Prospect of Patchouli oil (*Pogostemon cablin Benth*) as a Mosquito Repellent Lotion Against *Aedes aegypti*, the Vector of Dengue Hemorrhagic Fever

Maria Nindatu[1] ,Merry Pattipeilohy[2] , Hery Jotlely [3], Benezia Tuhumury[4], Chrisma Papilaya[5] , Priska Mariska Pattiasina[6]

[1,2,4] Postgraduate Program of Pattimura University, Poka Ambon, 97233 Indonesia
[3]Faculty of Health , , University of Christian Maluku, Ambon, Indonesia
[5,6]Faculty of sains and Technology, Pattimura University Poka Ambon, 97233 Indonesia
maria.nindatu@lecturer.unpatti.ac.id

Abstract. Research on the leaf prospects of patchouli plants (*Pogestemon cablin* Benth) as an anti-mosquito lotion *Aedes aegypti* dengue vectors will be performed. This research aims to find out Prospects of mosquito repellent lotion *Aedes aegypti* Dengue Fever Vector by knowing its effectiveness as a repellent. The type of research used is Experimental Laboratory. Assay tests to determine the potency of repellent are carried out in vitro. Phytochemical, antioxidant, and organoleptic tests were performed. Data analysis was conducted using Anova and followed by BNT tests. The results showed that the patchouli oil lotion was effective as a mosquito repellent. Formulations 2 and 3 did not differ significantly in their percentage of protective efficacy. These formulations, containing patchouli oil, white wood oil, and clove oil in ratios of 1:0.4:0.1 and 2:0.4:0.1, respectively, were further developed as a prototype named Patchoshield. This prototype has an effective dosage, is safe for human use, and shows promising potential for further development as a natural mosquito repellent.

Keywords: Patchoshield, mosquito repellent, Denque fever

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1.Introduction

Dengue Hemorrhagic Fever (DHF) is a disease caused by infection with the dengue virus, which is transmitted through the mosquito vector *Aedes aegypti*. This disease is considered a serious infectious illness and can lead to death within a short period of time [1]. Dengue affects all age groups, including toddlers, school-age children, adolescents, and adults. Clinical symptoms of dengue infection include sudden and continuous fever lasting 2–7 days, weakness, nausea, vomiting, petechial rash, and bleeding manifestations [2].

In Indonesia, dengue fever was first reported in Surabaya in 1968, with 58 recorded cases and 24 deaths, resulting in a mortality rate of 41.3%. In 2022, the number of dengue cases reached 138,127, showing a significant increase compared to 65,602 cases reported in 2018. To date, there is no specific vaccine or antiviral treatment available to cure dengue virus infection [3,4]

Given the serious and potentially fatal nature of dengue disease, effective mosquito control measures are essential. In general, mosquito control efforts rely on the use of synthetic insecticides, including mosquito repellent products. Repellents do not directly kill mosquitoes but function by repelling them, primarily through strong odors. Most synthetic repellents contain N,N-diethyl-meta-toluamide (DEET), which may cause adverse effects when used over long periods. These side effects range from skin disorders such as irritation, erythema, and pruritus to severe effects including seizures, respiratory disturbances, and coma [5].

Indonesia is a tropical country with abundant plant resources that have the potential to be developed as plant-based insecticides. One such plant is patchouli (*Pogostemon cablin* Benth.), which has considerable potential for use as a natural mosquito repellent. Patchouli is one of Indonesia's main essential oil producing plantation crops. Essential oils are secondary metabolites produced by plants that are aromatic, volatile, soluble in alcohol, and typically composed of terpene or sesquiterpene compounds. Therefore, research on natural repellents that are safe, inexpensive, readily available, and environmentally friendly is necessary to reduce negative impacts on human health [6].

