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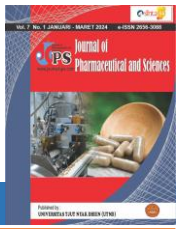

Lime Peel Extract and Citronella Oil Balm Stick as Aromatherapy and *Aedes aegypti* Repellent

Ektstrak Kulit Jeruk Nipis dengan Minyak Serai Wangi Stick Balm sebagai Aromaterapi dan Repellent Nyamuk *Aedes aegypti*

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Abstract

Lime (*Citrus aurantifolia*) is a plant that has been empirically recognized to possess insecticidal and repellent properties. Citronella oil (*Cymbopogon nardus)* is an essential oil with antidepressant properties and is commonly used as aromatherapy. The purpose of this study was to determine the physical properties and mosquito-repellent activity of a stick balm preparation formulated from lime peel extract (*Citrus aurantifolia*) as a repellent, with the addition of citronella oil (*Cymbopogon nardus*) as aromatherapy. This study employed an experimental research method. Stick balm preparations were made in four formulations with extract concentrations of 0%, 5%, 10%, and 15%. The formulations were evaluated for organoleptic characteristics, pH, homogeneity, spreadability, smearability, hedonic acceptance, irritation, and the presence of steroids and terpenoids, as well as tested for mosquito-repellent activity against Aedes aegypti. The evaluation results showed that all formulations met the established physical quality standards, indicating good stability and safety. The mosquito-repellent effectiveness test demonstrated that formulation F3 (15% lime peel extract) provided the highest protection at 94.74%, followed by F2 (84.21%), F1 (74.68%), and F0 (42.11%). Thus, stick balm preparations containing lime peel extract and citronella oil are physically stable, safe, and effective as mosquito-repellent aromatherapy, with F3 being the most effective formulation.

***Keywords*: Aedes aegypti, Aromatherapy, Lemongrass, Lime Peel, Repellent**

Abstrak

Jeruk nipis (*Citrus aurantifolia*) merupakan suatu tanaman yang secara empiris memiliki sifat insektisida dan repellent. Minyak serai wangi (*Cymbopogon nardus*) merupakan suatu minyak yang bersifat sebagai antidepresan yang bertindak sebagai aromaterapi. Tujuan pada penelitian ini untuk mengetahui sifat fisik dan aktivitas anti nyamuk dari sediaan stick balm ekstrak kulit jeruk nipis (*Citrus aurantifolia*) sebagai repellent dengan penambahan minyak serai wangi (*Cymbopogon nardus*) sebagai aromaterapi, yang kemudian didapatkan sediaan stick balm yang baik secara fisik, memiliki aktivitas anti nyamuk dan dapat digunakan sebagai aromaterapi. Metode yang digunakan merupakan penelitian eksperimental. Sediaan stick balmdibuat menjadi 4 formulasi dengan variasi konsentrasi, yaitu, 0%, 5%, 10%, dan 15 %. Sediaan stick balm dievaluasi fisik dan diuji aktivitas antinyamuk dengan metode uji daya proteksi repellent (daya tolak) terhadap nyamuk Aedes aegypti. Uji efektivitas stick balm diperoleh nilai perlindungan terhadap nyamuk Aedes aegypti menunjukkan bahwa sediaan F3 mempunyai nilai persentase perlindungan paling tinggi yaitu dengan persentase 94,74% diikuti sediaan F2 (84,21%), F1 (74,68%), dan F0 (42,11%).

***Kata Kunci:** Aromaterapi, Kulit Jeruk Nipis, Minyak Serai Wangi, Nyamuk Aedes, Repellent.*

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Introduction

Dengue Hemorrhagic Fever (DBD) or also known as Dengue Hemorrhagic Fever (DBD) is an infectious disease caused by the dengue virus (DENV) which is caused by insect bites. The carrier of the dengue fever virus is the *Aedes* sp mosquito. namely *Aedes aegypti* which is the main carrier of dengue fever in Asia, and the *Aedes* albopictus mosquito is the second carrier. According to the World Health Organization (WHO), the incidence of Dengue Hemorrhagic Fever (DHF) throughout the world has increased dramatically over the last 20 years, it is estimated that the number of people affected by this disease is 2.5-3 billion and 20 million people each year. *Aedes* mosquitoes are often found in countries with tropical climates, hot temperatures and humidity, for example in Indonesia. Cases of dengue fever have recently increased due to rising temperatures [1].

