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Formulation of Mosquito Repellant Freshener Gel with China Grass as Gel Base and Lemon Grass Oil as Mosquito -Repellant

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Mosquitoes transmit severe diseases, including malaria, dengue, and Zika virus, necessitating effective mosquito repellents. While traditional repellents are typically sprays or lotions, these can be inconvenient and leave residues. A more convenient alternative is mosquito repellent gel, offering ease of application, lasting effects, and a more enjoyable user experience. This study focuses on a gel-based mosquito-repelling air freshener containing lemongrass oil, known for its mosquito-repelling properties and fresh citrus-like scent.
Methodology: The study developed a mosquito repellent gel infused with lemongrass oil, containing active constituents such as neral, isoneral, and limonene. Sensory assessments

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evaluated the gel's color and odor using 150 individual's comments, and a hedonic test was conducted with 180 participants aged between 25-30 to assess product acceptability when applied to clothing and inanimate objects. To determine the longevity of the gel, total liquid evaporation was measured by weight loss over a four-week period, and the repellent's effectiveness was tested in a closed room.

Results: Sensory assessment confirmed an acceptable color and a citrus-like odor for the gel, while the hedonic test indicated a favorable user response. Weight loss calculations demonstrated the gel's sustained presence over time. The closed-room test confirmed the gel's effectiveness in repelling mosquitoes.

Conclusion: The lemongrass oil-based mosquito repellent gel is a promising alternative to traditional repellents, offering both user convenience and effective mosquito protection. Its long-lasting formula and positive sensory characteristics make it a viable option for personal and environmental use in mosquito-prone areas.

Keywords: China grass; lemon grass oil; mosquito repelling agent; texture of gels; xanthum.

1. INTRODUCTION

In recent years, there has been a growing demand for mosquito repellents that not only effectively ward off these pesky insects but also align with natural and eco-friendly principles (Das NG et al 2007). This shift has led to the development of natural mosquito repellent gels, which offer a compelling alternative to conventional chemical-based repellents. Natural mosquito repellent gels are formulated using plant-based ingredients known for their insect-repelling properties (Fradin M. S et al 2002). These ingredients, such as citronella, lemongrass, eucalyptus, and peppermint oils, have been used for centuries in traditional medicine and aromatherapy for their ability to deter mosquitoes naturally (Barnard et al 2004). Unlike their chemical counterparts, natural mosquito repellent gels typically do not contain synthetic pesticides like DEET (N,N-Diethyl-meta-toluamide) or picaridin (Willi E et al 2020). This makes them a preferred choice for individuals looking to minimize exposure to potentially harmful chemicals while still effectively protecting themselves against mosquito bites (Eden W et al 2018). By understanding the advantages of natural mosquito repellent gels and their sustainable approach to insect protection, consumers can make informed decisions about their health and environmental impact (Yoon J et al 2015). Join us as we uncover the natural solutions available to combat mosquitoes while embracing a greener approach to personal care (WHO 2009).

Standard formulations from **USP Pharmacopoeia** for gel-based systems highlighting that a mosquito repelling freshener gel must possess essential oils, Gel base like Carbopol, Agar, Xanthum Gum, Solvents like water, isopropyl alcohol, humectant like glycerin, propylene glycol, preservatives and stabilizers as selected. A number of mosquito-repelling freshener gel formulations with various concentrations of china grass and gelatin are shown in the following Table 1.

The requirements for the formulation is purchased by Chalapathi Institute of Pharmaceutical Sciences from National Scientific Products, Guntur, Andhra Pradesh.

Table 1. Detailed formulation of Mosquito repellent freshener Gel

S.No	Ingredients	F1	F2	F3	F4	F5
1	China grass (gm)	1	2	3	4	5
2	Gelatin (gm)	1	0.8	0.8	1.2	1.2
3	Xanthum gum (gm)	0.1	0.2	0.2	0.3	0.2
5	Sodium benzoate (gm)	0.5	1.5	0.5	0.5	1.5
6	Sandalwood oil (ml)	-	1.5	1.5	-	1.5
7	Lemon grass oil (ml)	1.0	1.5	2.0	2.5	2.5
8	Menthol (ml)	-	-	1.1	1.1	1.1
9	Water (ml)	45.4	41.5	40.9	40.4	36
10	Total	50	50	50	50	50

2. METHODOLOGY

2.1 Isolation of Essential Oil

Essential oils are concentrated plant extracts that retain the natural aroma and chemical properties of the plant they are derived from (Asawalam et al 2012). They are composed of volatile compounds like terpenes, alcohols, aldehydes, esters, phenols, and ketones, which contribute to their characteristic fragrance and biological activity**.**

1. From the plant *Cymbopogon citratus* the essential oil is extracted by hydro-distillation method (or) steam distillation method. Plant material is placed in a distillation chamber and steam is passed through the plant material, causing volatile compounds to evaporate (Isman M B 2006). The steam and essential oil vapours are condensed by cooling. The essential oil is separated from water since it is hydrophobic.

