential oil in aromatherapy candles and its effectiveness against Aedes aegypti mosquitoes.

This study presents a novel approach using quantitative analysis to test the effectiveness of basil leaf essential oil (Ocimum basilicum L) against Aedes aegypti mosquitoes in the form of aromatherapy candles, which has not been extensively explored empirically. Unlike previous studies that focused more on the physical properties of the wax or users' sensory preferences (Herawaty et al., 2021; Murniningsih et al., 2022), this study measures explicitly the repellent efficacy or insecticidal potential of the candles based on variations in essential oil concentration (2%, 4%, and 6%) through quantitative observation of the number of Aedes aegypti mosquitoes exposed to the candles. This approach provides an important contribution to strengthening the scientific basis for the use of herbal plants as vector-based disease control agents based on numerical data, ensuring that the results are not merely descriptive but also statistically testable. The primary objective of this study is to determine and compare the effectiveness of aromatherapy candles made from basil leaves in repelling mosquitoes, with the hope that they can serve as a safer, more economical, and environmentally friendly alternative to chemical insecticides to support preventive efforts in controlling the spread of Dengue Hemorrhagic Fever (DHF).

Literature Review and Hypothesis Development

Basil Leaf Essential Oil (Ocimum Basilicum L)

Basil leaf essential oil (Ocimum basilicum L.) is a volatile compound obtained through steam distillation of basil plant tissue, particularly the leaves. This compound has long been known for its diverse bioactive compounds and significant aromatic and therapeutic benefits. Among the main compounds contained in basil leaf essential oil are linalool and eugenol. Both are known to play a significant role in imparting antibacterial, antifungal, and natural insecticidal properties. Research conducted by Santos et al. (2024) demonstrated that basil essential oil exhibits effectiveness as a larvicide against Aedes aegypti and Culex quinquefasciatus mosquitoes, particularly when formulated as a nanoemulsion, which enhances the bioavailability of active compounds. Additionally, a study by López-Hernández et al. (2024) confirms that the chemical composition of basil essential oil from specific varieties contains high levels of antioxidants, making it relevant not only in the field of health but also in natural cosmetics. Linalool contributes to calming and sedative effects, while eugenol is well-known for its antiseptic and insect-repellent properties. The presence of these two compounds supports the use of basil essential oil in plant-based products, ranging from larvicides to aromatherapy and natural cleaners. The combination of biological activity and safety makes basil essential oil highly promising for commercial and scientific development.

The effectiveness of basil leaf essential oil as a natural insecticide has also been specifically studied in the context of controlling Aedes aegypti mosquitoes, which are the primary vectors of Dengue Hemorrhagic Fever (DHF). Wahyuni et al. (2022) in their study demonstrated that the distinctive aroma of basil essential oil can disrupt the mosquitoes' olfactory system and significantly reduce their landing activity. This effect is not only attributed to compounds such as linalool and eugenol. However, it is also enhanced by the presence of other secondary metabolites like flavonoids and saponins, which synergistically enhance the repellent and toxic effects against insects. Botelho et al. (2022) stated that variations in basil varieties, such as Ocimum basilicum var. minimum, also possess firm phytochemical profiles as larvicides, indicating that the effectiveness of essential oils is highly determined by genetic factors and the plant's growth environment. On the other hand, Lenti et al. (2022) emphasize the importance of accurate analytical techniques, such as gas chromatography, to ensure the optimal content and concentration of linalool and eugenol in each essential oil extraction. Standardization of raw materials is a key factor in ensuring the consistency of basil-based formulations. These findings collectively provide a strong scientific foundation that basil leaf essential oil is not only aromatic but also functional as an environmentally friendly insect control agent and suitable for large-scale applications, including aromatherapy candle formulations.

In the development of natural-based household products, lemongrass essential oil shows great potential, particularly in the formulation of aromatherapy candles. The combination of aromatic properties and insect-repellent effects makes lemongrass essential oil a multifunctional active ingredient. Aromatherapy candles containing basil essential oil not only serve as room fresheners but also provide relaxation effects and naturally protect homeowners from mosquito disturbances. Filho et al. (2025) state that the application of essential oils with larvicidal potential, including basil, is crucial in supporting ecosystem-based vector control strategies that minimize risks to humans and the environment. Products like lemongrass-based aromatherapy candles offer an effective solution to reduce reliance on synthetic insecticides, which often cause side effects. Additionally, Kačániová et al. (2022) emphasize the need for cross-species insect testing to evaluate the scope of essential oil's biological activity, ensuring its optimal use according to the target vector type. The use of basil essential oils in modern household products shows a positive trend in green products and sustainability approaches. This approach not only supports user health and comfort but also contributes to environmental conservation and the enhancement of the economic value of local plants.