According to data obtained from the Bengkulu City Health Office, Bengkulu Province,Indonesia is ranked 21st with 1,189 cases of DHF in 2021, DHF cases in the Bengkulu city area were 117 cases consisting of 68 male cases and 49 female cases with an Incidence Rate (IR) of 31.2 per 100,000 population. Cases of Dengue Hemorrhagic Fever (DHF) in Bengkulu City in 2021, the results of spatial analysis show that the most DHF cases in Bengkulu City in 2021 were in Gading Cempaka District, with 17 positive and negative cases. This is due to the density and number of public places that are gathering points for people from various regions. Public places that are crowded with visitors allow for the exchange of several types of dengue fever viruses which are quite large. In addition to Gading Cempaka, DHF cases also occurred in Teluk Segara District (7 cases), Ratu Samban (6 cases), Sungai Serut (5 cases), and Singaran Pati (4 cases). Overall, in 2021 there were 117 DHF cases in Bengkulu City with an Incidence Rate (IR) of 31.2 per 100,000 population. This number consists of 68 cases in men and 49 cases in women [2].

In the current situation, different control methods are needed to overcome mosquito vectors. One method that can be used is the use of repellents. Repellent is a type of insecticide used to protect the body (skin) from mosquito bites. Repellents can be in the form of sprays, lotions, and balm sticks [3]. Repellents in the form of lotion preparations are very popular because they contain water carriers that are impermeable to light, thin, non-fatty, tend to evaporate quickly with a cool feeling when applied to the skin [4]. The disadvantages of lotion preparations are that the risk of allergies is generally greater, the storage of lotion dosage forms is not durable and the lotion dosage form is less practical to carry everywhere [5].

Therefore, a formulation of lime extract stick balm (*Citrus aurantifolia*) with the addition of citronella oil (*Cymbopogon nardus*) was developed as a repellent and aromatherapy to become an innovation in mosquito repellent preparations with minimal side effects. Repellent contains active substances that can prevent mosquito bites. These active substances are Diethyltoluamide (DEET), Diclorovinil Dimethyl Phosphate (DDP), malathion, parathion, and others. However, the continuous use of repellents with synthetic chemical content can have a negative impact on human health, and can cause mosquito resistance. To reduce the use of chemicals, it is necessary to optimize the use of plants that have natural insecticidal abilities, especially for mosquitoe [6]. Optimization can be done through the use of natural repellents, namely types of repellents that come from plants and contain chemicals (bioactive) that are toxic to insects [3].

Lime peels, which have not been optimally utilized so far, actually have great potential. Lime peels contain many nutrients and secondary metabolite compounds such as essential oils, tannins, saponins, phenols, terpenoids and alkaloids [7]. The essential oils contained in lime peels have an effect on mosquito nerves, causing mosquitoes to become weak and eventually die. The essential oil content in lime peels

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involves several compounds, one of which is linalool [8]. Limes (*Citrus aurantifolia*) are commonly used because this plant is rich in chemical nutrients. Lime peels contain secondary metabolite compounds such as essential oils, flavonoids, saponins, steroids, and terpenes. Essential oils in lime peels such as limonene and limonoids inhibit the molting of mosquito larvae and can enter the body of mosquito larvae as poison [9].

Lemongrass (*Cymbopogon nardus* L.) has antidepressant properties supported by one of its components. One of the secondary metabolite compounds found in lemongrass plants contains aromatherapy components that can reduce stress by creating feelings of calm and comfort through physical and psychological effects [10]. Lemongrass essential oil contains 23.17% geraniol, 34.6% citronellal, and 12.09% citronellol, which are used in aromatherapy. Citronella in lemongrass works by inhibiting the enzyme acetylcholinesterase, causing acute poisoning such as seizures, disorders of the Central Nervous System, and respiratory paralysis due to the accumulation of acetylcholine, which ultimately results in death in insects [11]. The purpose of this study was to determine the repellent or anti-mosquito potential of lime peel extract (*Citrus aurantifolia*) with the addition of citronella essential oil (*Cymbopogon nardus*) in stick balm preparations.

