

Formulation and Evaluation of Lemongrass Scented Gel with a Combination of Carrageenan, Xanthan Gum, and HPMC Bases

Formulasi dan Evaluasi Gel Pengharum Serai Wangi dengan Kombinasi Basis Karagenan, Xanthan Gum, dan HPMC

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Abstract

Background: Unpleasant odors in bathroom areas are a common hygiene problem that requires practical and environmentally friendly solutions. Citronella oil (*Cymbopogon nardus* L. Randle) is known to contain active compounds with a distinctive aroma that has potential as a natural fragrance agent. However, an appropriate gel base is needed to maintain the stability and aroma retention of the preparation. **Objective:** This study aims to formulate and evaluate a bathroom fragrance gel from citronella oil with a combination of carrageenan, xanthan gum, and hydroxypropyl methylcellulose (HPMC) bases and to determine the concentration of citronella oil that produces the preparation with the best physical stability and aroma retention. **Methods:** This research was an experimental laboratory study. Citronella oil was formulated into gel preparations with four concentration variations (2.5%; 5%; 7.5%; and 10%) using a combination of carrageenan, xanthan gum, and HPMC bases. Evaluation of the preparations included organoleptic test, syneresis, liquid evaporation, preference test (hedonic), and aroma retention test for 15 days of storage. Data were analyzed statistically with a 95% confidence level. **Results:** The results showed that all formulas produced gels with good organoleptic characteristics (cloudy white color, characteristic citronella aroma, and semi-solid texture). The formula with 10% citronella oil concentration (F4) showed the best results with the lowest syneresis value (0.62%), the lowest liquid evaporation percentage (21.69%), and the highest remaining gel weight (92.03%). The preference test showed that F4 had the highest average value (4.25) in the like category, and the best aroma retention with a score range of 4.19-4.70 until day 15. **Conclusion:** The combination of carrageenan, xanthan gum, and HPMC bases can produce physically stable bathroom fragrance gel preparations. The formula with 10% citronella oil concentration (F4) is the best formulation and has the most potential to be developed as a natural bathroom fragrance product.

Keywords: Citronella Oil; Fragrance Gel; Carrageenan; Xanthan Gum; Hidroksipropil Metilselulosa

Abstrak

Latar Belakang: Bau tidak sedap pada area kamar mandi merupakan masalah kebersihan yang sering ditemui dan membutuhkan solusi praktis serta ramah lingkungan. Minyak serai wangi (*Cymbopogon nardus* L. Randle) diketahui mengandung senyawa aktif dengan aroma khas yang berpotensi sebagai bahan pengharum alami. Namun, diperlukan basis gel yang tepat untuk mempertahankan stabilitas dan ketahanan aroma sediaan. **Tujuan:** Penelitian ini bertujuan untuk memformulasi dan mengevaluasi sediaan gel pengharum kamar mandi dari minyak serai wangi dengan kombinasi basis karagenan, xanthan gum, dan hidroksipropil metilselulosa (HPMC) serta menentukan konsentrasi minyak serai wangi yang menghasilkan sediaan dengan stabilitas fisik dan ketahanan aroma terbaik. **Metode:** Penelitian ini merupakan penelitian eksperimental laboratorium. Minyak serai wangi diformulasikan ke dalam sediaan gel dengan empat variasi konsentrasi (2,5%; 5%; 7,5%; dan 10%) menggunakan kombinasi basis karagenan, xanthan gum, dan HPMC. Evaluasi sediaan meliputi uji organoleptis, sineresis, penguapan zat cair, uji kesukaan (hedonik), dan uji ketahanan

aroma selama 15 hari penyimpanan. Data dianalisis secara statistik dengan tingkat kepercayaan 95%. **Hasil:** Hasil penelitian menunjukkan bahwa seluruh formula menghasilkan gel dengan karakteristik organoleptis yang baik (warna putih keruh, aroma khas serai wangi, dan tekstur semi padat). Formula dengan konsentrasi minyak serai wangi 10% (F4) menunjukkan hasil terbaik dengan nilai sineresis terendah (0,62%), persentase penguapan zat cair paling rendah (21,69%), dan bobot sisa gel tertinggi (92,03%). Uji kesukaan menunjukkan F4 memiliki nilai rata-rata tertinggi (4,25) dalam kategori suka, serta ketahanan aroma terbaik dengan rentang skor 4,19-4,70 hingga hari ke-15. **Kesimpulan:** Kombinasi basis karagenan, xanthan gum, dan HPMC dapat menghasilkan sediaan gel pengharum kamar mandi yang stabil secara fisik. Formula dengan konsentrasi minyak serai wangi 10% (F4) merupakan formulasi terbaik dan paling potensial untuk dikembangkan sebagai produk pengharum kamar mandi berbahan alami.

