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PHYSICAL QUALITY EVALUATION OF EMULGEL FORMULATION CONTAINING LAVENDER (LAVANDULA ANGUSTIFOLIA) ESSENTIAL OIL WITH VARIATIONS IN CARBOPOL 940 CONCENTRATION

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Abstract

Background: Malaria remains a significant public health problem in Indonesia, particularly in Papua. Lavender essential oil (Lavandula angustifolia) is a natural alternative repellent, but its high volatility and irritant potential limit direct application. To overcome these limitations, a stable and effective emulgel formulation was developed. Carbopol 940 was chosen as the gelling agent due to its high viscosity and compatibility, with concentration expected to strongly influence physical properties. **Objective:** This study aimed to evaluate the effect of Carbopol 940 concentration on the physical quality of lavender essential oil emulgel formulations. **Methods:** An experimental design was conducted with three formulas: F1 (1% Carbopol 940), F2 (1.5%), and F3 (2%). Data were analyzed using one-way ANOVA. **Results:** All formulations exhibited white color, characteristic lavender aroma, and uniform emulgel consistency. Homogeneity was observed across all samples. The pH was 5.0 for F1 and F2, and 6.0 for F3. Spreadability decreased as Carbopol concentration increased (5.84 cm for F1, 4.93 cm for F2, 3.97 cm for F3). Adhesion showed the opposite trend (5.68 s, 10.49 s, and 13.27 s, respectively). Viscosity also increased with higher concentrations (4,920 cP, 13,060 cP, and 24,380 cP). All formulas remained stable with no phase separation during thermodynamic stability testing. **Conclusion:** Variations in Carbopol 940 concentration significantly influenced emulgel physical properties.

Keywords: Carbopol 940; Emulgel; Lavender essential oil; Physical quality evaluation

1. INTRODUCTION

Malaria continues to pose a significant health challenge in Indonesia, especially in eastern areas like Papua, Papua Barat, Maluku, and East Nusa Tenggara. Caused by Plasmodium parasites spread through Anopheles mosquito bites, malaria cases surged by 36.29% from 2021 to 2022, reaching 415,140 cases [8]. While synthetic insecticides and larvicides are commonly used for mosquito control, their long-term use raises concerns about health risks, such as cancer, and environmental damage due to low biodegradability [6], [17], [18].

To address these issues, natural essential oils from plants like citronella, geranium, eucalyptus, cinnamon, rosemary, basil, and lavender are being explored as mosquito repellents. Lavender (Lavandula angustifolia) essential oil, rich in linalool and linalyl acetate, is valued for its mosquito-repelling, calming, and stress-relieving effects [10], [14]. However, its volatility leads to quick evaporation and potential skin irritation, necessitating stable formulations for prolonged efficacy and safety [9].

Emulgel, a hybrid of emulsion and gel, is an effective delivery system for hydrophobic substances, offering easy application, non-sticky texture, washability, and enhanced stability [5], [11]. Carbopol 940, a preferred gelling agent, is favored for its fine particles, high viscosity, compatibility, and desirable sensory properties [3], [22]. Prior research has validated lavender oil's repellent efficacy and the suitability of emulgel for essential oil delivery [1], [3], [7].

This study evaluates the physical properties of lavender essential oil emulgel formulated with varying Carbopol 940 concentrations to optimize its performance.

2. METHODOLOGY

This study employed an experimental laboratory design to evaluate the physical quality of lavender (*Lavandula angustifolia*) essential oil emulgel with different concentrations of Carbopol 940 as a gelling agent. The research was conducted at the Pharmaceutical Formulation Technology Laboratory, Poltekkes Kemenkes Jayapura, during April–May 2025. The main research object was lavender essential oil obtained from an e-commerce supplier and verified by a Certificate of Authenticity (CoA).