2.2 Preparation of Fresheners

The china grass & the gelatin are made into a gel form by heating them with the help of water. Then add xanthum & menthol stir it. Upon slight cooling add sodium benzoate, mix it (Tomar P et al 2019). Add sandalwood oil & lemon grass oil to the mixture & stir continuously until it mixes. Freeze it for 1-2 hours (Mahajan UN et al 2017).

2.3 Product Assessment

The assessment of the formulated product is performed by the following tests:

1. Sensory assessment
2. Hedonic test
3. Total liquid evaporation
4. Mosquito repelling bioassay
5. pH and spreadability

1. **Sensory assessment:** Sensory assessment involves evaluating the physical, olfactory, and user experience attributes of a mosquito repellent freshener gel to ensure its acceptability and effectiveness. This process encompasses multiple parameters such as texture, color, fragrance, and overall user satisfaction (Elango G et al 2010). The texture of the gel is assessed for its smoothness, consistency, and non-stickiness, as these factors influence ease of application and comfort during use. A visually appealing color, often achieved using safe dyes, enhances consumer appeal, while the fragrance plays a dual role: masking the potentially strong odor of active repellent ingredients and providing a pleasant olfactory experience (Karamathulla N et al 2014). The scent is particularly critical as it must balance consumer preferences while effectively deterring mosquitoes. Evaluators often conduct blind testing to ensure impartial assessments, considering sensory preferences across diverse demographic groups. A total number of 5 gel formulations are formulated with varying concentrations of china grass, gelatin, xantham gum and active agents like lemongrass oil, sandalwood oil, eucalyptus oil and menthol as shown in the formulation table and are assessed by 150 individuals (Kumar S et al 2011).
2. **Hedonic test:** The hedonic test is a consumer-centered evaluation method used to measure the overall liking or acceptance of a mosquito repellent freshener gel (Zahir A A et al 2009). This test involves presenting the product to a panel of participants, typically representing the target audience, and asking them to rate their level of preference on a structured scale, such as a 5-point hedonic scale (ranging from "No fragrant" to "Extreme fragrant") (Perumalsamy H et al 2020). Key attributes evaluated include fragrance, texture, color, ease of use, and perceived effectiveness. The fragrance is particularly critical, as it must be pleasant enough to appeal to users while incorporating mosquito-repellent agents that may have strong or off-putting odors (Hazarika et al 2022). Additionally, the texture is assessed for comfort, ensuring that the gel is smooth, non-sticky, and easy to handle. Participants may also provide qualitative feedback on their impressions, offering insights into potential areas for improvement. (Gupta R et al 2017).

The test is performed with 180 individuals of age between 25-30 as the panellists who do not have allergic reactions in their past medical history. The panellists are asked to smell the formulation and the percentage of the preference of the formulation is calculated and the respective formulation is considered to be a good formula (Jadhav VD et al 2015).

2.4 Total Liquid Evaporation

Syneresis is defined as the contraction of a gel accompanied by the separating of the liquid. Syneresis is evaluated by calculating the amount

of liquid expelled from the formulated gel (Shinde PR et al 2013). The total liquid evaporation of the gel sample is calculated by weighing the sample once in every week for 4 weeks (Kweka et al 2012). With the help of this test, we can determine the total weight loss of the gel after 4 weeks i.e. the amount of the evaporated liquid from the gel (Patil SC et al 2015).

$$\%E = \frac{(\text{Initial weight} - \text{Final weight}) \times 100}{\text{Initial weight}}$$

Table 2. Assessment criteria for the freshening property of the gel formulation

S. No	Criteria	Score
1	Extreme fragrant	5
2	Fragrant	4
3	Moderate fragrant	3
4	Less fragrant	2
5	No fragrant	1

Where:

- **Initial weight** is the weight of the substance before evaporation.
- **Final weight** is the weight of the substance after evaporation