Kata Kunci: Minyak Serai Wangi, Gel Pengharum, Karagenan, Xanthan Gum, HPMC.



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Article History:

Received: 07/12/2025,
Revised: 23/02/2026,
Accepted: 24/02/2026,
Available Online: 24/02/2026.

QR access this Article



<https://doi.org/10.36490/journal-jps.com.v9i1.1459>

Introduction

Lemongrass is a plant that grows abundantly in tropical regions, including Indonesia. This plant is known as one of the producers of essential oils that have high economic value and health benefits. The main components of lemongrass essential oil are citronellal, citronellol, and geraniol, which provide a distinctive aroma as well as antibacterial, antifungal, and natural insecticidal properties. The aroma produced by this essential oil has the potential to be used as an ingredient in aromatherapy or as a room fragrance [1]. Air fresheners are prepared products used to provide a pleasant fragrance or neutralize unpleasant odors in a room [2]. Air fresheners have become an essential need for maintaining fresh air in various places, from living rooms to workspaces. However, their use is increasingly prioritized in bathroom areas, which are prone to unpleasant odors due to daily biological activities. With a refreshing scent, air fresheners not only serve to mask odors but also create a clean, comfortable, and more hygienic atmosphere around the bathroom [3].

Fragrance materials are divided into two types, namely synthetic and natural. Synthetic fragrances produce a stronger odor and can cause discomfort, such as dizziness. Meanwhile, natural fragrances, such as essential oils from plants, have a milder aroma and are more pleasant to inhale [3]. However, air fresheners made from natural materials like essential oils cannot last long when used at high temperatures or left in open spaces for too long. To make the scent last longer, a binding agent needs to be added [4]. Gel is a semi-solid preparation consisting of a suspension penetrated by a liquid, composed of small inorganic particles or large organic molecules [5]. Gel can be made using either natural or synthetic base materials. Natural polymers that can be used include gelatin, pectin, sodium alginate, gelatin, carrageenan, and xanthan gum. Meanwhile, synthetic polymers include methylcellulose (MC), hydroxyethyl cellulose (HEC), hydroxypropyl methylcellulose (HPMC), sodium carboxymethyl cellulose (Na.CMC), and polyvinyl alcohol [6].

In the study by Rahman et al., 2022, a formulation combining carrageenan and xanthan gum as a gel base with a ratio of 90:10 produced a room freshener gel that was chewy, firm, not easily broken, and had the lowest syneresis. Based on this description, further research is needed to design and evaluate a bathroom air freshener gel formulation made from lemongrass oil with a combination gel base. This formulation is designed by combining three gel-forming agents, namely carrageenan, xanthan gum, and HPMC. In this study, lemongrass oil functions as the main fragrance and is formulated at various concentrations, namely F1, F2, F3, and F4.

Experimental Section

Materials and Apparatus

The materials used were citronella oil obtained from PT. TAROMANESIA, carrageenan, xanthan gum, HPMC, propylene glycol, glycerin, sodium benzoate, citric acid, and distilled water. Instrumentation consisted of a containers for scented gel, ovens, measuring cup (pyrex), beaker (pyrex), analytical balance, stirring rod, dropper, stirrers, and magnetic stirrers. All glassware used was sterilized prior to experimentation.

Research Procedure

This study is an experimental research that uses citronella oil (*Cymbopogon nardus* L.) as the active ingredient, combined with carrageenan, xanthan gum, and HPMC as the gel base, and formulated into gel preparations with four concentration variations (2.5%, 5%, 7.5%, and 10%). The research process consists of several stages, namely:

Identification of Material

The identification and quality of materials are carried out by comparing the inspection/test results with the certificate of analysis of citronella essential oil and the national quality standards (SNI)

Formula Selection

The selection of the air freshener gel formulation was taken from research [4] and the formula was modified. The formulation was modified into a bathroom air freshener gel by adding HPMC and varying the concentration of citronella oil.

