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Repellent Activity Testing of an Essential Oil Gel Preparation of Cinnamon (Cinnamomun Burmanii) Bark) And Kaffir Lime Peel (Citrus Hytrix) Against Aedes Aegypti Mosquitoes

Fitriah Ardiawijianti Iriani[1], Rosita Irianti Dehi[2], Alpha Christyananda Damar[3]
[1,2,3] Department of Pharmacy, Health Polytechnic, Ministry of Health, Jayapura, Indonesia
Email: fitriahiriani92@gmail.com

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ABSTRACT

Dengue fever is still a disease that dominates, especially in the Papua region. To overcome this, it is necessary to modify preparations based on medicinal plants as mosquito repellents, one of which is gel preparations. This study aims to determine the repellent activity test of essential oil gel preparations of Cinnamon Bark (Cinnamomum burmannii) and Kaffir Lime Peel (Citrus Hystrix) against the Aedes aegypti mosquito. The method used in this research uses experimental methods. This research was conducted in April - November 2022. This research used two formulations, namely cinnamon bark and kaffir lime peel (FI) formulations which were compared with formulation preparations in the form of a base without active substances (FII). The tests carried out were physical quality tests and repellent tests on the Aedes aegypti mosquito. The research results show that based on physical quality tests, it is known that FI has a distinctive odor, slightly yellowish white color and a thick shape. Meanwhile, FII has the distinctive smell of patchouli oil, milky white color and thick shape. In the homogeneity test on FI and FII it was found to be homogeneous and fulfilled the requirements. In the adhesion and spreadability tests on FI and FII it was found that they met the requirements. In the pH test, the pH of FI and FII has a pH value of 7 and meets the requirements. In the repellent test using arm-in-cage with 3 replications using 20 Aedes aegypti mosquitoes. The formulas tested were FI and FII and observations made were by recording the number of mosquitoes that landed after using the repellent for 15, 30, 60, 120, 240 and 360 minutes. The research results showed that in the 15th minute the protection power was 88.3%, in the 30th minute the protection power was 88.3%, in the 60th minute the protection power was 72.3%, in the 120th minute the protection power was 67, 1%, in the 240th minute the protection power was 51.5%, and in the 360th minute the protection power was 47.7%. Based on the research results, it can be concluded that the essential oil formulation of cinnamon bark and Kaffir lime peel is efficacious as a repellent.

Keywords:*Aedes aegypti, Essential Oil, Repellent*

INTRODUCTION

Mosquitoes are the main vectors of several diseases, including dengue fever, malaria, yellow fever, and chikungunya. Important mosquitoes that transmit dengue fever (vectors) are Aedes aegypti, Aedes albopictus, and Aedes scutellaris, but until now the main vector of dengue fever is Aedes aegypti, and no cure or vaccine has been found. As an effort to prevent mosquito bites, in addition to using mosquito repellent in the form of spray or mosquito coils, preparations in the form of mosquito repellent are also practical to use by applying to the surface of the body's skin (Lukman et al, 2012). Nowadays, many people use traditional medicines to overcome health problems. Some types of plants in Indonesia that have the potential to become mosquito repellent plants include citronella, geranium, eucalyptus, cinnamon, rosemary, basil, garlic, kaffir lime and others (Medline, 2003). One of the thousands of plants that have the potential to repel mosquitoes is cinnamon (Cinnamomum burmannii) essential oil and kaffir lime peel (Citrus hystrix) (Mansjoer, 2000). The nature of essential oils is volatile so it is not effective when used directly on the skin because it will quickly disappear on the skin (Guenther, 1987).

The Aedes aegypti mosquito is the main vector of dengue hemorrhagic fever (DHF), which has become a global public health problem. The disease poses a heavy health burden, with a significant increase in cases in many parts of the world. In an effort to reduce the risk of dengue transmission, the use of repellents as one of the mosquito control strategies is essential. However, many commercial repellents contain synthetic chemicals that can cause side effects such as skin irritation, allergic reactions, or even long-term health impacts. The need for safer and more natural alternatives to repellents is driving research into natural ingredients that have effective mosquito repellent effects. In this context, gels containing essential oils from cinnamon (Cinnamomum burmannii) and lime peel (Citrus hystrix) were selected as potential active ingredients. Cinnamon is known to have strong antimicrobial and repellent properties, while lime peel contains natural components that have been shown to effectively repel various types of mosquitoes.

