

## THE EFFECTIVENESS OF AROMATHERAPY CANDLE PREPARATIONS AS A MOSQUITO REPELLENT FROM ROSEMARY ESSENTIAL OIL (*Rosmarinus Officinalis* L) COMBINED WITH PATCHOULI ESSENTIAL OIL (*Pogostemon cablin Benth*) AGAINST *Aedes aegypti* MOSQUITOES

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### ABSTRACT

Rosemary (*Rosmarinus officinalis* L.) and patchouli (*Pogostemon cablin Benth*) were plants that produced essential oils containing active compounds such as  $\alpha$ -pinene, 1,8-cineole, camphene, guaiene, and patchouli alcohol, which had mosquito-repellent properties. These essential oils began to be used as natural alternatives to chemical-based mosquito repellents because they were safer for humans and environmentally friendly. This study aimed to evaluate the physical properties of aromatherapy candles made from rosemary and patchouli essential oils and to test their effectiveness as mosquito repellents. The research method was a laboratory experiment using *Aedes aegypti* mosquitoes obtained from the Environmental Health Laboratory Center in Salatiga. The effectiveness test was carried out using a 70×70 cm glass chamber by counting the number of mosquitoes that died after exposure to the candle. The results showed that the essential oils of rosemary and patchouli had qualities that meet the Indonesian National Standard (SNI). All three aromatherapy candle formulations also meet the physical standards of SNI. Formula II demonstrated the highest effectiveness, with an average of 18 dead mosquitoes from three repetitions. The Kruskal-Wallis test showed no significant differences among the three formulations ( $p = 0.998$ ), indicating that all formulations had comparable mosquito-repellent effectiveness. Based on the findings, all three candle formulations were effective against *Aedes aegypti*, with Formula II showing the most optimal mosquito-killing activity.

Keywords: *aedes aegypti* mosquitoes; aromatherapy candles; patchouli; rosemary

### INTRODUCTION

Mosquitoes are insects that often disrupt human life. They belong to the insect class (Buang et al., 2022). One of the diseases transmitted by mosquitoes is Dengue Hemorrhagic Fever (DHF), caused by the Dengue virus. This virus is transmitted through the bite of *Aedes* sp. mosquitoes. According to the Ministry of Health, the number of DHF cases in Indonesia continues to rise, leading to an increase in the death toll. In 2021, there were 705 deaths due to DHF, but this number surged to 131,265 deaths in 2022. Although the death toll decreased in 2023, the number of cases rose again at the beginning of 2024, reaching 119,709 cases with 777 deaths. The highest number of DHF cases occurs in provinces with high population density (Badriah et al., 2024).

To help reduce mosquito disturbance, aromatherapy candles containing essential oils can be used. These candles are not only for relaxation and refreshing but also function as mosquito repellents. Aromatherapy candles are known to help relieve stress and refresh the mind (Utami et al., 2022). One of the benefits of these candles is as a mosquito repellent candle that contains insect-repelling substances with natural insecticides, which are considered safer than synthetic insecticides. Essential oils derived from plants such as rosemary and patchouli are often used as active ingredients in mosquito repellent candles. Rosemary (*Rosmarinus officinalis* L.) is known to have a repellent effect on mosquitoes due to its characteristic aroma. Research by Pratiwi & Purwanti (2021) shows that rosemary essential oil with a 6% concentration can provide more than 89.01% protection against *Aedes aegypti* mosquitoes. Compounds in rosemary, such as linalool, cineol, pinene, and camphor, contribute to its insecticidal

effect. In addition to rosemary, patchouli essential oil (*Pogostemon cablin Benth*) also has potential as a mosquito repellent. Patchouli essential oil contains patchouli alcohol, which acts as an insecticide and a fixative (Zuyasna et al., 2021). According to Sari et al. (2022), the protection test of patchouli essential oil at a 6% concentration shows excellent effectiveness, with a protection rate of 92% against mosquitoes, making it a promising alternative mosquito repellent.