Patchouli belongs to the Lamiaceae (Labiateae) family, which comprises approximately 200 genera worldwide. Patchouli essential oil contains a high proportion of patchouli alcohol (51.88%), which is the primary compound responsible for its repellent activity. Under laboratory conditions, patchouli oil has been reported to provide 100% protection against *Aedes aegypti* for up to two hours. In addition, patchouli leaves contain various bioactive compounds, including saponins, phenolics, alkaloids, and essential oils, which contribute to their potential as mosquito repellents [6]. Betel leaves also contain eugenol, although at much lower concentrations compared to clove leaves (30% versus 71%), which may influence their repellent effectiveness [7,8].

In the utilization of patchouli plant materials sourced locally from Ambon Island, phytochemical analysis is essential to provide comparative data. In addition, further evaluations, including organoleptic testing, are required for samples that demonstrate effectiveness as repellents against *Aedes aegypti*, the primary vector of dengue fever. Therefore, this study was conducted to further explore the potential of patchouli plants as a source of natural mosquito repellents.

The objective of this study was to investigate the potential of patchouli oil as a natural mosquito repellent. This study also provides information on a formulation composed of patchouli oil, white wood oil, and clove oil, which was developed as a prototype named Patchoshield. The formulation demonstrates an effective dosage, is safe for human use, and shows promising potential for further development as a natural mosquito repellent.

2. Materials and Methods

This study was conducted at the Zoology Laboratory, Faculty of Sains and Tecnology Pattimura University, for mosquito repellent assays and toxicity tests, and at the Basic Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Pattimura University, for phytochemical screening and antioxidant activity assays. Organoleptic testing was performed at the Ambon Industrial Standardization and Service Center. The study was undertaken from March to October 2024.

2.1 Research Design

This study employed a Completely Randomized Design (CRD) with one way ANOVA and three replications. Three treatments: patchouli oil, eucalyptus oil, and clove oil: Formula 1(P1) 1:0.4:0.1, Formula 2 (P2) 1:0.4:0.1, and Formula 3 (P3) 2: 0.4:0.1.
Lotions with different concentrations were applied from the head to the back of mice whose fur had been shaved. The positive control mice used Autan lotion and the negative control did not use anything.

2.2. Research Prosedure

Preparation sample of *Pogostemon cablin* Benth

The plants fresh aerial parts of *P. cablin*, collected from the forest region of Hative, central Maluku District, Indonesia. The plant material were collected in the month of February 2025, were air dried and essential oil was obtained by hydrodistillation of 5 kg of fresh leaves in a clavenger apparatus. For 6 hours. The resulting essential oil was dissolved in anhydrous sodium sulfate (Na_2SO4) and stored in a cool bottle for further analysis . The production of essensial oil from *Pogestemon cablin* was conducted following the procedure of Florenik et al and Ismail et al [9,10]

Preparation of Test Lotion Concentrations

The lotion concentration composition was divided into three treatments: patchouli oil, eucalyptus oil, and clove oil: Formula 1(P1) 1:0.4:0.1, Formula 2 (P2) 1:0.4:0.1, and Formula 3 (P3) 2: 0.4:0.1. The lotion ingredients were purified water, glycerin, cetyl alcohol, shea butter, virgin coconut oil, TiO_2, phenoxyl ethanol and tocopheryl acetate (vitamin E)

Mosquitoes rearing

The mosquitoes Ae. Aegypti larvae , was reared in the Laboratory of Parasitology Faculty of Science and Tecnology, Pattimura University. The larvae were fed on, chicken powder. Adults were provided with 10% honey solution and one week old chick for blood meal. Mosquitoes were held at (28) °C, 70%-85% relative humidity (RH)

2.3. Observations

Repellent activity assay

The repellent study was following the methods of WHO[11,12]. 3-4 days old blood starved female of selected mosquitoes (100) were kept in a net cage (45 cm×45 cm×40cm. The repellent effectiveness assay is as follows: A mosquito cage is prepared and filled with 25 *Aedes aegypti* mosquitoes . The test animals (mice) are prepared and their fur is shaved to facilitate mosquito blood feeding.The mice are. coated with various dosages. The mice are then clamped with wire and placed in a mosquito cage containing 25 *Aedes aegypti* mosquitoes. Observe and record the number of mosquitoes that land on the mice within 15 minutes for 6 hours. is then repeated for each treatment with each formula.