Aedes Aegypti Mosquito

The Aedes aegypti mosquito is a species of mosquito from the Culicidae family that is widely known as the primary vector for dangerous viral diseases that pose a threat to human health, such as Dengue Hemorrhagic Fever (DHF), Zika, Chikungunya, and yellow fever. This species has distinctive morphological characteristics, including a black body with white markings on the legs and thorax, and a tendency to bite humans, particularly in the morning and evening. One important characteristic of Aedes aegypti is its tendency to lay eggs in clean, stagnant water sources such as flower pots, empty cans, bathtubs, or other water containers around residential areas (Emidi et al., 2024). This mosquito is highly adaptive to urban environments, particularly due to the high availability of human-made habitats that support its life cycle. As reported by Egid et al. (2022), Aedes aegypti has high reproductive capacity and a preference for biting humans (anthropophilic), making it an extremely efficient vector for virus transmission. Furthermore, this mosquito can lay large numbers of eggs, and its eggs can survive in dry conditions for months before hatching when they come into contact with water again. These biological adaptations make this species difficult to eradicate and highly resilient in maintaining its population, especially in tropical and subtropical regions.

As global climate change progresses, the geographical distribution of Aedes aegypti mosquitoes is predicted to expand into areas that previously did not support their life cycle. A study conducted by Mejía-Jurado et al. (2024) estimates that rising temperatures and increased rainfall will expand the potential habitat of these mosquitoes into highland and subtropical regions, as has already been observed in some areas of Colombia. Similar phenomena have been observed in various African countries, where research by Montgomery et al. (2025) indicates that rapid urbanization, rising temperatures, and unpredictable rainfall patterns have directly contributed to a surge in Aedes aegypti populations. These findings align with research by Rosser et al. (2024), who developed a waste

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classification system to map mosquito breeding sites using drone imaging technology (UAV) in Kenya. Their findings revealed that household waste containing rainwater serves as the primary breeding site for these mosquitoes. From a behavioral perspective, Meyerhof et al. (2025) found that Aedes aegypti mosquitoes can recognize shadows and avoid visual threats while searching for hosts, even in low-light conditions. This indicates a high level of cognitive adaptation that further enhances the species' resilience in various environmental conditions. Therefore, ecology-based control approaches, mapping technology, and an understanding of insect behavior are crucial in future vector mitigation strategies.

Another challenge in controlling the Aedes aegypti population is the increasing resistance to chemical insecticides, especially from the pyrethroid class, which has been widely used in fogging and larval control activities. Emidi et al. (2024) demonstrated that Aedes aegypti populations in urban areas of Africa exhibit high levels of resistance to synthetic insecticides, accompanied by a shift in breeding habitat preferences from large water bodies to smaller, more concealed containers. As a result, approaches based on natural materials and more sustainable control strategies are increasingly developed. One such approach involves the use of essential oils from herbal plants such as Ocimum basilicum L. (basil), which have been found to contain active compounds like linalool and eugenol that act as repellents and toxins against mosquitoes. Additionally, a deeper understanding of mosquito host-seeking mechanisms continues to be developed. Chandel et al. (2024) in their study revealed that Aedes aegypti utilize infrared thermal signals to detect the location of the human body, particularly on the surface temperature of the skin. This discovery opens up opportunities for the development of heat signal disruption-based repellent technology, which could expand options for non-chemical control methods.

Aromatherapy Candles

Aromatherapy candles are one form of aromatherapy preparation formulated from wax-based ingredients such as paraffin, stearin, or vegetable wax (e.g., soy wax), mixed with essential oils as the primary active ingredient. This product is designed to provide therapeutic effects through the evaporation of aromatic compounds when the candle is burned. The essential oils used are derived from aromatic plant extracts with pharmacological effects, such as lavender, known for its calming effects, peppermint for refreshing, and lemongrass and basil, which function as natural mosquito repellents. In practice, aromatherapy candles not only serve as room fragrances but also as a medium to create a calm atmosphere, improve mood, and aid relaxation and sleep. According to Widowati et al. (2025), aromatherapy candles also have aesthetic and ergonomic value, as their shape and aroma can enhance decorative functions in both private and public spaces. The effectiveness of these candles depends heavily on the quality of the essential oils used, including their chemical composition, concentration, and aroma longevity during burning. The higher the quality of the essential oil, the stronger the aromatherapy effects are produced. Therefore, selecting the right essential oil is crucial in ensuring the therapeutic benefits of the formulated candle. Additionally, the base material of the candle, such as soy wax, is considered more environmentally friendly compared to paraffin, making it the primary choice in the production of modern aromatherapy candles.