## METHOD

### Tools and materials

The tools used in this research were stirring rods, spatulas, wooden clamps, pycnometers, test tubes, beaker thermometers, hot plates, capillary tubes, stopwatches, thermometers, balances, porcelain dishes, aromatherapy wax containers, test chambers (Chamber glass), GCMS (Shimadzu QP 2010 SE model), refractive index (Kruss DR 6000 model), and wax containers. The materials used in this research were beeswax, stearic acid, wicks, and essential oil of rosemary (*Rosmarinus officinalis* L.), combined with essential oil of patchouli (*Pogostemon cablin Benth*), 90% ethanol, aquades, and *Aedes aegypti* mosquitoes.

### Steam Distillation Essential Oils

Steam distillation was conducted to obtain essential oils from rosemary (*Rosmarinus officinalis* L.) combined with patchouli (*Pogostemon cablin Benth*) at the UPF Traditional Health Service in Tawangmangu, Central Java. The plants used were patchouli, which had been dried for 45 days, weighing 10 kg, and fresh rosemary, also weighing 10 kg. The plants were then chopped and placed into a container similar to a steamer, which is why this method is referred to as steaming. The process was carried out by heating water to a boil, with a separator placed between the water and the raw materials to ensure the essential oil was carried along with the steam flow, which was then directed to the condenser. The distillation process used a temperature of 100°C and a pressure of 40 psi, with water as the solvent, and the process duration was 6 to 7 hours. The essential oil produced by this method had high quality. The obtained essential oil was then analyzed using GC-MS to identify compounds and mixtures. The yield of essential oil was determined using the equation (Sefriyanti et al., 2020).

### Identification of Rosemary and Patchouli Essential Oils Using Gas Chromatography-Mass Spectrometry (GC-MS)

In this stage of the research, the main chemical components of rosemary and patchouli essential oils were analyzed to identify active compounds and determine the content of the essential oils. The identification was carried out using Gas Chromatography-Mass Spectrometry (GC-MS) at the Integrated Research and Testing Laboratory (LPTP) – Analysis Laboratory at the Islamic University of Indonesia, Yogyakarta.

### Formulation of Aromatherapy Candle

The formulation used in the preparation of aromatherapy wax consisted of essential oils of rosemary (*Rosmarinus officinalis* L.) combined with patchouli (*Pogostemon cablin Benth*). The reference formulation from this research is as follows:

Table 1.  
Formulation of Aromatherapy Candle with variant concentration

Ingredient	F1	F2	F3	Usage
Rosemarys Essential Oil	8%	10%	12%	Active Ingredient
Patchoulis Essential Oil	12%	10%	8%	Active Ingredient
Beeswax	40%	40%	40%	Base
Stearic Acid	40%	40%	40%	hardener

### **Preparation of Aromatherapy Candle**

The candle base and stearic acid to be used were weighed. Then, the base was placed into a beaker glass. Next, the base was melted on a hotplate at approximately 65-84°C and stirred until homogeneous using a stirring rod. The temperature was then allowed to cool to approximately 55°C. After that, rosemary and patchouli essential oils were added to three containers containing the candle base, with concentrations FI, FII, and FIII, and stirred until homogeneous. Finally, the mixture was poured into candle glass molds, with the wick attached at the center and measuring 4 cm in length. The candles were left to harden (Meryta et al., 2023).

### **Aromatherapy Candle Characteristic Test**

**Overall Appearance Test of the Candle,** This test was conducted to assess the candle's shape, ensuring it was even, free from cracks, defects, and breakage. The test was carried out through visual observation, with subjective evaluations made by each panelist. A total of 20 panelists were involved in this test. The panelists' assessments were recorded on a scale from 1 to 4, which included "somewhat like," "like," "really like," and "absolutely love" (Herawaty et al., 2021). **Air bubble test,** The test was conducted by observing the presence or absence of air bubbles in the produced aromatherapy candle. The color test was performed by visually inspecting the formed candle (Yuliana et al., 2023).

**Burn Time Test ,** The burn time test was conducted by lighting the candle wick and starting a stopwatch until the wick was completely burned. The burn time was obtained by calculating the difference between the starting time of the burn and the time when the wick was fully consumed or when the candle extinguished (Oktarina et al., 2021).