Precentage Repellency Responses

It was observed that percentage of mosquitoes avoiding mice that were treated with Pogestemon essential oil. The percentage protection was calculated by using the following formula:

$$\% = \frac{(Tb-Ta)}{Ta} \times 100\% \quad (1)$$

where: Ta = Number of mosquitoes in the control group Tb= is the number of mosquitoes in the treated group and % = percentage Repellency

Repellent activity (%) : 98-100= Good , 75- 97 = Moderate , 65-74 = Low

2.4 Data Analysis

All collected data were analyzed through Analysis of Variance (ANOVA)) to determine the effect of the repellent power of *Ae. aegypti* mosquitoes on various concentrations of *P.cablin* essensial oil compounds and continued with a BNT test to determine the effective concentration.Significant differences detected by ANOVA were further examined using BNT test at the 5% significance level.

3 Results and Discussion

The effectiveness of the lotion sample (Patchoshield) was tested in vitro using mice as experimental animals, compared to a negative control for the repellent power of *Aedes aegypti* mosquitoes. Three replications were performed using 25 mosquitoes for each treatment. The results are shown in Table 1.

Table 1. Repellent activity of *P. cablin* essential oil compounds tested against *Aedes aegypti* mosquitoes.

Treatment	Mean of mosquitoes that land on mice ± SD	Mean of Protection power (%)
K-	24.0 ± 1.73a	-
K+	0.0 ± 0.00b	100.0
P1	5.6 ± 0.57c	77.3
P2	3.3 ± 1.15d	86.6
P3	2.3 ± 1.52d	90.6

Note: Numbers followed by different letters indicate significantly different results based on the BNT test at the 5% level (P<0.05).

Table 1 presents the average number of *Aedes aegypti* mosquitoes landing on the bodies of mice. In the negative control (K-), an average of 24 mosquitoes landed, whereas no mosquitoes landed in the positive control (K+). Administration of patchouli leaf solution at dose 1 resulted in an average of 5.6 mosquitoes landing, corresponding to a protective efficacy of 77.3%. At dose 2, the average number of mosquitoes landing decreased to 3.3, with a protective efficacy of 86.6%, while dose 3 resulted in an average of 2.3 mosquitoes landing, representing a protective efficacy of 90.6%.

As shown in Table 1, the highest average number of mosquitoes landing was observed in the negative control (K-), while the lowest was observed in Formula 3. These findings indicate that higher concentrations result in fewer mosquito landings and moderate protective efficacy. Tables 1. Among three concentration tested, the maximum repellent activity was observed in patchouli alcohol at concentration P3 provided 90.6% protection up to 24 h against *Ae. Aegypti as well as most repellent l activity was fond in K+ against of Ae. Aegypti 100% mortality recorded.*

Based on the results of the ANOVA and Least Significant Difference (LSD) tests, Formulation 2 (P2) was identified as the most effective patchouli oil lotion as a repellent against *Aedes aegypti*, as its concentration did not differ significantly from Formulation

3 (P3). The analysis also showed a significant difference in the mean number of mosquito landings, with a p-value of 0.00 (<0.05), indicating that patchouli leaf lotion had a significant repellent effect.