The process of aromatherapy candles begins when the candle is lit and the heat releases volatile compounds from the essential oils into the air. These compounds are then inhaled by the user through the respiratory system and affect the central nervous system, particularly the limbic part of the brain, which is responsible for emotions, mood, and memory. This mechanism forms the scientific basis for the relaxation, stress-relieving, and even focus-enhancing and sleep-quality-improving effects of aromatherapy candles. A study by Hanphitakphong & Poomsalood (2024) revealed that lavender-based candles have a direct effect on reducing sympathetic nervous system activity and enhancing bodily relaxation within just a few minutes of burning. This effect is further enhanced by proper formulation, such as the use of soy wax with a low melting point that releases aroma consistently. Ahmad et al. (2023) also noted that combining essential oils, such as grapefruit and patchouli, can create a more complex, long-lasting, and layered aroma, thereby enhancing the user's sensory experience. Therefore, aromatherapy candles do not rely solely on a single scent but can be formulated with a blend of various essential oils to produce synergistic effects. Research also indicates that the psychological effects of aromatherapy candles are not merely subjective but can be observed physiologically through reduced heart rate, slower breathing, and lower stress levels, making them highly relevant for use in complementary therapy, meditation, or alternative health care.

In addition to psychological benefits, aromatherapy candles are now also being developed for other functional purposes, such as natural insecticides and environmental control. Some essential oils used in candles, such as citronella, lemongrass, and cinnamon, are known to contain bioactive compounds like linalool, eugenol, and citronellal that are effective in repelling insects, particularly mosquitoes. Dey (2025) emphasizes that candles made from essential oils with natural antioxidant content not only spread pleasant aromas but also provide safe and sustainable protection against insect disturbances in enclosed spaces. This opens up significant opportunities for the development of dual-purpose aromatherapy candles, serving as both a relaxation medium and a natural protector against disease-carrying insects in the home. Additionally, Chougule et al. (2024) developed a polisherbal candle designed as a natural repellent with significant results in reducing insect activity. Even the candle formulation from calamansi peel oil, as developed by Meryta et al. (2023), demonstrated a fresh aroma and high insect-repelling activity. On the other hand, aesthetics also play a crucial role in the marketing of aromatherapy candles. Widowati et al. (2025) highlight that candle design, color, and container shape are key factors in increasing consumer purchasing interest, particularly among urban consumers who seek a balance between functionality, aesthetics, and health.

Research Method

Research Design

This study used a quantitative approach with a laboratory experimental design. This approach was chosen to objectively measure the effectiveness of basil leaf essential oil (Ocimum basilicum L) against Aedes aegypti mosquitoes in the form of aromatherapy wax preparations. The research design aims to determine the optimal formulation of the wax preparation with different essential oil concentrations (2%, 4%, and 6%) in providing natural insecticidal effects. The experiment was conducted in a controlled laboratory environment to obtain numerical data that can be analyzed statistically.

Research Population and Sample

The population in this study consisted of 8 kg of fresh basil leaves obtained from Kebumen, Central Java. The sample used was 20 ml of essential oil distilled from basil leaves, which was then used to make aromatherapy candles. The formulated candles are suspected to contain active compounds such as flavonoids, saponins, alkaloids, eugenol, and linalool, which have potential as mosquito

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repellents. This study was conducted at the Pharmacy Biology Laboratory, Faculty of Pharmacy, Muhammadiyah University of Kudus, Indonesia.

Data Collection Techniques and Instruments

Data was collected through direct observation of the number of Aedes aegypti mosquitoes exposed to aromatherapy candles with different essential oil concentrations. Observations were conducted using a stopwatch to measure exposure time and the number of affected mosquitoes in a special cage. The equipment used in the research process included an analytical scale (Ohaus), dropper pipettes, stirring rods, test tube racks, test tubes (Pyrex), glass funnels (Pyrex), porcelain dishes, mosquito cages, candle wicks, stopwatches, distillation apparatus (condenser flasks), wax containers, and a hot plate (Maspion). The materials used were fresh basil leaves, white oil, paraffin, dye, concentrated HCl, amyl alcohol, distilled water, and Mayer, Bouchardat, and Dragendorff reagents for phytochemical testing to identify secondary metabolites in essential oils.

Data Analysis Techniques

Data analysis was performed using SPSS software version 25.0. The data analysis stages included normality tests to determine data distribution, homogeneity tests to test the similarity of variances between groups, and one-way ANOVA tests to determine significant differences between treatment groups. If significant differences are found, further post hoc tests are conducted to identify which treatment group yields the most optimal effect on the number of Aedes aegypti mosquitoes affected. This analysis aims to determine the effectiveness of each essential oil concentration in aromatherapy candles in a quantitative and statistically significant manner.