**Melting Point Test,** The melting point test was conducted using a test tube method. A beaker was filled with enough water, and the candle was cut into smaller pieces and placed into the test tube, which was equipped with a thermometer. The beaker containing the water was then placed over a Bunsen burner, and the test tube was secured inside the beaker. The water was heated until it began to boil, causing the wax inside the test tube to melt completely. The temperature at which the wax melted was recorded as the melting point of the wax, and the temperature was noted as the melting point of the standard candle formulation, which, according to SNI 0386-1989-A/SII 0348-1980, should range from 50°C to 58°C (Oktarina et al., 2021).

### **Mosquito Repellent Effectiveness Test**

This test was conducted by preparing a treatment chamber (Glass Chamber) measuring 70 cm x 70 cm x 70 cm, with one wall having a 20 cm x 20 cm sliding window. The chamber was populated with approximately 20 *Aedes Aegypti* mosquitoes. Each mosquito repellent formula was exposed to an aromatherapy candle containing rosemary essential oil and patchouli essential oil. The rosemary essential oil concentrations were 8% (FI), 10% (FII), and 12% (FIII), while the patchouli essential oil concentrations were 12% (FI), 10% (FII), and 8% (FIII). The candle was lit for 20 minutes, and the mosquitoes were observed and recorded for any signs of knockdown (paralysis) every minute, following the laboratory procedure for insecticide efficacy testing. After 20 minutes of exposure, the mosquitoes were transferred to a petri dish covered with gauze and cotton soaked in a 10% sugar solution. The mosquito mortality was then counted 24 hours after exposure. Each formula was repeated three times (Ashari Rasjid & Ridwan, 2022)

### **Data analysis**

This study conducted normality and homogeneity tests using SPSS 25 data analysis. The data obtained were analyzed with the help of statistical software. Before performing the Analysis of

Variance (ANOVA), the data were first tested for normality and homogeneity as prerequisites. The research data obtained were in the form of quantitative data which were analyzed using IBM SPSS Statistics ver. software. 25

## RESULT AND DISCUSSION

### Rosemary and Patchouli Essential Oils Through Steam Distillation

In this study, the research was conducted at the UPF RSUP Dr. Sardjito Tawangmangu, Central Java. The materials chosen were fresh, green rosemary (*Rosmarinus Officinalis* L.) with a weight of 10 kg, and patchouli (*Pogostemon Cablin Benth*) with a weight of 10 kg, which had a greenish-yellow color with slight browning after being air-dried for 5 days. The dried patchouli leaves produced a higher yield of patchouli oil compared to the fresh leaves. The yield of essential oils from rosemary and patchouli obtained through steam distillation with a distillation time of approximately 6-7 hours was 1.03% for rosemary and 1.97% for patchouli. The results showed that for the 10 kg sample, with a distillation time of approximately 6 hours using the steam distillation method, the essential oil yields were 103 ml for rosemary and 197 ml for patchouli.

### Essential Oil Characteristic Test for Rosemary and Patchouli

The essential oil characteristic test was conducted to assess the quality of the essential oils produced. The characteristics tested included several parameters: brightness/color, specific gravity, refractive index, and solubility in ethanol (Wibowo et al., 2016). These tests help determine the purity, stability, and suitability of the essential oils for various applications, ensuring that they meet the required standards. Table 2 and table 3 showed the result.

Table 2.

No	Test	Result	Standart result	Source	Category meet
1	Brighness/ Color	Blank, clear liquid with fresh aromatic scent from rosemary	Blank, clear liquid with fresh aromatic scent from rosemary	ISO 1342:2012	Yes
2	Density	0.900 g/mL	0,894-0,912	ISO 1342:2012	Yes
3	Refractive index	1,470	1,464-1,472	ISO 1342:2012	Yes
4	Solubility in ethanol	Solved in Ethanol 90% 1:3 or 1:10	Solved in Ethanol 90%	ISO 1342:2012	Yes

Table 3.