Experimental Section

Materials and Apparatus

Materials Lime was obtained from Lismawati Plantation, South Dempo, Pagaralam. Citronella oil was obtained from Tetesan Atsiri. Cera alba, adeps lanae, butyl hydroxytoluene (BHT), span 80 were obtained from CV Total Equipment Pharmacy. Ethanol 96% was obtained from PT Inti Medika. Lieberman-Bourchard reagent was obtained from PT Alfazza Multi Medikalindo. *Aedes aegypti* mosquitoes were obtained from ovitrap (oviposition trap).

Methods Plant Verification

Plant verification was done to ensure that the material used was really lime peel (*Citrus aurantifolia*) extract by matching the plant with the determination key conducted in the Biological Basic Science Laboratory of the Faculty of Mathematics and Natural Sciences of the University of Bengkulu.

Making Lime Peel Simple Drugs

Limes were taken as much as 15 kg at the Lismawati Dempo Selatan Pagaralam plantation. The outermost skin of the lime was taken, then cleaned using running water until the skin was clean. Furthermore, the skin was separated first from the lime flesh, then thinly sliced and dried in the sun with a tray covered with black cloth for 3 days. The dried simplisia was mashed with a blender, then sieved using a 40 mesh sieve.

Making Lime Peel Extract

500 grams of lime peel powder was extracted with 2 liters of 96% ethanol using the maceration method for 5 days, and stirred every 12 hours. Furthermore, the filtrate was filtered using filter paper and a funnel into another brown bottle. Then the filtrate was concentrated with a rotary evaporator until a concentrated extract was obtained.

Steroid and Terpenoid Test

As much as 2 ml of thick extract is dissolved in sufficient 96% ethanol. Then added with 5 drops of Lieberman-Bourchard reagent. If a brownish or violet ring is formed on the border of the solution, it indicates a positive terpenoid. While if a blue-greenish ring appears, it indicates a positive steroid.

Formulation and Making of Stick Balm

The combination of lime peel extract and citronella essential oil stick balm preparation was made using the melting method. Weigh the cera alba for all formulas the same, which is 4.95 grams, adeps lanae 1.5 grams, span 80 0.75 grams, BHT 0.015 grams, citronella oil 2 ml, and green dye to taste. Olive oil is measured according to the formulation, for F0 as much as 5.8 ml, F1 as much as 5 ml, F2 as much as 4.3 ml, and F3 as much as 3.5 ml. After all the ingredients are weighed, the cera alba is placed in a porcelain cup and heated on a hotplate until melted. Then adeps lanae is added, and stirred until homogeneous. Then add

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span 80 and BHT, stir until homogeneous, forming mixture 1. While the cera alba is melted, the thick lime peel extract is weighed according to the formulation, namely F0 does not use extract, F1 uses 5% extract as much as 0.75 grams, F2 uses 10% extract as much as 1.5 grams, and F3 uses 15% extract as much as 2.25 grams. Then the olive oil is measured according to the formulation, namely F0 as much as 5.8 ml, F1 as much as 5 ml, F2 as much as 4.3 ml, and F3 as much as 3.5 ml. The thick extract that has been weighed is put into olive oil and stirred until dissolved, then 2 ml of citronella essential oil is added, stirred and mixture 2 is formed. After both mixtures are homogeneous, add mixture 2 to mixture 1 in a porcelain cup while heating, then add enough dye and wait until it melts. After the mixture is homogeneous and completely melted, the mixture is put into a stick balm container and waited until the preparation hardens. The stick balm was formulated as a 15-gram preparation

Table 1. Stick Balm Formulation with Variations in Lime Peel Extract Concentration

Materials (b/b)	Function	Concentration (gram)			
		F0	F1	F2	F3
Lime peel extract	Active substance	0% (0 g)	5% (0,75 g)	10% (1,5 g)	15% (2,25 g)
Citronella oil	Active substance	0% (0 g)	13,9% (2.085 g)	13,9% (2.085 g)	13,9% (2,08 g)
Cera alba	Compactor	30% (4,5 g)	30% (4,5 g)	30% (4,5 g)	30% (4,50 g)
Adeps lanae	Binder	10% (1,5 g)	10% (1,5 g)	10% (1,5 g)	10% (1,50 g)
Butyl hydroxytoluene	Antioxidant	0,1% (0,015 g)	0,1% (0,015 g)	0,1% (0,015 g)	0,1% (0,015 g)
Span 80	Emulsifier	5%	5%	5%	5%
Olive oil	Emulsifier	Ad 15	Ad 15	Ad 15	Ad 15
Dye	Dye	q.s	q.s	q.s	q.s