Tabel 1. Formulation Design of Lavender Essential Oil Emulgel with Variations in Carbopol 940 Concentration

Ingredients	Function	Formula		
		I	II	III
Lavender flower essential oil (% v/b)	Active ingredient	25%	25%	25%
Tween 80 (%)	Surfactant	2,7%	2,7%	2,7%
Span 80 (%)	Surfactant	2,3%	2,3%	2,3%
Carbopol (%)	Thickener	1%	1,5%	2%
Trietanolamin (g)	Alkalizing agent	qs	qs	qs
Propilen glikol(g)	Moisturizer	1,3	1,3	1,3
Aquadest ad (g)	Solvent	50	50	50

Working Procedure

The emulgel was prepared by first mixing lavender essential oil with Tween 80 and Span 80 to form a uniform oil phase. Separately, Carbopol 940 was dissolved in hot distilled water and left for 24 hours to form a gel, after which Triethanolamine was added to adjust the pH to 4.5–7.5, followed by the addition of propylene glycol. The oil phase was then slowly incorporated into the aqueous phase under continuous high-speed stirring using a homogenizer until a homogeneous emulgel was obtained.

Physical Quality Tests of Emulgel

The quality of the lavender essential oil emulgel (*Lavandula angustifolia*) was evaluated through several tests. The **organoleptic test** assessed its color, form, and odor [19], while the **homogeneity test** confirmed uniform mixing without lumps (Nafisa et al., 2021). The **pH test** ensured skin compatibility within the 4.5–8 range [19]. The **spreadability** and **adhesion tests** measured ease of application and retention on the skin, with ideal values of 5–7 cm and over 4 seconds, respectively [19]. The **viscosity test**, using a Brookfield viscometer, confirmed acceptable thickness between 6,000–50,000 cPs [2]. Lastly, **thermodynamic stability tests**—centrifugation, freeze–thaw, and cycling—verified the formulations' physical stability.

3. RESULTS

The study results showed the physical quality test of lavender essential oil emulgel (*Lavandula angustifolia*) using three gelling agent formulas: FI (Carbopol 1%), FII (Carbopol 1.5%), and FIII (Carbopol 2%).

3.1 Organoleptic Test

The results of the organoleptic test of lavender (Lavandula angustifolia) essential oil emulgel formulations with various base combinations are shown in the table below.

Table 2. Results of Organoleptic Test

Formula	Color	Aroma	Form	Description
I	White	Characteristic lavender oil aroma	Emulgel	Meets the requirements
II	White	Characteristic lavender oil aroma	Emulgel	Meets the requirements
III	White	Characteristic lavender oil aroma	Emulgel	Meets the requirements

3.2 Homogenity Test

The results of the homogeneity evaluation of lavender (Lavandula angustifolia) essential oil emulgel formulations prepared with carbopol base combinations are presented in the table below.

Table 3. Results of Homogeneity Test

Formula	Homogenity	Remarks
I	Homogeneous with uniform color and no visible particles in the preparation	Meets the requirements
II	Homogeneous with uniform color and no visible particles in the preparation	Meets the requirements
III	Homogeneous with uniform color and no visible particles in the preparation	Meets the requirements

3.3 pH Test

The results of the pH evaluation of lavender (Lavandula angustifolia) essential oil emulgel formulations prepared with carbopol base combinations are presented in Table 4.

Table 4. Results of pH Test

Formula	pH	Remarks
I	5	Meets the requirements
II	5	Meets the requirements
III	6	Meets the requirements

3.4 Spreadability Test

The spreadability test of emulgel preparations containing lavender (Lavandula angustifolia) essential oil with a combination of carbopol bases can be seen in the table below.

Table 5. Results of Spreadability Test

Formula	Spreadability (cm)			Average	Remarks	Sig.
	R1	R2	R3			
I	5,83	5,87	5,82	5,84 ± 0,02	**Meets the requirements**	0,015
II	4,89	5,05	4,85	4,93 ± 0,10	**Does not meet the requirements**	
III	4,06	3,90	3,97	3,97 ± 0,08	**Does not meet the requirements**	

3.5 Adhesion Test

The adhesion test of the lavender essential oil (Lavandula angustifolia) emulgel preparation using a combination of carbopol can be seen in the table below.