Results and Discussion

Analysis Result
Plant Determination

Table 1. Data on the Determination of Basil Leaves

1b – 2b – 3b – 4b – 6b – 7b – 9b – 10b – 11b – 12b – 13b – 14b – 16a – 239b – 243b – 244b – 248b – 249b – 250b – 266b – 267b – 273b – 276b – 278b – 279b – 282a Labiatae 1a – 2b – 4b – 6b – 7b – Ocimum
Ocimum basilicum L

Sample Weighing

The following table shows the results of testing the distillation process of basil leaves (Ocimum basilicum L):

Table 2. Sample Weighing Results

Weight of Fresh Basil Leaves	Drying Results	Distillation Results	% Yield
8 kg	1 kg	20 ml	12,5%

Based on Table 2 obtained from weighing 8 kg of fresh basil leaves, the drying yield was 1 kg, resulting in 20 ml of distillate. The dried basil leaves (Ocium basilicum L) contained 2.09 g of moisture

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content and a yield of 12.5%, thus meeting the requirements for moisture content testing using a moisture balance and yield calculation (Wijaya & Noviana, 2022).

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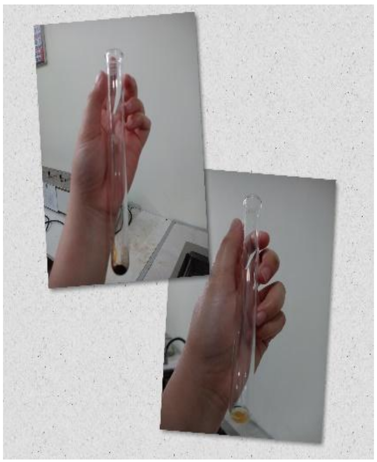

Figure 1. Alkaloid test

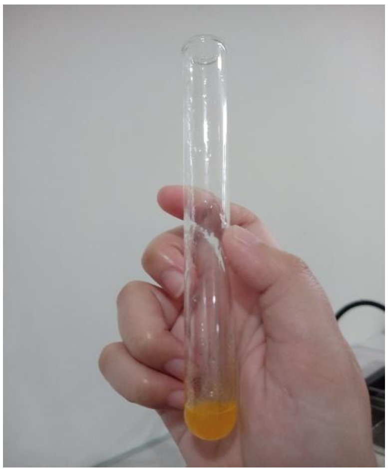

Figure 2. Flavonoid test

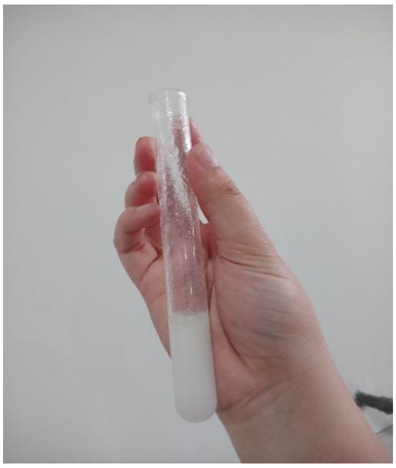

Figure 3. Saponin test

The following table shows the results of phytochemical screening tests:

Table 3. Phytochemical Screening Test Results

Test	Reagent	Before	After	Results
Alkaloid Test	Mayer	Clear	Yellow deposits formed	Positive for alkaloids
	Dragendroff	Clear	Orange deposits formed	Positive for alkaloids
Flavonoid Test	Concentrated HCI & amyl alcohol	Clear	Yellow	Positive for flavonoids
Saponin Test	Aquadest	Clear	Presence of foam that does not disappear	Positive for saponin

Based on Table 3 obtained from phytochemical screening tests, the results showed positive alkaloids, flavonoids, and saponins. This study is in line with the researchers (Intan et al., 2023).

Physical Properties Test

The following table shows the results of physical property testing on mosquito repellent aromatherapy candles against Aedes aegypti.:

- Physical and Organoleptic Properties of Aromatherapy Candles (Color, Taste, Smell)

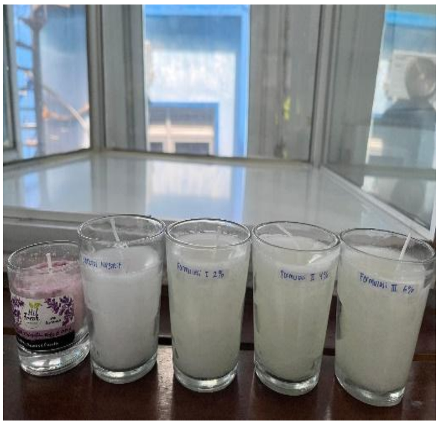

Figure 4. Aromatherapy Candle Preparation

Table 4. Results of Organoleptic Properties Test

Formulation	Color	Taste	Smell
Negative Control	Milk White	No Taste	Odorless
FI	Condensed Milk	Basil Leaves	Typical Basil Leaves
FII	Condensed Milk	Basil Leaves	Typical Basil Leaves
FIII	Condensed Milk	Basil Leaves	Typical Basil Leaves

Description:
Negative Control
FI: Concentration 2%
FII: Concentration 4%
FIII: Concentration 6%

Based on Table 4, which was obtained from the physical and organoleptic properties test of mosquito repellent aromatherapy candles against Aedes aegypti, the Negative Control produced a milky white color, was odorless, and tasteless because it was a wax base (without essential oils). Formulations I, II, and III produced a deep white color, had a distinctive basil leaf flavor, and produced a basil leaf scent.