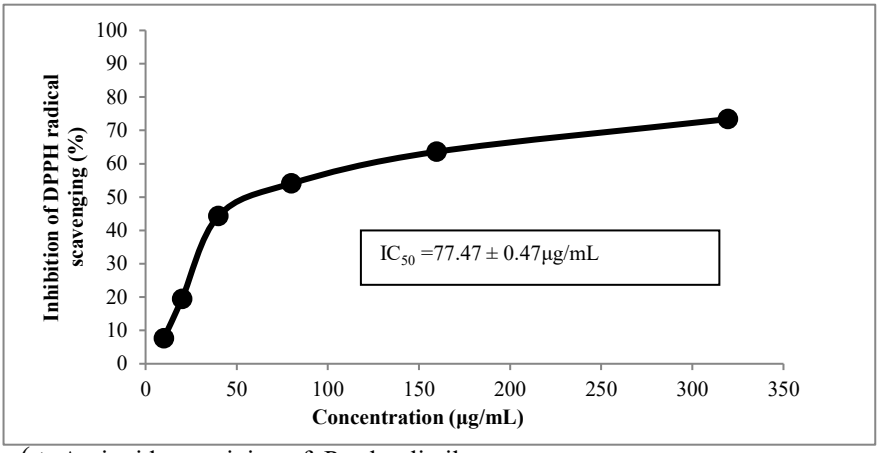
Insecticide efficacy is considered good when the protection value ranges from 98–100%; values below this range are classified as less effective [12]. Nevertheless, the observed repellent activity of patchouli oil lotion supports its classification as a biological insecticide, defined as a natural substance derived from plants containing secondary metabolites with bioactive compounds capable of controlling pests in the household environment.

Patchouli oil is suspected to contain several bioactive compounds responsible for its repellent activity. Patchouli oil contains phenolic and terpene compounds that also exhibit antioxidant properties [13]. In recent years, essential oils have gained increasing attention due to their biological activities, with essential oils from cinnamon, patchouli, and geranium being widely recognized for their antibacterial, antifungal, antiviral, and antioxidant effects [14].

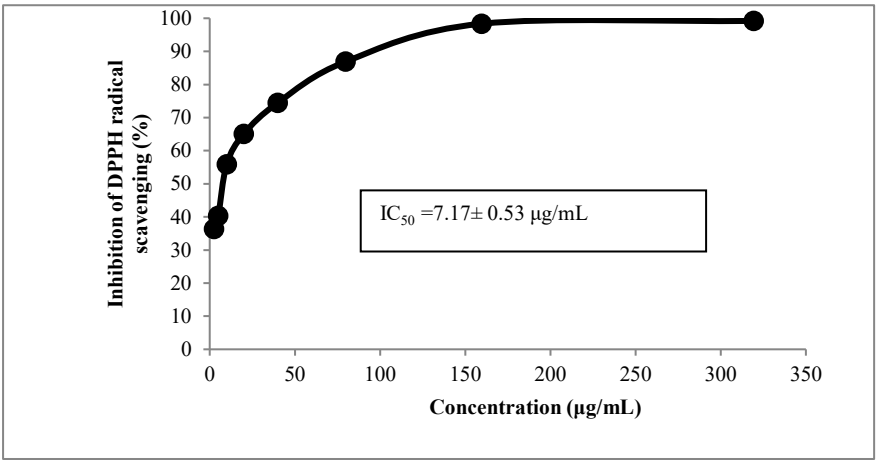
To determine the effective concentration of the repellent, a Least Significant Difference (LSD/BNT) test was performed. The results indicated that Formulation 3, with a composition of patchouli oil, clove oil, and eucalyptus oil at a ratio of 2:0.2:0.4, exhibited effective repellent activity. The analysis further showed that Formulations 2 and 3 had comparable protective efficacy as mosquito repellents.

The mechanism of action of patchouli oil as a repellent involves its adherence *to* the skin surface after application, allowing its volatile aroma to be detected by olfactory receptors. These receptors convert the chemical stimulus into nerve impulses that are transmitted to the central nervous system, triggering avoidance behavior in mosquitoes. Patchouli oil exerts its repellent effect by influencing the insect nervous system, primarily through its major active component, patchouli alcohol [15].

Antioxidant activity assays of the mosquito repellent lotion were conducted using the same lotion samples applied in the mosquito repellency tests. The results of the antioxidant assays are presented in Figure 1 (a–b).