The use of plants as traditional medicine is considered relatively effective and safe in wound management, because it rarely causes side effects and is quite affordable (Sari, 2021). Traditional medicine can be obtained from various parts of plants such as seeds, fruits, leaves, bark, stems, flowers, and roots, which contain chemical substances with therapeutic effects on various diseases. One example of a plant with these properties is cinnamon. Cinnamon contains various main chemical compounds such as cinnamic alcohol, coumarin, cinnamic acid, cinnamaldehyde, anthocyanins, and essential oils, which also contain sugars, proteins, simple fats, pectin, and others. Cinnamon bark that has been extracted contains the main antioxidant compounds in the form of polyphenols (tannins, flavonoids) and essential oils of the phenol group. Research shows that cinnamon has the ability as an antimicrobial, antifungal, antiviral, antioxidant, antitumor, blood pressure lowering, cholesterol, and has low fat compounds. The eugenol and cinnamaldehyde compounds in cinnamon are known to have antibacterial potential. Commonly known types of cinnamon include Cinnamomum burmanni, Cinnamomum verum, Cinnamomum loureirii, and Cinnamomum aromaticum (Gunawan, 2021). To utilize the properties of cinnamon, an extraction process is required. Extraction is the process of taking soluble chemical content so that it is separated from insoluble materials using liquid solvents (Tiwari, 2017). One of the extraction methods is maceration, which is the process of extracting simplisia using a solvent through several shaking or stirring

at room temperature. This method is effective in attracting substances that are efficacious and can survive heating and those that are not resistant to heating. Research by Reppi et al. (2016) confirmed the benefits of cinnamon extracts, showing the pharmacological potential of the compounds contained therein. The extraction and utilization of cinnamon in traditional medicine offers an effective and safe solution for various diseases, with minimal risk of side effects and relatively low cost.

In Indonesia, the utilization of traditional plants as alternatives in mosquito control, especially the Aedes aegypti mosquito which is the main vector of diseases such as dengue fever and zika, is gaining attention. One promising ingredient is cinnamon (Cinnamomum burmannii). Cinnamon contains essential oils obtained through a distillation process and has various active compounds with potential as mosquito control. The main compounds in cinnamon oil, such as eugenol and cinnamaldehyde, are known to be effective as repellents. Eugenol has strong mosquito-repellent properties, while cinnamaldehyde can disrupt the nervous system of mosquitoes, thus reducing their chances of biting humans. Besides eugenol and cinnamaldehyde, cinnamon oil also contains additional compounds such as safrole, tannin, and calcium oxalate. Safrole is known to have potential as an additional repellent, while tannin and calcium oxalate can function as mosquito larvae growth inhibitors. The combination of these compounds gives cinnamon a comprehensive capability in controlling mosquitoes. The use of cinnamon as a natural ingredient for mosquito control offers a more environmentally friendly and safe alternative to synthetic chemicals. In addition, cinnamon can also be obtained at a relatively low cost. However, to confirm the effectiveness of cinnamon in controlling Aedes aegypti mosquitoes, further research is needed. Such research should include evaluation of optimal dosage, appropriate application method, and effectiveness under various environmental conditions. With the right approach, cinnamon has the potential to be an innovative solution for mosquito control and prevention of mosquito-borne diseases in Indonesia.