No	Test	Result	Standart result	Source	Category meet
1	Brighness/ Color	Pale yellow clear liquid with strong scent from leaves	Pale yellow to amber colored clear liquid with strong scent from leaves and have long time for the smell to dissipate	SNI 9311:2024	Yes
2	Density	0.954 g/mL	0,940-0,985	SNI 9311:2024	Yes
3	Refractive index	1,506	1,504-1,515	SNI 9311:2024	Yes
4	Solubility in ethanol	Solved in Ethanol 90% 1:10	Solved in Ethanol 90%	SNI 9311:2024	Yes

In general, when compared to the Indonesian National Standard (SNI), the results above indicate that the patchouli essential oil sample meets the specifications of the quality standard parameters. This shows that the oil is of good quality and ready for application.

### Identification of Essential Oil Components Using GC-MS

The identification of essential oil elements using Gas Chromatography-Mass Spectrometry (GC-MS) was performed to separate and identify the components found in the essential oil. Research on the composition of rosemary essential oil and patchouli essential oil was carried out through mass spectrum analysis, referencing the "base peak" (the highest peak) and SI (Similarity Index) by comparing the spectrum with Willet 299.LIB. The results from Gas Chromatography-Mass Spectrometry (GC-MS) analysis of rosemary essential oil showed the highest compounds in the essential oil. The major components identified were  $\alpha$ -pinene 50.40%, 1-8 Cineole 22.61%, Camphene 3.71%,  $\beta$ -pinene 2.90% and Bicyclo: 2.79%. as for the patchouli essential oils were Patchouli alcohol 34.04%, Delta-guaiene: 26.16%,  $\alpha$ -guaiene: 16.29%, Seychellene: 5.25%,  $\alpha$ -patchoulene: 3.87%. The detailed data showed in table 4 and table 5 as for GC-MS result in the appendix.

Table 4.  
 Essential Oil from Rosemary (*Rosmarinus officinalis* L.) using GC-MS

No	Chemical Compound	Content (%)
1	$\alpha$ -pinene	50,40%
2	1,8 Cineole	22,61%
3	Camphene	3,71%,
4	$\beta$ -pinene	2,90%
5	Bicyclo	2,79%
6	Bornylene	2,78%
7	Linalol	1,85%
8	$\beta$ -mycrene	1,46%
9	Champor	1,26%
10	Borneol Aceta	1,20%

Table 5.  
 Essential Oil from Patchouly (*Pogostemon cablin Benth*) using GC-MS

No	Chemical Compound	Content (%)
1	Patchouli alcohol	34.04%,
2	delta-guaine	26,16%,
3	$\alpha$ -guaine	16,29%,
4	Seychellene	5,25%
5	$\alpha$ -patchoulene	3,87%.
6	Caryophyllene	3,17%
7	Seline-dieme	3,05%
8	A-gurjunene	1,38%
9	Beta-seline	0,53%
10	Widdrene	0,44%