Table 1. Formulation of Bathroom Air Freshener Gel Using Citronella Oil

Ingredients	Deodorizing Gel Formulation			
	F1	F2	F3	F4
Citronella oil	2,5	5	7,5	10
Carrageenan (g)	0,25	0,25	0,25	0,25
Xanthan gum (g)	1	1	1	1
HPMC (g)	1,5	1,5	1,5	1,5
Natrium Benzoat (g)	0,2	0,2	0,2	0,2
Propylene Glycol (ml)	2,5	2,5	2,5	2,5
Glycerin (ml)	5	5	5	5
Citric Acid (g)	0,1	0,1	0,1	0,1
Aquadest ad	100 ml	100 ml	100 ml	100

Making the Fragrant Gel

The gel making process is carried out by following the procedure for making a gel base with some modifications, namely the addition of ingredients such as HPMC and variations in lemongrass oil concentration as a fragrance component. The first step is to prepare all the necessary equipment and materials according to the formulation table. The ingredients are weighed according to the specified measurements. Distilled water is heated by pouring it into a beaker and placing it on a hot plate. Heating is done until the temperature reaches 75°C, followed by the gradual addition of thickening agents, namely carrageenan, xanthan gum, and sodium benzoate, and citric acid, while stirring until homogeneous using a magnetic stirrer. Once all the ingredients are mixed, the beaker is removed from the stirrer, and then HPMC is dissolved in the previously heated distilled water in a separate beaker, after which it is added and quickly stirred using a stirring rod until the temperature drops to 65°C. Next, propylene glycol, glycerin, and lemongrass oil are added, then the solution is stirred until homogeneous. Finally, the solution is poured into molds and left at room temperature until it forms a gel [4].

Organoleptic Test

The org noleptic test conducted includes the shape, color, and smell of the gel assessed visually. The expected gel texture is elastic, chewy, and not watery [7].

Syneresis Test

The gel that has formed in the gel mold container is weighed to determine its initial weight (M_0) and then transferred to containers marked for each formulation. The samples are stored for 24 hours in an oven at a temperature of 25°C in an open state. After 24 hours, the samples are transferred to containers corresponding to the sample codes and weighed to determine their final weight (M_i). Before weighing, the sample is first dried from the liquid on the surface of the gel using tissue so that the liquid released from the gel is not included in the weight [8]. The data calculated is the percentage of syneresis, determined with the following calculation:

$$\text{Syneresis (\%)} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100 \quad (1)$$

Liquid Evaporation Test

The liquid evaporation test can be carried out by weighing the gel every 3 days for up to 15 days. From the results of this test, the decrease in gel weight every 3 days and the gel weight loss after 15 days of storage can be obtained. The difference in weight represents the amount of liquid that has evaporated [9].

$$\% \text{ Total Evaporation of Liquid} = \frac{\text{initial gel weight} - \text{gel weight on day 15}}{\text{initial gel weight}} \times 100 \quad (2)$$

Percentage of remaining gel weight:

$$\% \text{ remaining gel weight} = \frac{\text{initial gel weight}}{\text{gel weight on day 15}} \times 100 \quad (3)$$

Preference Test

In the preference test, 20 panelists were used. The panelists were already familiar with the sensory properties of the preparation to be evaluated and met the requirements to become panelists. They were asked to express their personal impressions regarding the level of liking for the deodorant gel preparation using a 5-point aroma effect scale, which includes 1 (dislike very much), 2 (dislike), 3 (neutral), 4 (like), and 5 (like very much) [10]. The data obtained from the questionnaires were tabulated and the preference values for each preparation were determined by calculating the mean results for each panelist at a 95% confidence level [11].

Fragrance Retention Test

The fragrance retention test can be carried out on the 3rd, 6th, 9th, 12th, and 15th days using 20 panelists [9]. During the testing process, the sample is placed at a 45° angle to the sense of smell, at a distance of 15–20 cm, and the aroma is directed to the nose with the help of hand movements. Testing was carried out by comparing the scent strength of the test gel using a scale from 5 to 1, where 5 (very fragrant), 4 (fragrant), 3 (slightly fragrant), 2 (not fragrant), and 1 (very not fragrant). The data obtained from the questionnaire were tabulated and the values for each preparation were determined by finding the average result for each panelist at a 95% confidence level [12].