Cinnamon bark oil in lotion form at a concentration of 15% has been shown to be effective in repelling Aedes aegypti mosquito bites for six hours. Such effectiveness suggests that this concentration is optimal enough to provide long-lasting protection against mosquito bites, making it a good choice for daily protection. Meanwhile, oleum citronellae, when encapsulated in gel form at a concentration of 10%, showed very high repellency, reaching 97% against Aedes albopictus mosquitoes over the same time period. This result indicates that oleum citronellae also has great potential as an effective repellent, capable of providing almost complete protection against mosquito bites. A comparison between these two ingredients revealed that both cinnamon bark oil and oleum citronellae, albeit at different concentrations and dosage forms, provided significant protection against mosquitoes. Cinnamon bark oil, in lotion form, offered effective protection at relatively high concentrations, while oleum citronellae, in gel form, provided very high protection at lower concentrations. Both ingredients show impressive effectiveness in mosquito bite prevention, yet they offer different advantages in terms of concentration and formulation. Therefore, the choice between the two may depend on the user's preference as well as specific needs regarding protection against mosquito bites.

More than 2,400 plant species from 255 families are known to contain ingredients with pesticidal activity, one of which is cinnamon (Cinnamomum burmannii) (Gunawan, 2011). Ethanol extracts of cinnamon have been shown to be effective in controlling larvae of Aedes aegypti, a major vector of diseases such as dengue fever and zika. The insecticidal potential of cinnamon extract is related to the content of chemical compounds

in it, especially eugenol. Eugenol is neurotoxic to larvae, affecting the central and peripheral nervous system by poisoning nerve axons, disrupting impulse transmission along axons, and prolonging the excitation phase of neuronal cells, thus causing paralysis and death of mosquito larvae (Sari, 2011). Research by Edra et al. (2014) showed that the concentration of cinnamon ethanol extract required to kill 50%, 90%, and 99% of Aedes aegypti larvae (LC50, LC90, and LC99) within 24 hours were 85.727 ppm, 135.180 ppm, and 175.497 ppm, respectively. In addition, research by Paringga (2009) found that essential oil from cinnamon bark also has a significant larvicidal effect against Aedes aegypti larvae, with an LC50 value of 73.186 ppm and LC99 at a concentration of 156.376 ppm. This study aims to evaluate the effectiveness of cinnamon extract as a natural larvicide and potentially offer an alternative mosquito control that is more environmentally friendly and safe compared to synthetic pesticides.

A common method of preventing dengue fever is by using mosquito repellent, known as repellent. Repellents are chemicals that serve to prevent insect bites or harassment, including mosquitoes. Repellents can be applied to the skin or sprayed on exposed areas. Criteria for effective repellents include comfort when used, non-sticky, has a pleasant aroma, and is safe and non-irritating to the skin. Among the active substances often used in repellents is Diethyltoluamide, or DEET. DEET is known as an effective mosquito repellent, although it is odorless, it can cause a burning sensation if exposed to the eyes, so its use should be done with caution. Besides DEET, ethyl hexanediol is also an alternative ingredient that can be used to repel mosquitoes. Ethyl hexanediol has a similar mechanism of action to DEET, but its duration of effectiveness is shorter than DEET (Soedarto, 2013). Although both ingredients are effective in repelling mosquitoes, it is important to consider the duration of protection and possible side effects when choosing a repellent. Therefore, choosing a repellent that suits individual needs and conditions is essential to ensure optimal protection against mosquito bites and the risk of dengue fever.

The gel used in this study as a mosquito repellent preparation is a semi-solid system consisting of a suspension of fine inorganic particles or large organic molecules dispersed in a liquid. This system provides a distinctive texture and facilitates application on the skin surface. Gels have various advantages that make them an ideal choice for mosquito repellent preparations. One of the main advantages of gels is their ability to provide a cooling sensation upon application, which increases user comfort. This cooling effect not only makes using the gel more enjoyable but also helps to relieve skin irritation that may arise from using other products. In addition, the gel dries quickly after application, forming a thin, non-sticky layer. This layer provides protection that works effectively as a barrier against mosquito bites, while still being easy to wash off when needed. Another advantage of the gel is its ease of use. The gel absorbs quickly into the skin, allowing precise application control without leaving unwanted residue. The consistency of the gel also ensures that the product can be applied evenly over a large area of skin, which is important for effective protection against mosquito bites. From a practical perspective, gels also offer advantages in terms of storage and use. Not only are they easy to carry and use in various situations, but they are also more durable compared to some other dosage forms. With these advantages, the gel not only serves as an effective mosquito repellent but also offers comfort and convenience in daily use. These advantages make gels an efficient and convenient option for protection against mosquitoes.