- Physical Properties Test of the Melting Point of Aromatherapy Candle Preparations

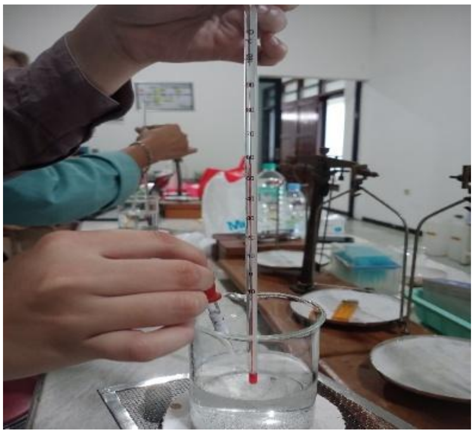

Figure 5. Melting Point Test

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Table 5. Results of Physical Properties Test of Melting Point

Formulation	Melting Point Temperature	Description
Negative Control	57°C	Meets Melting Point Test Requirements
FI	56°C	Meets Melting Point Test Requirements
FII	55°C	Meets Melting Point Test Requirements
FIII	54°C	Meets Melting Point Test Requirements

Description:
Negative Control
FI: Concentration 2%
FII: Concentration 4%
FIII: Concentration 6%

Based on Table 5 obtained from the physical properties test of the melting point of mosquito repellent aromatherapy candles against Aedes aegypti mosquitoes, the Negative Control and Formulations I, II, and III met the melting point test requirements. According to SNI 0836-1989-A/SII 0348-1980, the melting point should be between 50°C and 58°C. In this study, the physical properties test for the melting point of the aromatherapy wax formulations showed a temperature range of 54°C to 58°C.

- Physical Properties Test of Burning Time of Aromatherapy Candle Preparations

Table 6. Results of Physical Properties Test of Burning Time

Formulation	Time Information		Baking Time	Description
	Start	Finish		
Negative Control	01.00	01.20	20 Minutes	Meets Burn Time Test Requirements
FI	01.00	11.01	10 hours	Meets Burn Time Test Requirements
FII	01.00	10.58	9 hours 58 minutes	Meets Burn Time Test Requirements
FIII	01.00	10.57	9 hours 57 minutes	Meets Burn Time Test Requirements

Description:
Negative Control
FI: Concentration 2%
FII: Concentration 4%
FIII: Concentration 6%

Based on Table 6 obtained from the physical properties test of the burning time of mosquito repellent aromatherapy candles against Aedes aegypti mosquitoes, the Negative Control and Formulations I, II, and III have met the burning time test requirements. According to SNI 0836-1989-A/SII 0348-1989, the active ingredient (essential oil from basil leaves) is highly volatile, so the higher the concentration of essential oil, the faster the candle burns (extinguishes). In this study, the physical

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properties of the burn time were tested for 9–10 hours, but not with the Negative Control, which only burned for 20 minutes because there were no active ingredients in the candle. This aligns with the research by Herawaty et al. (2021), which states that the properties of essential oils significantly influence the burn time test.

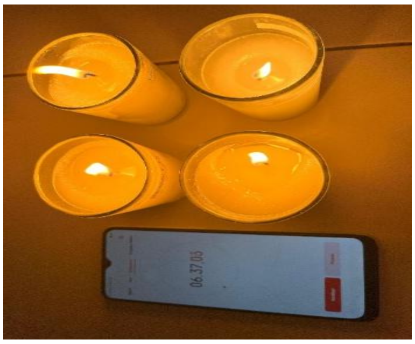

Figure 6. Burn Time Test

Testing the Effectiveness of Basil Leaf Essential Oil (Ocimum basilicum L) in Aromatherapy Candles as a Repellent against Aedes aegypti Mosquitoes.

The following table shows the results of the effectiveness test of basil leaf essential oil (Ocimum basilicum L) in aromatherapy mosquito repellent candles against Aedes aegypti mosquitoes.