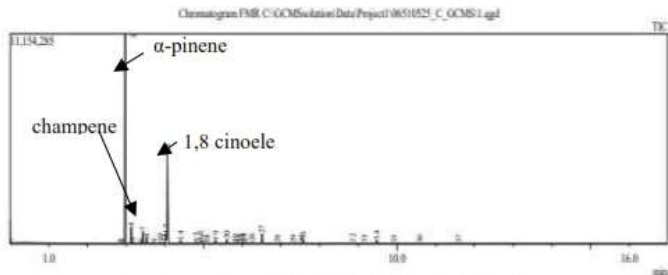


Image 1. GC result from Rosemary essential oil

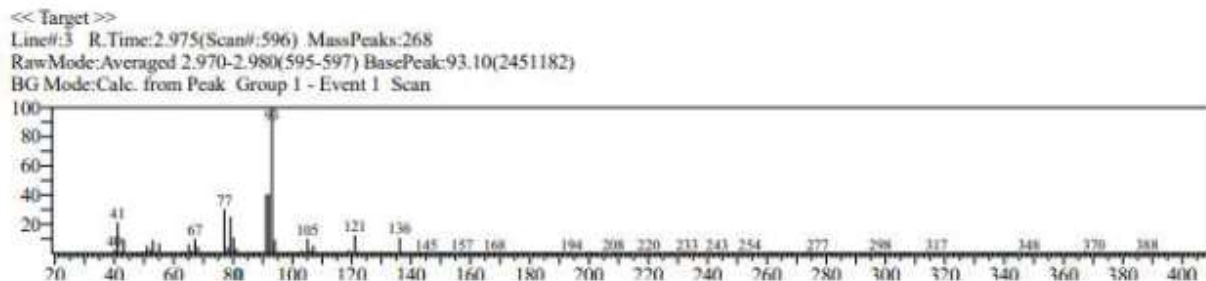


Image 2. MS Spectrum from  $\alpha$ -pinene from Rosemary Essential Oil

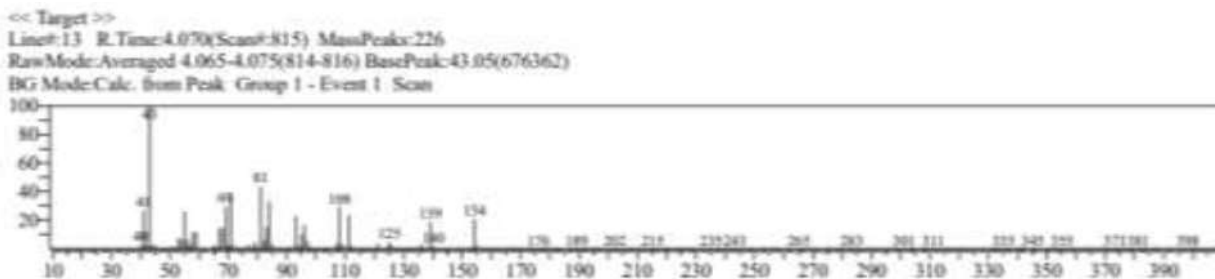


Image 3. MS Spectrum from 1,8 Cineole from Rosemary Essential Oil

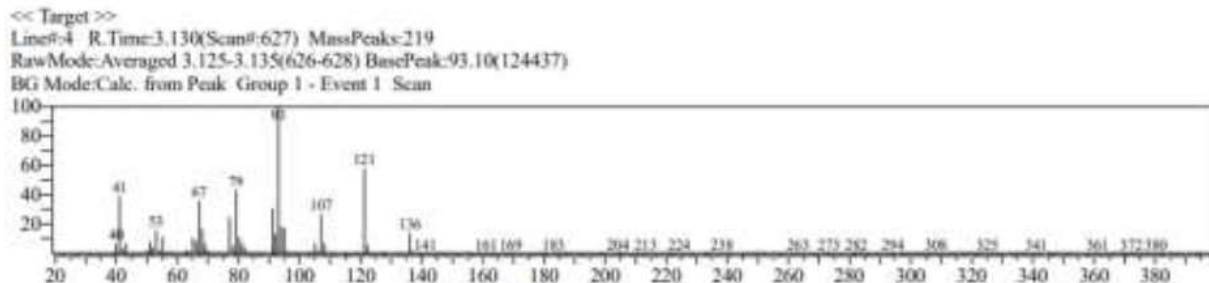


Image 4. MS Spectrum from Camphene from Rosemary Essential Oil

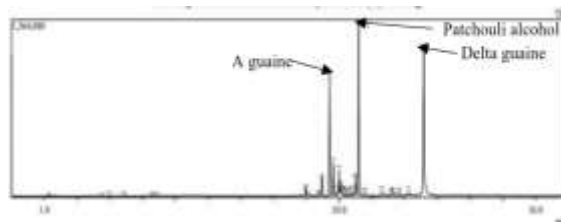


Image 5. GC result from patchouli essential oil

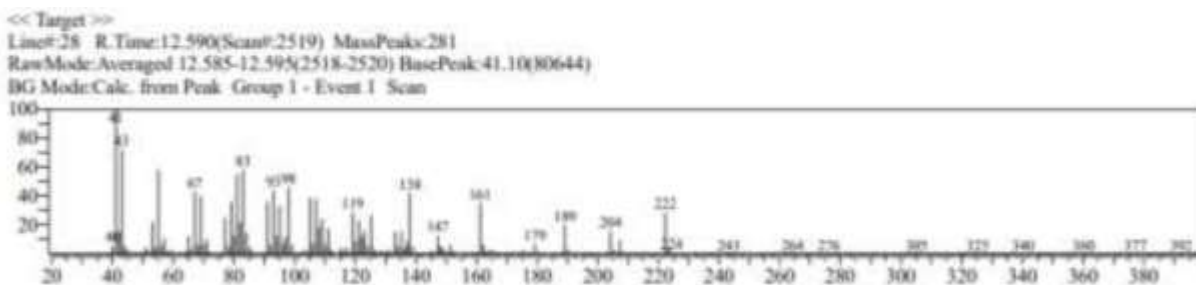


Image 6. MS Spectrum from patchouli alcohol from patchouli essential oil

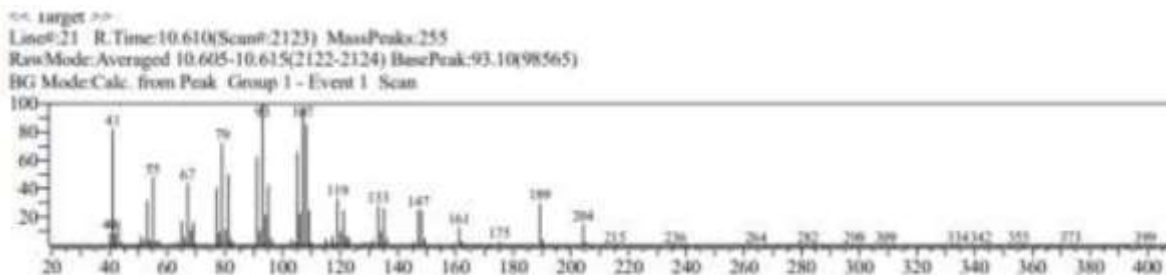


Image 7. MS Spectrum from delta-guaine from patchouli essential oil

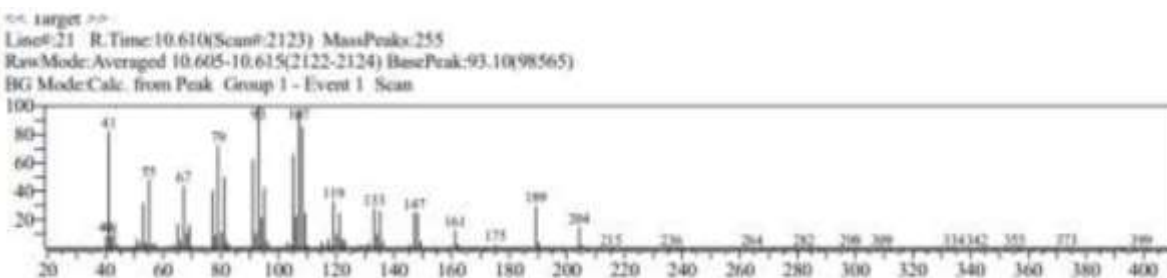


Image 8. MS Spectrum from  $\alpha$ -guaine from patchouli essential oil

### Overall Appearance Test of the Candle

The standardization of candles for organoleptic testing is based on SNI 0386-1989-A/SII 0348-1980, which specifies that the physical characteristics of a candle should include uniform color, no cracks, no defects, and no breakage (BSN, 1989). This is consistent with the observations of the overall appearance of the aromatherapy candles formulated with varying concentrations of rosemary and patchouli essential oils (FI, FII, and FIII). The results showed that the candles met the standard with uniform color, no cracks, no defects, and no breakage, fulfilling the BSN (1989) guidelines.

Table 6.

Overall Appearance Test of the Candle	
Candle Formulation	Properties
FI	uniform color, with no cracks, defects, or breakage
FII	uniform color, with no cracks, defects, or breakage
FIII	uniform color, with no cracks, defects, or breakage

### Air bubble test

Based on the observations from the air bubble test with the comparison of essential oil concentration formulations FI, FII, and FIII, it was found that no air bubbles appeared on the surface of the aromatherapy candles. The formation of air bubbles on the candle surface may occur if the liquid wax temperature is too low, below 40°C, or if the pouring and molding process is done too quickly, which can trap air during the pouring

process (Meryta et al., 2023).