Reducing the risk of side effects that may arise from the use of chemical-based repellents can be done by switching to natural-based repellents. This research focuses on

gel formulation utilizing essential oils from cinnamon bark Cinnamomum burmannii and kaffir lime peel Citrus hystrix as the main ingredients. The gel was designed as a safer alternative to chemical repellants, as natural ingredients tend to be more environmentally friendly and have lower potential side effects. Essential oils from cinnamon bark and kaffir lime peel were chosen as both are known to have effective repellant effects; cinnamon contains active compounds such as eugenol and cinnamaldehyde, while kaffir lime peel contains citronellal and limonene. The gel has undergone a series of effectiveness tests to evaluate its ability to repel mosquitoes, as well as other aspects such as durability, comfort of use, and potential side effects. The results of this study are expected to offer a more natural and environmentally friendly alternative to repellants, while reducing the health risks associated with the use of synthetic chemicals.

METHOD

This study implemented a quantitative approach with a laboratory experimental design to evaluate the effectiveness of a gel containing cinnamon essential oil Cinnamomum burmanii and kaffir lime peel Citrus hystrix as a repellent against Aedes aegypti mosquitoes (Notoadmojo, 2012). The research was conducted from April to November 2022 at the Pharmaceutical Laboratory of the Health Polytechnic of the Ministry of Health Jayapura. The process of making the gel began with the preparation of the gel base which involved mixing viscolam with TEA, using a magnetic stirrer to obtain a homogeneous mixture. Once the gel base was ready, the essential oils of cinnamon and kaffir lime peel were mixed together with the carrier ingredients propylene glycol and glycerin. This mixture was then combined with the prepared gel base, and the remaining distilled water was added until the total reached 100 grams.

In the physical quality test, the gel was examined through several aspects, including organoleptic evaluation of the shape, odor, color, and taste when applied to the skin. This examination also includes microscopic analysis to ensure the visual quality of the gel (Nugraha, 2012). The homogeneity test is conducted by applying a thin layer of gel on a glass object and evaluating the results microscopically and macroscopically. The gel is considered homogeneous if it has an even texture and does not show any lumps. The pH test was conducted by dissolving 0.5 grams of gel in 5 mL of distilled water and using pH paper to measure the color change, which indicates the acidity or basicity of the gel. The adhesion test was performed by placing 0.25 grams of gel on a glass slide and pressing it with a 1 kg weight for 5 minutes, then recording the time taken for the gel to release after the 80 gram weight was lifted. The spreadability test measures how wide the gel spreads on the glass surface under successive loads, with the circle area measured after one minute of added load, with ideal spreadability ranging from 5 cm to 7 cm (Garg, 2002 in Nugraha, 2012).

A test of effectiveness as a repellent was conducted using five volunteers (probandus) involved in an arm-in-cage study. In this test, 20 mosquitoes were put into a test drum, and the probandus was asked to put the arm that had been smeared with repellant gel according to the formula into the drum. The test followed the modified method of Fradin & Day (2002) to evaluate the ability of the gel to repel mosquitoes. Participant criteria included adults between 18 and 55 years of age who had not used any fragrance or repellant products in the past 12 hours and did not smoke. These criteria ensured that the results of the repellent test were not influenced by external factors that could affect mosquito attraction. This process provides an accurate picture of the

effectiveness of the gel in providing protection against mosquito bites, as well as assessing the safety and comfort of the product for users.