Description:
Cera alba is melted, so the preparation is added with 10%
F0: Stick balm without lime peel extract
F1: Stick balm with 5% lime peel extract
F2: Stick balm with 10% lime peel extract
F3: Stick balm with 15% lime peel extract

Lime Peel Extract Stick Balm Testing

The evaluation of the lime peel extract stick balm included several quality assessment parameters. Organoleptic testing was conducted by directly observing the color, aroma, texture, and overall physical form of the preparation to ensure its sensory acceptability. Homogeneity testing was performed by placing a sufficient amount of the stick balm on a glass slide, spreading it evenly, and visually examining it to confirm the absence of coarse particles or uneven distribution of ingredients. For the pH test, an adequate amount of the preparation was melted at 60°C, after which a pH meter was immersed into the liquefied sample and allowed to stabilize until a constant reading was obtained, ensuring the pH remained within the safe range for topical application. The spread power test was conducted by placing 0.5 g of the stick balm on a glass plate with a diameter of 10 cm, which was positioned over millimeter block paper. The sample was then covered with another glass plate and subjected to a load of 100 g for 5 minutes, followed by additional loads of 50 g incrementally, using the same procedure to evaluate the formulation's ability to spread under applied pressure. Lastly, the spreadability test was carried out by applying the stick balm onto the dorsal skin of the hand, allowing it to sit briefly, and observing the ease with which the preparation adhered and distributed on the skin surface. These combined tests ensured that the stick balm formulation met the required physical and functional characteristics for topical use.

Hedonic Test

This test was conducted by observing the color, aroma, texture, ease of application, and container design. The panelists tested in this study were students of Bengkulu University with a total of 10 panelists. The panelists were asked to provide responses regarding the level of preference for the formulation of the stick balm repellent preparation and their willingness to fill out the test form based on the code. The test procedure was to provide four stick balm samples, then each panelist was asked to fill out the test form according to their personal opinion. In this study, the scale used by the researcher consisted of 5 scales, namely: (1) very dislike, (2) dislike, (3), neutral, (4) like, and (5) very like.

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Irritation Test

The irritation test was conducted on 10 panelists who had been asked for their consent to undergo an irritation test. This test was conducted using the open patch test method, which was carried out by applying the preparation to the lower arm and leaving it open for 5 minutes, and the reactions caused were observed, including redness, swelling, and itchy skin.

Mosquito Repellent Test

This test uses a tightly closed square chamber measuring 40 cm x 40 cm x 40 cm, room temperature (27 ° C), and not too bright light adjusted to the habitat of *Aedes* sp. mosquitoes. Stick balm is applied to the surface of the volunteer's lower arm skin, by applying 5x evenly. Then the arm is inserted into a mosquito chamber containing 25 female mosquitoes that have been fasted for 24 hours. Furthermore, the mosquitoes that land within 15 minutes are counted and the percentage of protection power is calculated. The repellent protection power (repulsion power) tested is determined based on the protection power calculated using the following formula.

$$DP = \frac{K - P}{K} \text{ x } 100\%$$

Description :
Dp : Protection Power
K : Many mosquitoes on the control arm
P : Many mosquitoes on the treatment arm
It is said to be effective if the protection power reaches 90%

Data Analysis

Data were analyzed using descriptive and statistical tests. For data obtained from organoleptic observations, homogeneity, pH measurement, spreadability, irritation and hedonic, were analyzed using descriptive tests while the repellent activity of stick balm extract of orange peel and lemongrass oil against Aedes aegypti mosquitoes was analyzed using parametric statistical tests One Way ANOVA using SPSS (Statistical Package for the Social Science) 16.0 software.