Data Analysis

The results of the preference test and fragrance durability test were obtained using statistical formulas. Data collected from the questionnaires were tabulated, and the preference values and fragrance durability for each preparation were determined by calculating the mean for each panelist at a 95% confidence level. The formula used to calculate the mean quality value interval for each panelist is as follows:

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n} \quad (4)$$

$$S^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n} \quad (5)$$

$$s = \sqrt{S^2} \quad (6)$$

$$p \left(\bar{x} - \left(1,96 \cdot \frac{s}{\sqrt{n}}\right) \leq \mu \leq \left(\bar{x} + \left(1,96 \cdot \frac{s}{\sqrt{n}}\right)\right) \right) \cong 95\% \quad (7)$$

Information :

- n : many panelists
- S^2 : uniformity of preference values
- 1,96 : Standard deviation coefficient at 95% level
- X : average preference value X
- X_i : value from panelist i, where $i = 1, 2, 3, \dots, n$

S : standard deviation of preference values
 P : confidence level
 μ : range of values

Results and Discussion

Organoleptic Test

Table 2. Results of Organoleptic Test

Organoleptic Test			
Formula	Color	Aroma	Texture
F1	Cloudy white	Characteristic lemongrass scent	Semi solid gel
F2	Cloudy white	Characteristic lemongrass scent	Semi solid gel
F3	Cloudy white	Characteristic lemongrass scent	Semi solid gel
F4	Cloudy white	Characteristic lemongrass scent	Semi solid gel

The results obtained from the organoleptic testing of gels made from lemongrass oil with a base of carrageenan gel, xanthan gum, and HPMC in each formula showed consistent visual characteristics, with no changes in appearance, color, or texture. However, there were changes in the gel form, which shrank, and changes in aroma during 15 days of storage.

Gel Syneresis Test

Table 3. Syneresis Test Results

Formula	Initial Weight	Final Weight (24 Hours)	%Syneresis
F1	60,05	59,26	1,32
F2	63,25	62,61	1,01
F3	66,58	65,8	1,17
F4	69,05	68,62	0,62

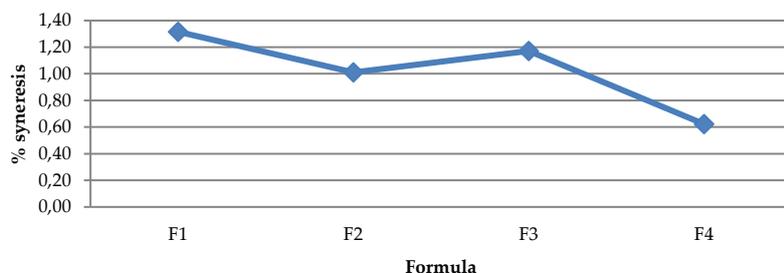


Figure 1. Graph of Gel Syneresis Test Percentage Results

Based on the results obtained from the syneresis test, formulas F1, F2, and F3 showed syneresis values above 1%, indicating that these formulations are quite stable. Meanwhile, F4, which has a higher lemongrass oil content, showed a value below 1%, indicating low syneresis. The standard for a good gel syneresis value is below 1% [9]. This indicates that the concentration of essential oil in a formulation affects the stability of the gel produced. The use of an appropriate concentration of lemongrass oil in gel preparations is important not only in providing a pleasant aroma but also in ensuring the stability and effectiveness of the gel as a fragrance gel product [13].

Evaporation Test of Liquid Substance

Based on the data in tables 4 and tables 5, the results obtained from the liquid substance evaporation test, there was a reduction in the remaining gel weight that varied. The highest remaining gel weight value was found in the 10% lemongrass oil formula, which was 92.03, with a liquid substance evaporation amount of 21.69%. The 2.5% lemongrass oil formula showed the lowest remaining gel weight value, which was 75.22,

with a liquid substance evaporation amount of 24.78%. The decrease in gel weight can be observed through the evaporation process, where the volatile substances in the gel decrease over time during storage. The product's aroma durability highly depends on the remaining gel weight as well as the rate of liquid substance evaporation from the gel [14].