(a). Antioxidant activity of Patchouli oil



(b). Antioxidant activity of sampel (DPPH)

According to Molyneux, the IC_{50} value represents the concentration required to inhibit 50% of free radical activity. The IC_{50} values are commonly used to classify antioxidant activity as very strong (< 50 ppm), strong (50–100 ppm), moderate (100–150 ppm), weak (150–200 ppm), and inactive (> 200 ppm) [16]. Based on this classification, patchouli oil can be categorized as a strong antioxidant, with an IC_{50} value ranging from 50 to 100 µg/mL.

The chemical composition of natural oils (NOs) extracted from patchouli leaves collected from Ambon Island was analyzed using gas chromatography (GC) and gas chromatography–mass spectrometry (GC–MS). Seven components were identified according to their elution order on an Rtx-5 column (Table 2), with patchouli alcohol (56.13%) and seychellene (13.16%) identified as the major constituents.

Table 2. Chemical Composition of Nilam leaves oil

No	RT (min)	Compounds	Formula	Concentration area (%)
1.	3.202	Diacetone Alcohol	$C_6H_{12}O_2$	4.56
2.	15.808	α-Guaiene (Alpha-Guaiene)	$C_{15}H_{24}$	9.96
3.	15.992	Seychellene	$C_{15}H_{24}$	13.56
4.	16.142	α-Patchoulene (Alpha-Patchoulene)	$C_{15}H_{24}$	5.83
5.	16.625	δ-Guaiene (Delta-Guaiene)	$C_{15}H_{24}$	8.12
6.	17.583	Caryophyllene Oxide	$C_{15}H_{24}$	4.84
7.	18.525	Patchouli Alcohol	$C_{15}H_{26}O$	56.13

*RT =Retention time (min), *compound concentration based on GC-FID peaks

The percentage compositions of remaining five compounds ranged from 4.56% - 9.96% .Patchouli oil extract is suspected to contain several bioactive compounds that contribute to its biological activity. Patchouli oil contains phenolic and terpene compounds, which are known to exhibit antioxidant properties. In addition, flavonoids, saponins, and d-limonene have been reported to act as contact and respiratory poisons in insects, particularly *Aedes aegypti* mosquitoes. Flavonoids, which belong to the phenolic compound group and are widely distributed in plants, play an important role in insect control [13,15].

Flavonoids possess insecticidal properties by targeting the nervous system of insects, disrupting vital physiological functions and causing symptoms such as nervous system weakness and respiratory failure, which may ultimately lead to death [16–18]. Saponins are also toxic to insects and can damage cell membranes; however, due to their volatile nature, their effectiveness may be limited [19,20]. Despite this limitation, these compounds are considered relatively safe for the environment, humans, and livestock because they are natural and biodegradable, allowing residues to degrade rapidly and reducing the likelihood of resistance development [21,22].

In general, the effectiveness of insecticides is directly proportional to their concentration, meaning that higher doses increase insect control efficacy. Compared with chemical pesticides, biopesticides offer significant safety advantages, particularly due to their higher biodegradability [23,24]. Although studies directly evaluating the long-term effects of biopesticide use on human health remain limited, their application is considered safer than synthetic insecticides. Biopesticides decompose more readily in the environment, minimizing ecological pollution and reducing adverse effects on non-target organisms. In contrast, synthetic insecticides are often persistent, leading to environmental contamination and potential harm to other living organism

4 Conclusion

Patchouli leaf lotion showed a significant repellent effect, indicating its effectiveness as a mosquito repellent. Formulation 2 (P2) , containing patchouli oil, clove oil, and eucalyptus oil at a ratio of 1:0.4:0.1, and Formulation 3 (P3) at a ratio of 2:0.4:0.1 exhibited comparable protective efficacy as repellents.

Patchouli oil is considered a good antioxidant, with an IC_{50} value ranging from 50 to 100 µg/mL. This antioxidant activity is attributed to the presence of phenolic and terpene compounds in patchouli oil. In addition, phytochemical components such as flavonoids, saponins, and d-limonene have been shown to act as contact and respiratory poisons in insects, particularly *Ae. aegypti*.

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