Results and Discussion

Making Lime Peel Simple Drugs

Lime was taken as much as 15 kg at the Lismawati Dempo Selatan Pagaralam plantation. The lime peel was then dried in the sun using a black cloth, which aims to block sunlight from directly hitting the lime peel, so as to minimize damage to active substances from sunlight [12]. Based on the [13] which states that organoleptically, lime peel simplicia has a brownish green color (outer skin) and yellowish white (inner skin), has a distinctive lime odor, astringent, bitter, and slightly sour taste. This is similar to the research conducted, which showed that the lime peel simplicia obtained had a green and brownish yellow outer skin, and a white inner skin, which had a distinctive aromatic lime odor, and had a bitter and bitter taste. The dried lime peel simplicia was then ground into a fine powder. This is done so that the surface area of the sample becomes larger, so that the solvent can more easily enter the cells and the active substances contained in the herbal medicine can be maximally attracted [14].

Making Lime Peel Extract

Lime peel simplicia was extracted using the maceration method as much as 500 grams using 96% ethanol solvent for 5 days. The extraction method used is the maceration method, where maceration is a simple extraction process that uses solvents with repeated shaking or stirring at room temperature or room temperature [15]. This maceration method was chosen because in addition to being simple and practical, it also does not involve heating at high temperatures which can damage the compounds contained in the sample [16].

The solvent used in this extraction is 96% ethanol. The advantages of this solvent are that 96% ethanol has polar, universal, easily obtained, and inexpensive properties. In addition, 96% ethanol is non-toxic, selective, and has good absorption and extraction capabilities, so it can extract all compound properties. 96% ethanol solvent can easily enter the sample cell to produce a concentrated extract [17]. The ratio of the

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simplicia to the solvent used is 1:4. During maceration, stirring is carried out consistently so that contact between the simplicia and the solvent is faster [14].

The maceration filtrate was concentrated using the evaporation method. This evaporation aims to evaporate or remove the solvent so that a thick extract is obtained [16]. The thick lime peel extract was obtained as much as 76 grams, so that the rendement percentage was 15.2%. This rendement result is in accordance with the [13], which states that the rendement of good thick lime peel extract is not less than 15%.

Table 2. Results of Lime Peel Extract Rendement

Solvent	Weight of Simplicia (gram)	Solvent Volume (mL)	Weight of Extract (gram)	Rendement
Ethanol 96%	500	2000	76	15,2%

Steroid and Terpenoid Test

The results of the Liebermann-Bourchard test of terpenoid compounds in lime peel extract showed that the sample was positive for containing terpenoid compounds. Positive terpenoid test results are indicated by a change in the color of the brownish ring, the more concentrated the color of the test results, the more terpenoid content [18].

Evaluation of Lime Peel Extract Stick Balm

Organoleptic Test

Figure 1. Organoleptic Test (From left to right is F0; F1; F2; F3)

Organoleptic testing aims to determine the shape, color, aroma, and texture of the stick balm [19]**.** The results of the organoleptic test F0 0% tosca green color, soft, easy to spread, moist, semi-solid form. F1 5% young leaf green color, distinctive aroma of lemongrass and olive oil, soft, easy to spread, moist, semi-solid form. F2 10% lime green color, distinctive aroma of lemongrass and olive oil, soft, easy to spread, moist, semi-solid form. F3 15% olive green color, distinctive aroma of lemongrass and olive oil, soft, easy to spread, moist, semi-solid form.

Homogeneity Test

The results can be seen in Figure 4, the homogeneity test aims to determine the distribution of active ingredients contained in the stick balm preparation, whether it has been mixed evenly and there are no coarse grains. The results of the homogeneity test show that all stick balm preparations are homogeneous. This is in line with previous research which states that the requirements for a preparation to be said to be homogeneous if it does not contain coarse grains or clumped particles [20]. And no more prominent color was found in the preparation [21].