Table 7. Mosquito Repellent Effectiveness Test Results

Formulation	Replication	The Death of a Mosquito	Total Mosquito Deaths	Average Death Rate	% The Death of a Mosquito
Negative Control	1	0	0	0	0%
	2	0			
	3	0			
FI	1	2	7	2,3	35%
	2	2			
	3	3			
FII	1	3	9	3	45%
	2	2			
	3	4			
FIII	1	3	9	3	45%
	2	3			
	3	3			
Positive Control	1	3	12	4	60%
	2	4			
	3	5			

Description:
Negative Control
FI: Formulation 2%
FII: Formulation 4%
FIII: Formulation 6%
Positive Control

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Based on Table 7 obtained from the efficacy test of Ocimum basilicum L leaf essential oil in an aromatherapy mosquito repellent candle formulation against Aedes aegypti mosquitoes, the Negative Control showed a 0% mortality rate due to the absence of active compounds in the candle. Formulation I (2%) showed a mosquito mortality rate of 35%. Formulation II (4%) and III (6%) showed the same result of 45%. Positive Control (commercial brand) showed a result of 60%. This study found a similarity in the percentage of mosquito mortality between Formulation II (4%) and Formulation III (6%); however, during each replication, the number of mosquito deaths varied. Positive Control had a high mosquito mortality rate because it is already available on the market and has undergone several testing phases.

Test Data on the Effectiveness of Aromatherapy Candles Against Aedes Aegypti Mosquitoes at the Center for Vector and Disease Reservoir Research and Development (B2P2VRP) in Salatiga.

Data Analysis on the Efficacy Test of Basil Leaf Essential Oil (Ocimum basilicum L) in Aromatherapy Candle Preparations Against Aedes Aegypti Mosquitoes Using SPSS Version 25.0

Normal Test Results Data

The results of the normality test using SPSS 25.0 indicate that the data are normally distributed because they are greater than 0.05. The data can be seen in Shapiro-Wilk (data less than 50), showing a significance value in the formulation of 0.103 (Usmadi, 2020).

Homogeneity Test Results Data

The homogeneity test with a significance value of 0.117 greater than 0.05 shows that the data is homogeneous (Usmadi, 2020).

One-Way ANOVA Test Results Data

Based on the one-way ANOVA test, there was a significant difference in the average mosquito mortality rate in several formulations, with a significance value of 0.000 less than 0.05. It can be concluded that there is a significant difference between the formulations and the mosquito mortality rate of HADIYANTI.

Post Hoc Test Results Data

Based on post hoc testing using the Tukey HSD method, if the p-value is less than 0.05, the data shows a significant difference from other groups. If the p-value is greater than 0.05, the data shows no significant difference from other groups. The results of the post hoc test show that in the Negative Control group, the p-value is greater than 0.05; in the 2% Formulation group, the p-value is greater than 0.05; in the 4% Formulation group, the p-value is less than 0.05; in the 6% Formulation group, the p-value is less than 0.05; and in the Positive Control group, the p-value is less than 0.05. In the Negative Control group, there were no significant differences; in the Formulation (2%) group, there were no significant differences; in the Formulation (4%), (6%), and Positive Control groups, there were significant differences.

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Discussion

Determination

Based on Table 1, the determination of basil leaves (Ocimum basilicum L) was conducted at the Biology Laboratory of Ahmad Dahlan University on January 25, 2025. Basil leaves (Ocimum basilicum L) belong to the Labiatae family.

Ethical Clearance

Based on Table 2, ethical clearance was obtained from Muhammadiyah University Purwokerto (KEP-UMP), which has obtained ethical approval for research with registration number KEPK/UMP/384/III/2025.

Raw Material Analysis

Based on Table 3, 8 kg of fresh basil plants were harvested and then dry-sorted to separate the basil leaves from contaminants attached to the leaves. Wet sorting was then carried out using clean running water to ensure good quality basil leaves, which were then dried in an oven at 50ºC. The oven temperature must not be below 50°C, as this can damage the content of the basil leaves. This is in line with research (Krismayadi et al., 2024) stating that drying in an oven should not exceed 50°C, as this can damage the chemical compounds in the basil leaves. Next, a moisture content test was conducted by weighing 50 g of the dried leaves using a moisture balance, resulting in a moisture content of 2.09%. This indicates that the moisture content is appropriate to maintain the quality of the dried leaves and prevent spoilage and mold growth. This study aligns with Wijaya & Noviana (2022), who stated that the moisture content set to maintain the quality of the simplisia is less than 10%.

The process of extracting essential oil from basil leaves was carried out through distillation. Distillation is a process of separating a mixture based on boiling points and vapor pressure at a specific temperature to produce essential oil. Distillation was performed by weighing 500 grams of the material, placing it in a round-bottom flask, mixing it with 5 liters of distilled water, and heating it for 5 hours until the distillate was obtained. This process is repeated twice to accommodate the round-bottomed flask. From the total of two repetitions, the essential oil is separated from the water, yielding 20 ml of distillate. This aligns with research by Azriyenni et al. (2022), which found that the distillation process at a temperature of 75°C yielded 0.86 mg/L when the essential oil was filtered with distilled water, resulting in the desired distillate according to the requirements.