RESULT

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1. Uji Kualitas Fisik

The physical quality test of gel preparations includes several important aspects. Organoleptic tests assess the shape, odor, color, and taste of the gel to ensure aesthetic and sensory suitability. The homogeneity test examines the distribution of active ingredients, ensuring that the gel is free of lumps and has an even texture. The adhesion test measures the ability of the gel to stick to the skin after application, while the spreadability test evaluates the extent to which the gel spreads on the skin surface,

ensuring an even and comfortable distribution. Finally, the pH test ensures that the gel has an acidity level that matches the pH of human skin, avoiding irritation and maintaining product safety. The combination of these tests ensures the quality of the gel as an effective, safe and convenient repellent. The physical quality tests conducted include organoleptic test, homogeneity test, adhesion test, spreadability test and pH test. The physical quality test results are presented in the following table:

Table 1. Homogeneity Test

Formulas	Macroscopic	Microscopic	Information
FI	Homogeneous	Homogeneous	M.S
FII	Homogeneous	Homogeneous	M.S

Source: Data Processing

Table 2. Adhesion Test

Formulas	Stickiness	information
FI	25 seconds	M.S
FII	20 seconds	M.S

Source: Data Processing

Table 3. Spreadability Test

Formulas	Spread Power	Information
FI	6 cm	M.S
FII	5.4 cm	M.S

Source: Data Processing

Table 4. Ph test

Formulas	PH	Information
FI	7	M.S
FII	7	M.S

Source: Data Processing

2. Repellent Test

Repellent tests were conducted to evaluate the effectiveness of repellent formulas against mosquitoes. The test results are presented in a table that includes the number of mosquitoes that landed on the probandus, the repetition rate of the formula, and the repellent protection power by formula and time. The repetition rate of the formula indicates the consistency of the formula in providing protection. Protection power is measured by the duration of effective protection provided by each formula. This table helps determine which formula is most effective and stable in protecting against mosquito bites.

Tabel 6. Tingkat pengulangan rumus

No.	Concentration	Time						Mean	elementary school
		1 (15 Minutes)	2 (30 Minutes)	3 (60 Minutes)	4 (120 Minutes)	5 (240 Minutes)	6 (360 Minutes)		
1	FI	1	1	3.6	4.6	6.3	8	4.08	2.82
2	FII	8.6	9	13	14	13	15.3	12.15	2.73

Source:Data Processing

Tabel 7. Daya proteksi repelen berdasarkan formula dan waktu

Concentration	Time					
	15	30	60	120	240	360
FI	88.3 %	88.3%	72.3%	67.1%	51.5%	47.7%

Source: Data Processing

DISCUSSION

Based on The developed gel preparations exhibit excellent physical qualities, meeting various standards applicable to cosmetic and pharmaceutical products. The pH of the gel is within a safe range and matches the natural pH of the skin, reducing the risk of irritation and ensuring comfort during use (Basri, 2018). Optimal gel adhesion guarantees that the product stays in place after application, while effective spreadability ensures even distribution of the gel on the skin surface, thus providing consistent and thorough protection. The repellent activity test showed that the gel has significant potential as a mosquito repellent. The combination of cinnamon essential oil and lime peel in the gel is not only effective in repelling Aedes aegypti mosquitoes, but also offers the added advantage of unique organoleptic properties. Cinnamon essential oil provides a warm aroma and distinctive characteristics, while lime peel oil adds a refreshing citrus scent. The differences in scent and color between formulas reflect each ingredient's contribution to the sensory profile of the gel, which may influence user preference but not reduce its effectiveness (Ramadhania, 2020). Although the test results show that the gel is effective in its repellent function, it is important to conduct a more in-depth evaluation of the duration of protection it can provide as well as the potential for skin irritation in long-term use. Further research is needed to identify the effective duration of protection and to evaluate possible side effects that may arise from continued use. In addition, this study highlights the potential use of natural ingredients in repellent formulations as a safer and more sustainable alternative to synthetic chemicals (Paringga, 2019). It also emphasizes the need for continuous innovation and improvement in product formulation, to ensure that the gel is not only effective, but also safe and convenient for users in the long term. Going forward, further studies can develop better formulations, improve product stability, and explore combinations of other natural ingredients to create more efficient and environmentally friendly repellent solutions (Devitria, 2021).