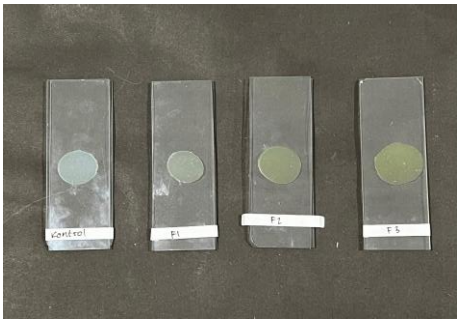

Figure 2. Homogeneity Test

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pH Test

The pH testing of the stick balm preparation aims to ensure that the pH obtained is in accordance with the pH of human skin, which is in the range of 4.5-6.5 [20]. The results of the pH test on each formulation were repeated 3 times and obtained different results, namely at F0 0% with an average pH value of 5.60, F1 5% with an average pH value of 5.26, F2 10% d with an average pH value of 5.30, and F3 15% with an average pH value of 5.44. Based on the results obtained for each formulation, it has been shown that the pH value obtained is still at a normal pH that can be accepted by human skin and meets the criteria for the pH of topical preparations. This is in accordance with previous research which states that topical preparations are expected to have a pH that is at the pH of normal skin [19].

Hedonic Test

The hedonic test was conducted to see the level of preference for the preparations made which were tested on panelists [23]. This study conducted a visual hedonic test of the stick balm preparation on 10 panelists. The following are the results of the hedonic test that has been carried out.

Based on table 3, it can be seen from the average in the color column, many panelists like the F0 preparation or control preparation, because the F0 preparation has a soft tosca green color. In terms of aroma, panelists like the aroma of the F0 and F1 preparations, because these two preparations do not have a very strong aroma. The F0 and F1 preparations also have a texture that is widely preferred by panelists, this can happen because the olive oil content in the F2 and F3 preparations is less than the F0 and F1 preparations. The F0 and F1 preparations have good values for ease of application, but for the F2 and F3 preparations they also have quite good values for ease of application. In the container design, the value is the same for preparations F0 to F3, because the container design for all preparations is the same. For the graph of the hedonic test, it can be seen in Figure 4, it can be seen that the F0 graph is higher than the other graphs, so F0 is the most popular preparation.

Table 3. Hedonic Test Results of Stick Balm Preparations

Panelist	Color				Flavour				Texture				Ease of Application				Container Design			
	F0	F1	F2	F3	F0	F1	F2	F3	F0	F1	F2	F3	F0	F1	F2	F3	F0	F1	F2	F3
1	5	4	4	1	4	4	4	1	4	4	4	4	5	3	5	3	5	5	5	5
2	3	4	3	3	4	5	5	4	5	5	5	3	4	5	4	4	5	5	5	5
3	5	4	3	3	5	4	3	5	5	5	4	5	5	4	4	4	5	5	5	5
4	3	3	3	3	2	4	4	3	4	4	3	4	3	5	3	5	5	5	5	5
5	4	4	3	3	4	3	3	4	3	2	4	3	4	3	4	4	4	4	4	4
6	3	3	3	3	4	4	2	3	2	3	2	4	3	4	3	4	4	4	4	4
7	5	4	3	3	5	4	4	3	4	4	3	2	4	4	4	3	4	4	4	4
8	4	4	4	4	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4
9	4	4	4	4	4	4	4	4	3	3	3	3	4	4	4	4	4	4	4	4
10	4	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Total	40	37	33	30	39	39	36	34	38	38	36	36	40	40	39	39	44	44	44	44
Average	4	3,7	3,3	3	3,9	3,9	3,6	3,4	3,8	3,8	3,6	3,6	4	4	3,9	3,9	4,4	4,4	4,4	4,4

Description :
1 = very dislike
2 = dislike
3 = neutral
4 = like
5 = very like

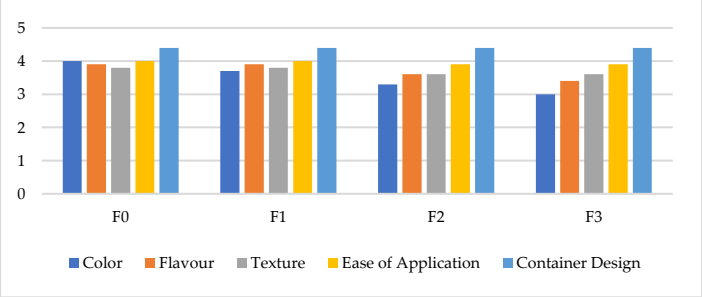

Figure 4. Hedonic Test Results Graph

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Spread Power Test

Testing the spreadability of the preparation aims to determine the softness of the preparation so that it can be seen how easy it is to apply the preparation to the skin. Good spreading power will result in wider and more even contact between the preparation and the skin so that the spread of the preparation onto the skin occurs quickly [19]. The results of the spreadability test that have been carried out obtained values of F0 (5.2 cm), F1 (5 cm), F2 (5.1 cm), and F3 (5 cm). These results indicate that the preparation meets the requirements, the requirements for good spreadability for topical preparations are 5-7 cm [22].