Phytochemical Screening Test

Based on Table 4, the phytochemical screening test on basil leaf essential oil (Ocimum basilicum L) contains alkaloid, flavonoid, and saponin compounds. The alkaloid test was conducted by adding five drops of essential oil to 3 drops of Mayer's reagent from a clear solution, resulting in the formation of a yellow precipitate, and three drops of Dragendroff's reagent, resulting in the formation of an orange precipitate, indicating the presence of alkaloids. The flavonoid test was conducted by adding five drops of essential oil and three drops of concentrated HCl and amyl alcohol from a clear solution until the mixture turned yellow, indicating the presence of flavonoids. Next, a saponin test was conducted by adding five drops of essential oil and 5 ml of aquadest reagent from the clear solution until foam formed that did not disappear, indicating the presence of saponins. These changes in color during the phytochemical screening test of basil leaf essential oil (Ocimum basilicum L) were due to the addition of the reagents. This aligns with research by Simbolon (2022), which revealed that basil leaves contain flavonoids, alkaloids, and saponins. Basil plants also have medicinal benefits, functioning as natural antibiotics and anti-inflammatory agents (steroids).

Physical Properties Test

The results of physical property tests of aromatherapy wax preparations include organoleptic tests, burning time, and melting point.

Physical and Organoleptic Properties Test (Color, Taste, Smell)

Organoleptic testing aims to observe the color, taste, and smell of aromatherapy wax preparations. Physical testing of wax on a wax base (Negative Control) resulted in a milky white color, no taste, and no smell. Next, Formulation I at a concentration of 2% resulted in a milky white color that was more intense than the Negative Control, with a distinctive basil leaf taste and smell. Formulation II at a concentration of 4% produced a milky white color that was more intense than the concentration of 2%, with a distinctive basil taste and odor. Formulation III at a concentration of 6% produced a milky white color that was more intense than the concentration of 4%, with a distinctive basil taste and odor. The results of the research and evaluation from the study (Sidiq, 2022) using organoleptic testing with the five senses, including odor, color, texture of the formulation, and consistency of preparation, were conducted using respondents (with specific criteria) by establishing testing criteria (type and items), calculating the percentage of each criterion obtained, and making decisions through statistical analysis. This aligns with the research conducted by each test.

Physical Properties Test of Melting Point

The melting point test on the wax base and formulations I, II, and III met the burn time test requirements by SNI 0836-1989-A/SII 0348-1989, namely 50ºC - 58ºC. In this study, the wax base (positive control) showed a temperature of 57°C, FI (2%) showed a temperature of 56°C, FII (4%) showed a temperature of 55°C, while FIII (6%) showed a temperature of 54°C. This is consistent with the study by Herawaty et al. (2021), as differences in the concentration of the active ingredient (essential oil from basil leaves) can influence the melting point of aromatherapy candles. If the essential oil concentration is high, the resulting melting point of the wax is lower, and if the essential oil concentration is low, the melting point becomes higher (Herawaty et al., 2021). In this study, the melted wax was placed in a dropper, then stored in a refrigerator at 4°C to 10°C for 16 hours. The dropper was attached to a thermometer and placed in a 500 ml beaker containing half-filled water. The water was heated, and the first movement of the wax in the dropper was observed. The temperature reading on the thermometer was recorded as the melting point of the wax (Sidiq, 2022). The melting point test was not replicated because the researcher prioritized testing the effectiveness of the mosquito repellent and the limitations of the essential oil preparation from basil leaves (Ocimum basilicum L).

Physical Properties Test of Burning Time

The burn time test on the wax base and formulations I, II, and III met the burn time test requirements by SNI 0836-1989-A/SII 0348-1989. On the wax base (positive control), the burn time was 20 minutes, FI (2%) resulted in a burn time of 10 hours, FII (4%) resulted in a burn time of 9 hours 58 minutes, and FIII (6%) resulted in a burn time of 9 hours 57 minutes. This is consistent with the study by Herawaty et al. (2021), which found that the active ingredient (essential oil from basil leaves) easily evaporates, so that the higher the concentration of essential oil, the faster the candle burns (extinguishes). In this study, the physical properties of burning time were tested for 9–10 hours, but not for F0 (wax base), which only burned for 20 minutes because it contained no active ingredients. In line with the study by Herawaty et al. (2021), the properties of essential oils significantly influence the burn time test. The burn time test was conducted by making candles using glass candle molds, with each formulation prepared in 100-gram portions and three different essential oil concentrations. The candles were then lit, and a stopwatch was used to measure the time it took for the wax to melt until the candle no longer burned (Paramawidhita et al., 2023). The burn time test was not replicated because the researchers prioritized testing the mosquito-repellent effectiveness and were limited by the availability of basil leaf essential oil (Ocimum basilicum L).