2.5 Cage Test for Mosquito Repellent Activity

The cage test is a widely accepted laboratory method for evaluating the efficacy of mosquito repellent products, including freshener gels (Dhivya SM et al 2014). It involves exposing human or animal skin or treated surfaces to live mosquitoes in a controlled environment to determine the product's repellency and duration of effectiveness (Srivastava A K et al 2018). This test is crucial for validating the repellent's performance before advancing to field trials. Mosquitoes, typically from species like *Aedes aegypti* or *Anopheles gambiae*, are reared under controlled conditions (temperature 25–28°C, relative humidity 70–80%) (Tiwari M et al 2007). Adult female mosquitoes, aged 5–7 days and starved of blood for 12–24 hours, are selected for testing as they actively seek a blood meal (Banoli et al 2022). A standard cage, often made of mesh (30 cm × 30 cm × 30 cm), is used. The cage is designed to safely confine the mosquitoes while allowing interaction with the test sample (Amer A et al 2006). The test product (e.g., mosquito repellent gel) is applied uniformly on a defined surface such as artificial membranes (1mg/cm^2). 50 mosquitoes are released into the cage and the treated surface is introduced into the cage, with the untreated control surface tested simultaneously for comparison (Sritabutra D et al 2011). Observations are made at regular intervals (e.g., every 1 hour for up to 4 hours) to assess mosquito landing, probing, and biting behavior (Burt S 2004). The number of mosquitoes landing or biting on the treated surface is compared to the untreated control to calculate the percentage repellency (Harris I I et al 2013).

$$\%\ \text{Repellency} = \text{C-T/C} * 100$$

2.6 pH and Spreadability

The pH of the formulation is determined by immersing the probe of the pH meter (ELICO LI120 pH) in a solution made by dissolving the gel formulation of 0.5g in 25 ml of distilled water (Maia MF et al 2011). Likewise, the spreadability of the formulation is determined by spreading the 0.5g of gel on the surface of a glass plate, the second glass plate is placed on the slide and pressure is applied (Hikal W L et al 2017). The time required for the gel to cover the surface of 2cm is determined (Karunamoorthy K et al 2008).

$$\text{Spreadability} = \frac{\text{Amount of pressure applied on glass slide x Length of a glass slide(2cm)}}{\text{Time taken (sec) for the gel to cover the area}}$$

3. RESULTS AND DISCUSSION

3.1 Sensory Assessment

Table 3. Comments and reviews of 150 individuals on Sensory assessment

Formulation	Colour	Odour
F1	Pale pink	Camphory
F2	Pink	Woody, camphory
F3	Buff-pink	Strong, lemon
F4	Pale pink	Sweet, Minty
F5	Cherry pink	Strong, minty

The sensory assessment data shows that the formulation F3 with a Strong lemon odour is the most preferred i.e. formula comprising active agents including eucalyptus oil, and lemongrass oil. Menthol and sandalwood oil. The formula F2 with active agents including sandalwood oil and eucalyptus oil is less preferred (Geetha K et al 2017). The buff-pink appearance of the gel was found to be more pleasing and appealing. The scent of the formulation F3 i.e. Strong, the lemon odour of the gel is further considered agreeable and satisfying.

3.2 Hedonic Test

The results from the Hedonic test show that the formulation F3 with 6% china grass and 1.6% xantham gum was most preferred and the formulation F1 with 2% china grass and 0.2% xantham gum was less preferred. Higher the concentration of china grass then the ability to maintain the scented (active agents) gel formulation to be better and more favoured. This occurs because the odour of the active agents is stored in the china grass which is been expanded into the gel and is slowly released so as to last longer.

3.3 Total Liquid Evaporation Test

The gel formulation is weighed for 4 weeks and the total liquid evaporation is calculated. The weights of the essential oil and the water are lost as they get evaporate. Therefore, the major weight loss is inversely proportional to the endurance of the gel. The greater the weight loss of the gel, the more the volatile oil and water get evaporated, and the lesser the resistance scented gel.

Initially, the weight of the formulated gel is the same and then updated for 4 weeks once a week (Mosbah H et al 2020). Gravimetrically, the weight of the gel is calculated and the remaining weight percentage of the initial weight of the product is calculated. A freshener gel product with higher evaporation indicates it has a smaller scent, or a higher resistance to fragrance, relative to its starting weight percentage.

The reduction in the size of the gel from highest to lowest is the formulation F1 with 30.10% followed by formulation F4 at 24.89% and formulation F2 at 24.89% followed by formulation F5 at 23.3% and followed by formulation F3 at 21.82%. The loss of water through evaporation is high in formulation F1 as we had taken small quantities of china grass and xantham gum when compared to other formulations F2, F3, F4 and F5. The formulation containing more china grass shows less and slower evaporation of the active agents and water.