Spreadability Test

The results can be seen in Figure 3, the results of the application test can be concluded that the four formulas are able to stick to the skin. This shows that all formulas can stick well to the surface of the skin of the arm [20].

Before After

Figure 3. Spreadability Test

Irritation Test

Table 4. Results of Irritation Test of Stick Balm Preparation

Observation	Formulation	Panelist									
		1	2	3	4	5	6	7	8	9	**10**
Reddish Skin	F0	-	-	-	-	-	-	-	-	-	-
Swollen Skin		-	-	-	-	-	-	-	-	-	-
Itchy Skin		-	-	-	-	-	-	-	-	-	-
Reddish Skin	F1	-	-	-	-	-	-	-	-	-	-
Swollen Skin		-	-	-	-	-	-	-	-	-	-
Itchy Skin		-	-	-	-	-	-	-	-	-	-
Reddish Skin	F2	-	-	-	-	-	-	-	-	-	-
Swollen Skin		-	-	-	-	-	-	-	-	-	-
Itchy Skin		-	-	-	-	-	-	-	-	-	-
Reddish Skin	F3	-	-	-	-	-	-	-	-	-	-
Swollen Skin		-	-	-	-	-	-	-	-	-	-
Itchy Skin		-	-	-	-	-	-	-	-	-	-

Based on table 4 it can be seen that the panelists did not show any reaction results such as redness, swelling, and itchy skin. From the results of the irritation test, it is known that the stick balm preparation made in this study is safe to use.

Mosquito Repellent Test

Aedes aegypti mosquitoes are obtained from ovitrap results, Ovitrap (oviposition trap) is a container-shaped tool made of plastic, cans, glass or bamboo with a black/dark color filled with water. Ovitrap has a function, namely to detect the presence of *Aedes aegypti* mosquitoes. Dark colors can absorb heat and also easily emit heat so that they can attract *Aedes aegypti* mosquitoes to come [24]. The use of ovitrap has many advantages such as being cheap and simple because its components can be made using used goods and are easy to maintain and clean where you only need to brush the inside and change the water every week [25].

The ovitrap used was made from a used 1.5 liter bottle and had a height of 15 cm wrapped in black plastic, and filled with well water as much as three-quarters. The characteristics of well water, such as low salinity and organic content, pH in the neutral range, and low turbidity (clear) are very suitable for the habitat of pre-adult *Aedes aegypti* [26].

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The research sample was a house unit selected using purposive sampling technique. The research location was Selebar, Gading Cempaka, Ratu Agung and Muara Bangkahulu sub-districts. Based on the number of cases that occurred in 2023, Gading Cempaka sub-district was the place with the most DHF cases. Measurements were taken outside the house during installation and retrieval for 1 week and 7 observations were made.

Table 5. Mosquito Repellent Test Results

Extract Concentration	Many Mosquitoes on the Treatment Arm	Protection Power
F0 (0%)	11	42.11%
F1 (5%)	5	74.68%
F2 (10%)	3	84.21%
F3 (15%)	1	94.74%