Table 7.  
Air Buble Test Result

Candle Formulation	Properties
FI	No air bubble
FII	No air bubble
FIII	No air bubble

#### Burn Time Test

The results of the study showed that the longest burn time was achieved by formula FII, which lasted up to 475 minutes, or 7 hours and 55 minutes. On the other hand, the fastest burn time was observed in formula FIII, which lasted 447 minutes, or 7 hours and 27 minutes. It was found that all three formulations met the requirements of SNI 0386-1989 A/SII 0348-1980, which stipulates that the minimum burn time for a candle should be 2-3 hours. Although formula FIII had a slightly faster burn time compared to the other formulas, there was no significant difference in burn time across the three formulas. This is attributed to the balanced concentration of the base and essential oils in each formulation.

Table 8.  
Burn Time Test Result

Candle Formulation	Properties	Standart Burn Time
FI	7 Hours 49 Minutes	2-3 hours
FII	7 Hours 55 Minutes	2-3 hours
FIII	7 Hours 27 Minutes	2-3 hours

#### Melting Point Test

According to SNI 0386-1989-A/SII 0348-1980, the melting point of a candle is estimated to be between 50°C and 58°C (BSN, 1989). The melting point is influenced by the main ingredients, such as beeswax and stearic acid. Additionally, a higher concentration of active ingredients can lower the melting point of the candle, whereas a lower concentration of essential oils results in a higher melting point. The results from the melting point test of the aromatherapy candles indicated that the average melting points of Formula FI and Formula FII were 54.3°C, while Formula FIII had a melting point of 54°C. These results align with the SNI reference. Based on the research findings, there was no significant difference in the melting points of the formulations. This can be attributed to the balanced concentration of beeswax and stearic acid used in the candle production, with both ingredients being used in equal proportions (50%:50% of the total ingredient concentration). Furthermore, 6 grams of essential oils were added uniformly across all treatments, which is why FI, FII, and FIII all exhibited the same melting point in the range of 54°C. This consistency is due to the similar concentration of wax and essential oils.

Table 9.  
Melting Point Test Result

Candle Formulation	Melting Point (°C)	Standart Melting Point (°C)
FI	54,3	50-58
FII	54,3	50-58
FIII	54	50-58

#### Mosquito Repellent Effectiveness Test

The test was conducted by preparing a treatment chamber (Glass Chamber) with dimensions of 70 cm x 70 cm x 70 cm, with one wall having a sliding window measuring 20 cm x 20 cm. The chamber contained approximately 20 *Aedes aegypti* mosquitoes for each formula (Rasjid & Ridwan, 2022). The mosquitoes were exposed to aromatherapy candles made with a combination of rosemary essential oil

and patchouli essential oil, with the following concentrations: rosemary essential oil at 8% (FI), 10% (FII), and 12% (FIII), and patchouli essential oil at 12% (FI), 10% (FII), and 8% (FIII).

The candles were lit for 20 minutes, and the mosquitoes were observed and recorded for signs of knockdown (paralysis) every minute, according to the laboratory procedure for insecticide efficacy testing. After 20 minutes of exposure, the mosquitoes were transferred to petri cups containing gauze and cotton soaked in a 10% sugar solution and held for 24 hours. The mortality rate of the mosquitoes was recorded 24 hours after exposure (B2P2VRP, 2011). Each formula was replicated three times. The mosquitoes used for this research were *Aedes aegypti*, aged 3-5 days. The temperature during the test was 25.1°C, and the humidity was 86.3%, with a 20-minute exposure time, in accordance with the laboratory procedure for insecticide efficacy testing. *Aedes aegypti* mosquitoes can survive at temperatures between 11°C and 35°C. Below 11°C, mosquito activity decreases, and above 35°C, their lifespan shortens. The optimal humidity for *Aedes aegypti* is between 60% and 90%, where the mosquitoes thrive best (Suhada et al., 2016). The Effectivity result showed at table 10.