Table 4. Remaining Gel Weight Results (%)

Formula	Initial Weight (g)	Residual Gel Weight (%)				
		Day-3	Day-6	Day-9	Day-12	Day-15
F1	60,05	96,72	92,56	89,01	82,01	75,22
F2	63,25	95,10	89,49	86,64	84,33	79,88
F3	66,58	97,28	93,66	90,78	94,12	86,41
F4	69,05	97,77	93,74	91,30	97,30	92,03

Table 5. Results of Liquid Substance Evaporation Percentage (%)

Formula	Initial Weight (g)	Percentage of Remaining Gel Weight (%)	
		Weight on Day 15	Evaporation (%)
F1	60,05	45,17	24,78
F2	63,25	47,97	24,16
F3	66,58	51,89	22,06
F4	69,05	54,07	21,69

Preference Test

Table 6. Results of the Preference Test (Hedonic Test)

Formula	Average Level of Preference
F1	3,1
F2	3,3
F3	3,5
F4	4,25

Based on the results obtained from the preference testing by 20 panelists who provided ratings using a 5-1 scale with a 95% confidence analysis method, it shows that the average value obtained by formulation F4 is the highest, which is 4.25. Therefore, it can be concluded that formulation F4 can be used as a scent gel, such as in the bathroom, because its aroma is greatly liked by the panelists. Khairan et al. (2025) stated that the results of the hedonic test on aroma parameters showed that the F3 formulation was preferred, while the F0, F1, and F2 formulations respectively received scores in the moderately liked category. The reason for this assessment is suspected to be that some panelists found the aroma slightly pungent, which is suspected to be influenced by the oil content used as a natural fragrance at a relatively high concentration, especially with the use of fragrant pandan oil.

Fragrance Longevity Test

Table 7. Results of Fragrance Longevity Test

Formula	Storage Duration				
	Day-3	Day-6	Day-9	Day-12	Day-15
F1	2,85 – 3,04	2,56 – 2,93	2,44 – 2,85	2,33 – 2,76	2,23 – 2,66
F2	3,28 – 3,71	2,90 – 3,49	2,91 – 3,29	2,73 – 3, 16	2,69 – 3,00
F3	3,96 – 4,23	3,66 – 4,13	3,53 – 4,00	3,38 – 3,81	3,14 – 3,55
F4	4,62 – 4,97	4,50 – 4,90	4,44 – 4,85	4,24 – 4,75	4,19 - 4,70

Based on the results obtained from the fragrance longevity testing, there are differences between the formulations. Formulation F4, with the highest essential oil concentration, has the highest aroma durability and the slowest aroma decline over 15 days of storage. Meanwhile, F1, which has the lowest concentration,

experiences a significant and rapid decline in aroma, indicating that essential oil concentration directly affects aroma longevity [15]. Overall, the test results show that F4 is the best at retaining fragrance. Formulations with higher concentrations can produce better physical properties and longer-lasting aromas [16]. In line with the research by Khairan et al. (2025), which stated that the evaluation of fragrance longevity tests conducted under the same room conditions and temperature, the results obtained showed that the fragrance longevity observed in formulations F0, F1, F2, and F3 continuously increased over time. Fragrance longevity is greatly influenced by the amount of volatile ingredients, where the longer the storage time, the more ingredients evaporate, leading to a decrease in fragrance longevity.

Conclusions

Based on the results of the study, it can be concluded that the combination of carrageenan, xanthan gum, and HPMC bases successfully formed a physically stable bathroom air freshener gel with good fragrance durability. All formulations exhibited organoleptic characteristics that met the requirements for gel preparations. The formulation containing 10% citronella oil (F4) was identified as the best formulation, as it demonstrated the most superior performance across all tested parameters. This was supported by the lowest syneresis value (0.62%), indicating the highest physical stability; the lowest percentage of liquid evaporation (21.69%) with the highest remaining gel weight (92.03%), reflecting an enhanced ability to retain volatile components; as well as the highest panelist preference score (4.25), categorized as "liked," and the best fragrance retention, with scores ranging from 4.19 to 4.70 up to the 15th day of storage. Therefore, formulation F4 with 10% citronella oil concentration is considered the most effective and has strong potential to be developed as a natural-based bathroom air freshener product with optimal physical stability and fragrance durability.

Conflict of Interest

The authors declare that there are no financial, personal, or organizational conflicts of interest that could inappropriately influence the work reported in this manuscript. All experimental procedures, data analyses, and interpretations were conducted independently without external bias.

Acknowledgment

The authors gratefully acknowledge the Faculty of Pharmacy and Health, Tjut Nyak Dhien University, for providing the facilities that supported the conduct of this research.

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