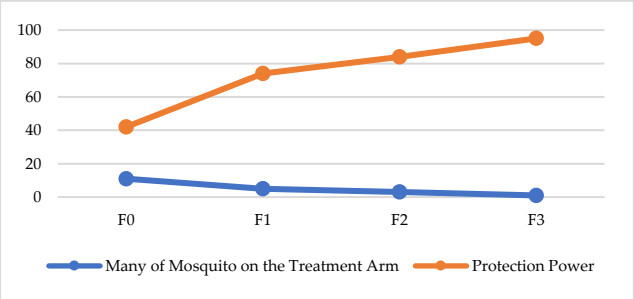

Figure 5. Graph of Mosquito Repellent Test Results

The effectiveness test of the repellent stick balm preparation or mosquito repellent test was carried out to determine the protective effect of the formulation against *Aedes* mosquitoes and to determine the percentage of protection power [27]. Based on the results of observations of the effectiveness test of the lime peel extract stick balm and lemongrass oil, the protection power value against *Aedes aegypti* mosquitoes showed that the F3 preparation had the highest percentage of protection power, namely 94.74%, followed by preparations F2, F1, and F0 with percentages of 84.21%; 74.68%; 42.11% (respectively). This shows that the F3 stick balm with an extract concentration of 15% has significant effectiveness as a repellent for *Aedes aegypti* mosquitoes. The formula is said to be effective if the protection power value reaches 90% [27].

The results of the study showed that lime peel extract at several concentrations given greatly influenced the landing of mosquitoes on the volunteers' hands, the difference in the protection power results in each formula was due to the different amounts of lime peel extract used. Based on Figure 5, it can be seen that there is an increase in the graph in the protective power from F0 to F3, while there is a decrease in the graph in the number of mosquitoes in the treatment arm. This is in accordance with previous research, which states that the higher the concentration of extract given in the preparation, the higher the protective power that will be produced The superior activity of F3 may be attributed to the higher levels of bioactive compounds present in lime peel, particularly limonene, which is known to act as a natural mosquito repellent by disrupting the olfactory receptors of mosquitoes and inhibiting their ability to recognize host odors [29].

Similar compounds such as citral and flavonoids in lime peel have also been reported to enhance repellent properties through synergistic effects [30]. When compared with other studies, the repellency of F3 (94.74%) is consistent with or higher than previous reports using natural essential oils, such as citronella-based formulations, which typically exhibit protection values in the range of 80–90% [31]. This suggests that lime peel extract, particularly at 15% concentration, provides not only significant repellent activity but also competitive efficacy compared to other natural mosquito repellents reported in the literature [28].

Table 6. ANOVA test

Sum of Squares		df	Mean Square	F	Sig.
Between Groups	212.250	3	70.750	154.364	.000
Within Groups	5.500	12	.458		
Total	217.750	15			

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Based on the results of the analysis using One-Way ANOVA that the p value <α (0.000 <0.05), indicates that there is a significant influence from the observation results of the effectiveness test of lime peel extract and lemongrass oil stick balm so that the value of protective power against Aedes aegypti mosquitoes is obtained. The F3 preparation has the highest percentage value of protective power, namely with a percentage of 95% followed by F2, F1, and F0 preparations with a percentage of 84%; 74%; 42; (respectively). This shows that the F3 stick balm with an extract concentration of 15% has significant effectiveness as a repellent for Aedes aegypti mosquitoes. The formula is said to be effective if the protective power value reaches 90% [27]. The results of the study showed that lime peel extract at several concentrations given greatly influenced the landing of mosquitoes on the volunteers' hands, the difference in the results of protective power in each formula was due to the different amounts of lime peel extract used. The higher the concentration of extract given in the preparation, the higher the protective power that will be produced [28]. The following are the product results from the preparation of stick balm with lime peel extract and citronella oil.

Figure 6. Product Results.

Conclusion

From the results of the study, it can be concluded that stick balm preparations containing lime peel extract (*Citrus aurantifolia*) and lemongrass oil (*Cymbopogon nardus*) at varying concentrations—F0 (0%), F1 (5%), F2 (10%), and F3 (15%)—met the established physical and quality standards. Among these, formulation F3 with 15% lime peel extract showed the highest percentage of protection in the repellent test against Aedes aegypti, with a value of 94.74%. In addition to its repellent activity, the preparation also demonstrated an acceptable aroma in hedonic testing, supporting its potential role as an aromatherapeutic agent. However, these findings should be interpreted with caution, as the study did not employ extended duration testing, detailed control designs, or statistical analysis to further validate the differences among formulations. Therefore, while F3 appears most promising within the scope of this study, further research with longer observation times, more rigorous control conditions, and comprehensive statistical evaluation is recommended to confirm its effectiveness and broader applicability.

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Conflict Of Interest

The authors hereby declare that no actual or potential conflicts of interest exist with respect to the research, authorship, and publication of this article. All procedures and interpretations were carried out independently and without bias..

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