Table 1, the organoleptic test results show clear differences in odor and color between formulas FI and FII, although both formulas have similar shapes. This difference can be explained by the use of different active substances in each formula. Formula FI contains a combination of cinnamon bark essential oil and kaffir lime leaf essential oil, which affect the organoleptic characteristics of the gel, including aroma and color. Cinnamon bark essential oil gives a warm and distinctive aroma, while kaffir lime leaf essential oil adds a fresh citrus aroma. The combination of these two essential oils significantly affected the appearance and odor of the gel. The warm aroma of cinnamon oil and the fresh aroma of kaffir lime oil interact to produce a distinctive and complex odor, and give the gel a different color. These differences show how variations in active substances can affect the organoleptic characteristics of the final product. Formula FI, with a blend of cinnamon and kaffir lime oils, offers a more diverse aroma profile and distinct color, while formula FII, which may contain a different combination of active substances, shows other organoleptic characteristics. This emphasizes the importance of

active substance selection in determining the final product properties, both in terms of aroma, color, and overall appeal.

In contrast, formula FII may use different active substances or variations in concentration, resulting in differences in odor and color compared to FI. Despite variations in odor and color, the gel form of both formulas remains consistent as they were designed and formulated using identical methods. The same gel formulation process ensures that the physical form of the final product, i.e. gel consistency and texture, remains uniform. Thus, the organoleptic differences observed between formulas FI and FII are more reflective of differences in the composition of the active substances, while the consistent shape of the gel indicates the success of the formulation method used for both formulas. The results showed FI and FII were macroscopically and microscopically homogeneous.

Formula FII likely uses different active substances or variations in concentration compared to formula FI, which causes differences in odor and color between the two. Despite the differences in odor and color appearance, the gel form in both formulas remained consistent as they were designed and formulated using similar methods. The same formulation method ensures that the physical form of the final product, including the consistency and texture of the gel, remains uniform. Therefore, the organoleptic differences seen between formulas FI and FII are more due to variations in the composition of the active substances, while the uniformity of the gel shape indicates the effectiveness of the formulation method applied. The homogeneity test was conducted to ensure that the gel preparation was evenly mixed, both at the macroscopic and microscopic levels. The results showed that both formulas FI and FII had good homogeneity. This indicates that both gel formulas were evenly mixed without any separation or imbalance of active ingredients. The success of this homogeneity test ensures that the consistency and quality of the gel remains optimal, making it effective and ready for use.

The gel spreadability test aims to assess the extent to which the gel can spread evenly when applied to the skin. Ideal spreadability standards range from 5 to 7 cm, as outlined by Garg et al. (2002). Spreadability that is too small can make it difficult for the gel to spread well, making application less effective. Conversely, if the spreadability is too large, the gel will spread too quickly when applied, which can cause discomfort to the user. The results showed that formula FI had a spreadability of 6 cm, while formula FII showed a spreadability of 5.4 cm. Both of these results are within the recommended range, so both formula FI and FII meet the set standards. In other words, both gel formulas have good spreadability, ensuring that the gel can be applied evenly and comfortably on the skin without any problems in product distribution.

Based on the results of the study, the pH of the FI and FII preparations were each recorded at 7, which is in line with the normal pH of human skin, which ranges from 4.5 to 7.0 as described by Lukman et al. (2013). Ideally, the pH of a topical preparation should be close to the pH of the skin to ensure that the product does not cause irritation or discomfort to the user's skin. If the pH of the preparation is too acidic, it can cause irritation, redness, and stinging sensation on the skin, which can interfere with the comfort of use. Conversely, preparations with a pH that is too alkaline can cause the skin to become dry, itchy, and uncomfortable, as stated by Simon (2012). Thus, ensuring that the pH of the preparation is within the range that matches the pH of the skin is key to avoiding unwanted side effects. The pH test results showing a value of 7 in both formulas, FI and

FII, indicate that these preparations have an optimal pH and are suitable for topical application. This indicates that both gel formulas are well designed, adhere to safe pH standards, and do not have the potential to cause skin irritation or problems. Success in maintaining the right pH not only improves user comfort, but also ensures that the gel preparations can be used safely and effectively in skin care.