3.4 Mosquito Repellent Assessment

The number of mosquitos at the end of hour 4 is the parameter to assess the mosquito-repelling property of the formulation. The percentage repellency of the formulation is calculated. Based on the results shown in the above table Formulation F3 displayed the maximum mosquito-repelling activity followed by formulations F2, F5, F4 and F1 respectively.

Table 4. Hedonic test at different time intervals of different formulas

Time	F1	F2	F3	F4	F5
Week 1	Moderate fragrant	Fragrant	Very fragrant	Less fragrant	Fragrant
Week 2	Less fragrant	Moderate fragrant	Fragrant	Less fragrant	Moderate Fragrant
Week 3	No fragrant	Less fragrant	Moderate fragrant	No fragrant	Less fragrant
Week 4	No fragrant	No fragrant	Less fragrant	No fragrant	No fragrant

Table 5. The percentage of the gel air freshener's residual weight after five weeks

Week	F1 %	F2 %	F3 %	F4 %	F5 %
1	48.1	48.2	48.1	48.6	48.9
2	42.5	45.2	46.5	43.2	45.8
3	39.1	40.1	42.1	39.1	41.2
4	34.2	37.6	39.2	37.1	39.6
5	33.5	36.2	37.6	36.5	37.4
Total Liquid Evaporation(%)	**30.10**	**24.89**	**21.82**	**24.89**	**23.3**

Table 6. Mosquito repellent data for 4 hours

	Number of mosquitos			
Hours	**Hour 1**	**Hour 2**	**Hour 3**	**(Finally) Hour 4**
Absence of formulation (Initially)	40	40	40	40
F1	9	11	12	18
F2	10	10	11	11
F3	6	6	6	7
F4	11	12	12	13
F5	11	11	12	12

Table 7. Mosquito repellent potential of the formulated gel for 4 hours

Formulation	**% Repellency**			
	1st Hour	**2nd Hour**	**3rd Hour**	**4th Hour**
F1	77.5±0.10	72.5±0.20	70±0.01	55±0.01
F2	75±0.40	75±0.08	72.5±0.03	72.5±0.03
F3	85±0.01	85±0.02	85±0.01	82.5±0.01
F4	72.5±0.03	70±0.07	70±0.90	67.5±0.90
F5	72.5±0.40	72.5±0.05	70±0.50	70±0.30

Table 8. pH, transparency and spreadability of five formulations

Formulation	**pH**	**Transparency**	**Spreadability (cm/min)**
F1	7.1± 0.01	Less Translucent	16.12±0.10
F2	7.01±0.01	Translucent	15.41±0.05
F3	7.52±0.02	Translucent	13.56±0.01
F4	7.24±0.01	More Translucent	9.85±0.03
F5	7.37±0.03	Translucent	7.48±0.01

3.5 pH and Spreadability

The pH and spreadability of the formulations are determined by the appropriate instruments and techniques and the results are reported.

The pH of the formulations was found to have a neutral pH and the spreadability of the formulations is calculated and recorded. The transparency of the formulation is viewed and the resultant property is detailed in the Table 8.

4. CONCLUSION

A high-quality mosquito repellent freshener gel offers a blend of effectiveness, convenience, and pleasantness that makes it a standout choice for personal insect protection. Firstly, the dual functionality of repelling mosquitoes while freshening the air sets these gels apart from traditional repellents. They provide a continuous defense against mosquitoes in indoor spaces, making them ideal for homes, offices, and other enclosed environments. Secondly, the formulation of these gels often includes natural ingredients like lemon grass oil, sandal wood oil, menthol, china grass which not only repel mosquitoes effectively but also emit a refreshing aroma. This natural approach appeals to consumers seeking alternatives to chemical-based repellents, ensuring a safer and more environmentally friendly option. Thirdly, the convenience of application cannot be overstated. Mosquito repellent freshener gels are typically easy to use, requiring minimal effort to place or hang in strategic locations. This simplicity encourages regular use, ensuring consistent protection against mosquito bites without the hassle of traditional repellent applications. Moreover, the longevity of effectiveness is another key benefit. Many of these gels offer prolonged protection, often lasting several weeks depending on environmental conditions. This feature reduces the need for frequent reapplication, enhancing user convenience and cost-effectiveness.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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