Testing the Effectiveness of Basil Leaf Essential Oil (Ocimum basilicum L) in Aromatherapy Candles Against Aedes aegypti Mosquitoes

The mosquito species used in this study was female Aedes aegypti mosquitoes, which remain the primary vector for the transmission of Dengue Hemorrhagic Fever (DHF). These mosquitoes are characterized by a distinctive silver-white band or stripe on a black base, with a body size ranging from 3–4 mm, and white rings on their legs. This study aligns with the research by Nurfadilah & Moektiwardoyo (2020), which also used female Aedes aegypti mosquitoes due to their higher vector efficiency for Dengue Fever (DF) compared to male Aedes aegypti mosquitoes. The effectiveness of mosquitoes in aromatherapy wax formulations was tested in three replicates. Twenty females Aedes aegypti mosquitoes were used in each formulation. In FI (2%), FII (4%), and FIII (6%), the negative control and positive control showed the same percentage of 45% in Formulation II (4%) and Formulation III (6%).

In the mosquito mortality efficacy test for Aedes aegypti, the negative control showed 0%, Formulation I (2%) 35%, Formulation II (4%), Formulation III (6%) 45%, and the positive control showed 60%, with no more than 10 mosquitoes. According to previous research principles (Paramawidhita et al., 2023), the higher the concentration of essential oil used, the greater the number of mosquitoes killed. According to research and development regulations, sampling was conducted every 20 minutes for each formulation, with three replicates, resulting in total mosquito mortality of 0 in Negative Control, seven mosquitoes in Formulation I (2%), nine mosquitoes in Formulation II (4%) and Formulation III (6%),

Positive Control had 12 mosquitoes. The Positive Control had a high mosquito mortality rate because it had already been on the market and had passed several testing stages. In the study (Yusmitaria, 2020), observations and calculations were conducted to determine the most effective essential oil concentration for causing mosquitoes to fall and die in a closed room using specific formulations.

This was done by placing several mosquitoes in containers starting from the negative control, Formulation I (2%), Formulation II (4%), Formulation III (6%), and the positive control, each containing 20 mosquitoes. The higher the essential oil concentration used, the more mosquitoes died and fell into the container. This aligns with previous research, which reported the following mosquito mortality percentages: Negative Control 0%, Formulation I (2%) 35%, Formulation II (4%), and Formulation III (6%) 45%, Positive Control 60%.

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The next step involved conducting an SPSS test to determine whether there were significant differences or no significant differences. The normality test showed a significance value of 0.103, indicating that the p-value is greater than 0.05, meaning the data is normally distributed (Usmadi, 2020). Following this, a homogeneity test was conducted, yielding a significance value of 0.117, indicating that the p-value is greater than 0.05 (Usmadi, 2020). A one-way ANOVA test was conducted to follow the results of the normal distribution and homogeneity tests. From this test, a p-value of 0.00 was obtained, indicating that the p-value is less than 0.05, and there is a significant difference (Hadiyantini et al., 2022). Next, a post hoc test was conducted using the Tukey HSD method. If the p-value was less than 0.05, the data showed a significant difference from other groups. If the p-value was greater than 0.05, the data showed no significant difference from other groups. The results of the post hoc test showed that in the Negative Control group, the p-value was greater than 0.05; in the 2% Formulation group, the p-value was greater than 0.05; in the 4% Formulation group, the p-value was less than 0.05; in the 6% Formulation group, the p-value was less than 0.05; and in the Positive Control group, the p-value was less than 0.05. In the Negative Control group, there were no significant differences; in the Formulation (2%) group, there were no significant differences; in the Formulation (4%), (6%), and Positive Control groups, there were significant differences.

Conclusion

This study aimed to test the effectiveness of basil leaf essential oil (Ocimum basilicum L) in aromatherapy candles against Aedes aegypti mosquitoes using a quantitative approach. Based on observations and statistical analysis, it was found that an increase in essential oil concentration was directly proportional to an increase in the number of dead mosquitoes. Formulations with concentrations of 4% and 6% showed higher efficacy compared to the 2% formulation, while the negative control showed no mosquito mortality. The data indicated significant differences between treatments, proving that basil leaf essential oil has potential as a natural insecticide in the form of aromatherapy candles.

The value of this study lies in its contribution to developing safer, more economical, and environmentally friendly insecticide alternatives based on natural ingredients. This study offers a new approach by integrating herbal plants into functional products such as aromatherapy candles, which not only function as mosquito repellents but also as room fresheners and relaxants. The public can apply the practical implications of this research in controlling mosquitoes in residential environments without relying on synthetic chemicals. From a managerial perspective, these findings open opportunities for creative industries and SMEs to develop high-value products based on local plants.

This study has several limitations. The study was conducted in a laboratory setting on a limited scale and did not include testing against other mosquito species or long-term effects on humans. Additionally, not all environmental parameters were fully controlled. Therefore, it is recommended that future researchers conduct further studies on a larger scale, with more varied field tests, and explore other herbal plants with potential as active ingredients in aromatherapy candles. The research could also be expanded to include evaluations of the long-term safety of use for human health and domestic animals in domestic environments.

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