Based on the results of the repellent test, the study showed that the average number of mosquitoes that landed on the probandus' hands reached the highest number after 360 minutes, with an average of 8 mosquitoes (SD=2.82). Statistical test results showed a significant effect of contact duration on the number of mosquitoes that landed, with a p-value of less than 0.05. This indicates that the longer the contact time between the repellent gel and the proband's skin, the more mosquitoes stayed. This study highlights that while repellent gels are initially effective in deterring mosquitoes, their effectiveness tends to decrease over time. Over longer contact periods, the decrease in protection may be due to a decrease in the concentration of active ingredients on the skin surface or a decrease in the adhesion of the gel. Thus, although the gel provides reasonably good protection upon initial application, users may need to reapply periodically to maintain its effectiveness. This study shows the importance of considering application time in the use of repellent gels. To ensure optimal protection, users should pay attention to the timing of application and reapply if necessary. Further research could focus on determining appropriate application intervals and developing formulas that can maintain effectiveness for longer, as well as exploring formulation strategies to improve product resistance to effectiveness reduction over time.

Kaffir lime peel showed potential as a mosquito repellent. However, this gel has not met the standards set by the Indonesian Pesticide Commission (KPI) and WHOPES 2000. KPI stipulates that repellants should be able to provide up to 90% protection for six hours, while WHOPES 2000 requires that repellants should provide more than 95% protection for at least 30 minutes. The findings of this study show that the gel did not achieve the expected level of protection according to these standards. This decrease in gel effectiveness is consistent with the results of a study by Utomo and Supriyatna (2014), which identified that the evaporation of active ingredients, such as linalool from the skin, contributed to the decrease in protective power. Factors such as body temperature and ambient temperature can accelerate the evaporation of active ingredients, thereby reducing the effectiveness of the gel as a repellant. In addition, a non-optimal formulation process can affect product homogeneity, which is an important aspect in ensuring even distribution of active ingredients. Problems in the homogeneity of the gel manufacturing process can also lead to decreased effectiveness. Unevenness in the distribution of active ingredients can reduce the repellency of the gel, as described by Fadilah et al. (2017). If the formulation is not homogeneous, some areas may have lower concentrations of active ingredients, which impacts the overall effectiveness of the product. To improve the performance of the gel as a repellant, further research is needed to refine the formulation and manufacturing methods. This research needs to focus on developing formulation techniques that can reduce evaporation of active ingredients and improve product homogeneity. In addition, exploration of alternative active ingredients or the addition of stabilizing agents may be necessary to meet established protection standards. With these improvements, it is expected that the gel can provide more effective protection and meet the criteria expected by regulatory agencies.

CONCLUCION

The results showed that the gel containing cinnamon bark oil (Cinnamomum burmanii) had good quality in terms of organoleptic, pH, and physical stability. The gel proved effective as a mosquito repellent for six hours against Aedes aegypti mosquitoes, with formula II containing 15% cinnamon bark oil showing the best performance. Nonetheless, all variants of the gel caused skin irritation, which is an important concern regarding user safety. The results of the favorability test showed that the gel was less accepted by the panelists due to its unpleasant aroma and appearance. Unattractive aroma and unsatisfactory appearance may reduce the attractiveness of the product in the market. In addition, the study showed that the concentration of cinnamon extract required to effectively kill Aedes aegypti larvae was 0.20%. Increasing the concentration of the extract will increase larval mortality, with an LC50 value, i.e. the concentration that kills 50% of the larvae, identified at 0.10%, and an LC90 value requiring a higher concentration to achieve 90% mortality of the larvae. The gel containing essential oils from cinnamon bark and kaffir lime peel (Citrus hystrix) had excellent physical qualities, including homogeneity, spreadability, adhesiveness, and safe pH. The gel also showed effectiveness as a repellent against Aedes aegypti mosquitoes, thanks to the combination of active compounds from both ingredients. The satisfactory physical qualities and repellent effectiveness make this gel a safe and efficient alternative for protection against mosquitoes. There were some drawbacks in terms of user acceptance, with improvements in organoleptic aspects, this product has great potential as a protection solution against mosquito bites.

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