Table 6. Results of Adhesion Test

Formula	Adhesion Test (detik)			Average	Description	Sig.
	R1	R2	R3			
I	5,42	5,90	5,73	5,68 ± 0,24	Meets Requirements	0,037
II	10,59	10,92	9,97	10,49 ± 0,48	Meets Requirements	
III	13,61	12,97	13,25	13,27 ± 0,32	Meets Requirements	

3.6 Viscosity Test

The viscosity test results for the lavender essential oil emulgel preparation using a combination of bases are presented in the table below:

Table 7. Results of Viscocity Test

Formula	Viscocity Test (cP)			Average	Description	Sig.
	R1	R2	R3			
I	4,933	4,900	4,933	4,920 ± 0,02	Does Not Meet Requirements	0,007
II	13,07	13,23	12,87	13,06 ± 0,20	Meets Requirements	
III	24,37	24,30	24,47	24,38 ± 0,05	Meets Requirements	

3.7 Thermodynamics Test

The thermodynamics test results for the lavender essential oil emulgel preparation using a combination of bases are presented in the table below:

Table 8. Results of Centrifugation Test

Formula	Centrifugation	Description
I	No separation and stable	Meets requirements
II	No separation and stable	Meets requirements
III	No separation and stable	Meets requirements

Table 9. Results of Freeze Thaw Test

Formula	Freeze-Thaw	Description
I	No separation and stable	Meets requirements
II	No separation and stable	Meets requirements
III	No separation and stable	Meets requirements

Table 10. Results of Cycling Test

Formula	Cycling Test	Description
I	No separation and stable	Meets requirements
II	No separation and stable	Meets requirements
III	No separation and stable	Meets requirements

4. DISCUSSION

Lavender essential oil, produced through steam distillation or solvent extraction from fresh lavender flowers (Lavandula angustifolia), is known to have properties that repel mosquitoes and provide a relaxing effect for users. According to research by [14], the compounds in lavender oil are highly beneficial, including providing relaxation, reducing stress, and acting as a mosquito repellent. Lavender, a member of the Lamiaceae family, is an aromatic shrub [20].

Organoleptic testing was conducted directly to assess the color, aroma, and form of the preparation using the five senses. This organoleptic test is crucial as it determines the quality of the emulgel preparation visually and evaluates the physical characteristics of the emulgel, including its color, aroma, and form. Based on the data in Table 2, the organoleptic test results for FI, FII, and FIII show a white color, a distinctive lavender essential oil aroma, and an emulgel form.

Homogeneity testing for FI, FII, and FIII was performed using two methods: macroscopic visual observation with the naked eye and microscopic examination using a microscope. Macroscopically, no coarse particles or granules were observed, the color of the preparation appeared uniform, and there were no signs of phase separation. Microscopically, the results showed a homogeneous dispersion of essential oil within the gel base, with relatively uniform particle sizes and a consistent gel structure. This indicates that the active ingredient (essential oil) and excipients are evenly mixed, ensuring consistent therapeutic effects with each use. A homogeneous preparation confirms that the active substance is uniformly distributed. The test also assessed the presence of clumps and whether the emulsion separated into oil and water phases [19].

The pH test was conducted to determine the acidity level of each emulgel formulation containing lavender essential oil (*Lavandula angustifolia*). The ideal pH range for topical preparations is typically between 4.5 and 7.5, as it aligns with the slightly acidic physiological pH of human skin. A formulation with too low a pH may cause irritation, while one that is too high can disrupt the skin's barrier and lead to dryness or scaling [12]. As shown in Table 9, the pH values of formulations FI and FII were both 5, and FIII had a pH of 6. These results indicate that all three formulations fall within the acceptable range for topical products, remaining safe and compatible with normal skin pH.