Table 10.  
 Mosquito Repellent Effectiveness Test Result

Candle Formulation	Average dead Mosquitoes Body Count	Percentage (%)
FI	16.67	83.3
FII	18	90
FIII	15.33	76.6
Positive Control	20	100
Negative Control	0	0

Table 10, the average mosquito knockdown was highest in the Positive Control, with an average mortality of 20 mosquitoes, followed by Formula FII, which resulted in the death of 18 mosquitoes. The lowest mortality was observed in Formula FIII, with 15 mosquitoes dying. The mosquito repellent efficacy data were then analyzed using a One-Way ANOVA test, which is used to determine the differences in the concentrations of Formula I, Formula II, Formula III, and the positive control in the aromatherapy candles on the mortality rate of *Aedes aegypti* mosquitoes. The negative control, which contained only the base with a 0% mortality rate (average of 0 mosquitoes killed), indicates that the addition of essential oils to the aromatherapy candles enhanced the mosquito-killing efficacy. This suggests that the essential oils in the candles played a crucial role in improving the effectiveness of mosquito mortality. This statistical test helps to evaluate whether there is a significant difference in the mosquito kill rate between the different formulations and the control group. Based on the data above, the p-value from the Kruskal-Wallis test is 0.998, meaning the significance value is greater than 0.05. This indicates that there is no significant difference in the mosquito mortality rate between the concentrations of FI, FII, FIII, and the positive control in the aromatherapy candle formulations regarding their mosquito-killing efficacy against *Aedes aegypti* mosquitoes. Based on the research results, it was found that mosquito mortality was influenced by the compounds contained in the combination of rosemary and patchouli plants. As seen in Table 10, the highest mortality rate was observed in Formula II, which contained 20% total essential oils with a balanced combination of 10% rosemary essential oil and 10% patchouli essential oil. This balanced formulation resulted in the most optimal mosquito-killing effect. This is in line with a study by Suleman et al. (2022), which found that Formula II, with a combination of 5% patchouli essential oil and 5% marigold essential oil, was the most effective formula for killing *Aedes aegypti* mosquitoes.

Rosemary essential oil contains key compounds such as  $\alpha$ -pinene, 1,8-cineole, and camphene, which act as natural repellents. The primary compound,  $\alpha$ -pinene, is a terpenoid that inhibits the enzyme acetylcholinesterase, which breaks down acetylcholine (a chemical messenger for nerve impulses).

Disruption of acetylcholinesterase function leads to the accumulation of acetylcholine, causing neurotoxicity characterized by central nervous system disturbances, seizures, respiratory paralysis, and cell death in insects (Pratiwi & Purwati, 2020). 1,8-cineole, a compound in rosemary oil, is a natural insecticide with repellent properties and is toxic to the insect respiratory system and cell membranes. Over time, it leads to insect death (Mitasari et al., 2024).

Patchouli essential oil, on the other hand, contains patchouli alcohol, which inhibits the olfactory receptors in mosquitoes, disrupting their nervous system and leading to mosquito death. Additionally, patchouli alcohol interferes with insect metabolism, including that of mosquitoes (Jafar et al., 2023). Furthermore, patchouli alcohol helps in prolonging the fragrance in mosquito repellent formulations (Suryaningrum, 2017). The presence of guaiene in patchouli oil provides a spicy aroma that repels insects. As a terpenoid, guaiene acts as an insecticide, entering the mosquito's body through its respiratory system and blocking the spiracles, leading to suffocation and death due to lack of oxygen (Souhoka et al., 2020).

The use of essential oils has gained attention as an alternative to chemical-based mosquito repellents, as they are safe for human use and environmentally friendly. In addition to their repellent properties, aromatherapy candles made from essential oils serve other functions, such as calming the mind, improving libido, and stimulating the skin. Aromatherapy candles offer an alternative method of use through inhalation, where the fragrance is absorbed while the candle is burning (Ginting et al., 2024).

## CONCLUSION

Aromatherapy candles made from a combination of rosemary essential oil (*Rosmarinus officinalis* L.) and patchouli oil (*Pogostemon cablin* Benth) can be used as mosquito repellents because they meet all the characteristic evaluation standards of SNI (Indonesian National Standards). These candles not only possess the required physical and chemical properties but also demonstrate effectiveness in repelling mosquitoes, making them suitable for both therapeutic and practical uses in controlling mosquito populations. The aromatherapy candle with a formulation concentration of 10% rosemary essential oil and 10% patchouli essential oil (Formula FII) proved to be the most effective as a mosquito repellent. When both essential oils are used in equal concentrations, they produce a more optimal repellent effect, enhancing the candle's ability to repel mosquitoes efficiently.

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