The spreadability test was conducted to evaluate the ability of the emulgel to spread evenly across the skin surface. A formulation that spreads more easily allows wider distribution of the active ingredient, resulting in a more effective topical action [13]. The spread diameters were 5.82 cm for FI, 4.93 cm for FII, and 3.97 cm for FIII, indicating that the concentration of Carbopol influenced spreadability. Statistical analysis using One-Way ANOVA ($p<0.05$) showed a significant difference among the formulations, confirming that variations in Carbopol concentration had a notable effect on spreadability. This relationship is inversely proportional to viscosity—formulations with higher viscosity exhibit lower spreadability, while those with lower viscosity spread more easily due to their more fluid nature [15], [21]. The decrease in spreadability across formulations corresponds to increased viscosity caused by higher Carbopol concentrations.

The adhesion test was conducted to determine how long the emulgel could adhere to the skin surface. A good topical formulation should have an adhesion time of more than 4 seconds [19]. The results showed that all formulations met this requirement, with adhesion times of 6.68 seconds for FI, 9.16 seconds for FII, and 11.17 seconds for FIII. Statistical analysis using One-Way ANOVA ($p<0.05$) indicated a significant difference among the formulations, meaning that variations in Carbopol concentration had a considerable effect on adhesion. Adhesion is inversely related to spreadability; higher adhesion corresponds to lower spreadability. The increase in adhesion time across formulations was influenced by higher viscosity due to increased Carbopol concentration, which allowed the emulgel to stay longer on the skin surface. This prolonged contact enhances the absorption of the active ingredients, making the formulation more effective [15].

The viscosity test aimed to measure the thickness of the emulgel formulations. The results showed viscosity values of 4.920 cP for FI, 13.06 cP for FII, and 24.38 cP for FIII. Among these, FI did not meet the required standard range for emulgels, which is 6,000–50,000 cPs (SNI 16-4399-1996). Statistical analysis using One-Way ANOVA ($p<0.05$) indicated significant differences among the formulations, confirming that variations in Carbopol concentration had a notable effect on viscosity. The findings demonstrated that higher Carbopol concentrations increased viscosity, as greater amounts of the gelling agent strengthened the gel matrix. Viscosity is an essential parameter in emulgel testing because it influences spreadability—formulations with higher viscosity tend to have lower spreadability, and vice versa. Both Carbopol and TEA in the formulation contribute to viscosity enhancement [13].

The stability test aimed to evaluate the physical stability of the lavender essential oil emulgel under high-speed centrifugation and varying storage conditions at room temperature. The centrifugation test results (Table 8) showed no phase separation in formulations FI–FIII after spinning at 5000 rpm for 30 minutes. Similarly, in the freeze–thaw test, where samples were stored for 48 hours at 4°C and then at 25°C, no visible changes were observed. The cycling test results (Tables 9 and 10) also indicated that all formulations remained stable after six storage cycles, showing no phase separation or changes in appearance. These findings suggest that the lavender emulgel formulations are physically stable and can be expected to remain stable for at least one year [3]. The absence of creaming or phase separation during centrifugation, freeze–thaw, and cycling tests indicates good stability against gravitational and temperature variations [16]. Overall, all formulations demonstrated good physical stability with no significant differences before and after testing.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The lavender essential oil (*Lavandula angustifolia*) emulgel formulations with varying Carbopol 940 concentrations (FI–FIII) met the quality standards for topical preparations. All were white, homogeneous, and had the characteristic lavender scent. The pH values (5–6) were within the acceptable range for skin compatibility. Increasing Carbopol concentration resulted in higher viscosity and adhesion but lower spreadability. Stability tests (centrifugation, cycling, and freeze–thaw) showed no phase separation, indicating good physical stability. In conclusion, all formulations were stable and suitable for topical use, with higher Carbopol levels providing better adhesion and stability, while lower levels improved spreadability.

5.1 Recommendations

Further research is recommended to optimize the emulgel formulation of lavender essential oil (*Lavandula angustifolia*) using various concentrations of Carbopol 940, focusing on improving physical properties (such as spreadability and viscosity) and evaluating the irritation or sensitivity potential of the formulation.

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