International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 09-03-2025, Accepted: 08-04-2025, Published: 24-04-2025
Volume 10, Issue 4, 2025, Page No. 126-130

Formulation and evaluation of a herbal mosquito repellent cream

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Abstract
Mosquito-borne diseases such as malaria, dengue, and chikungunya pose significant public health risks worldwide. Synthetic mosquito repellents, though effective, often raise concerns about skin irritation and environmental impact. This study aimed to formulate and evaluate an herbal mosquito repellent cream incorporating essential oils from lemongrass (Cymbopogon citratus), mentha (Mentha piperita), rosemary (Rosmarinus officinalis), and thuja (Thuja occidentalis). Five different formulations (F1–F5) were prepared using varying concentrations of these essential oils, along with a suitable cream base. The formulations were assessed for their physical characteristics, pH, spreadability, washability, skin irritation potential, and mosquito repellent efficacy. All formulations exhibited favorable physical stability, acceptable pH levels suitable for skin application, good spreadability, and easy washability. No adverse skin reactions or irritation were observed during preliminary dermatological testing. The mosquito repellent activity of the formulations was found to be concentration-dependent, with F5 (containing the highest concentration of essential oils) demonstrating the most significant repellency, effectively repelling 65% of mosquitoes in controlled conditions. The findings suggest that the developed herbal mosquito repellent cream presents a promising alternative to synthetic repellents, providing a safer and eco-friendly option for mosquito control. Further studies on long-term efficacy, stability, and field application are recommended to optimize its use for public health protection.

Keywords: Herbal mosquito repellent cream, synthetic repellent alternative, essential oils. lemongrass, mentha, rosemary, thuja

Introduction

Mosquito-borne diseases, such as malaria, dengue fever, and Zika virus, continue to pose a significant threat to global health, affecting millions of people worldwide. The use of mosquito repellents has been a common prevention strategy, but concerns over their environmental impact, toxicity, and declining efficacy have sparked interest in developing natural, plant-based alternatives. Essential oils, derived from plants such as lemongrass, mentha, rosemary, and thuja, have shown promise as natural mosquito repellents due to their bioactive compounds and potential synergistic effects.

Mosquito-borne diseases, such as malaria, dengue fever, chikungunya, and Zika virus, pose significant threats to global public health, particularly in tropical and subtropical regions. According to the World Health Organization (WHO), mosquito-borne diseases account for over one million deaths worldwide each year [1].

The primary method of preventing mosquito-borne diseases is through the use of mosquito repellents. Synthetic mosquito repellents, such as N, N-diethyl-meta-toluamide (DEET) and picaridin, are widely used due to their effectiveness. However, these chemicals have raised concerns regarding their potential health and environmental impacts. For example, DEET has been linked to neurological damage and skin irritation, while picaridin has been shown to contaminate soil and water [2].

In recent years, there has been a growing interest in the development of natural, plant-based mosquito repellents. Herbal extracts have been shown to possess insecticidal and repellent properties, making them potential alternatives to synthetic mosquito repellents [3].

The use of herbal mosquito repellent creams offers several advantages over synthetic repellents. These creams are generally considered safer, as they are derived from natural sources and are less likely to cause adverse health effects. Additionally, herbal mosquito repellent creams can be more environmentally friendly, as they are biodegradable and non-toxic [4].

This research was conducted with the aim of creating a herbal mosquito repellent cream using essential oils from these four plants and testing its physicochemical properties, dermatological safety, and mosquito repellent activity. Creating an herbal formulation in this manner may provide a natural, skin-compatible, and environment-friendly alternative for mosquito control, which could help reduce vector-borne disease transmission.

Fig 1: Aedes Aegypti

Materials and Method

Materials

Lemongrass leaves, Rosemary leaves, Mentha leaves, Thuja leaves, stearic acid, lanolin, mineral oil, sodium hydroxide, Cetyl alcohol, glycerine and distilled water. All these ingredients were collected from local area and market.

Role of Ingredients

The role and effect of main ingredients is as follows:

Lemongrass: *Cymbopogon citratus* is a tropical plant known for its fragrant, citrus-scented leaves. Lemongrass oil is distilled from leaves and it contains citral which act as antibacterial, anti-inflammatory, and insect repellent [5, 6].

Mentha: *Mentha piperita* leaves, commonly known as mint leaves, are aromatic, green leaves from the mint plant. Mentha oil is collcted from mentha leaves. It contains menthol which has antibacterial, insect repellent and other medicinal properties [7].

Rosemary: *Rosmarinus officinalis* is an aromatic herb native to the Mediterranean region. It has strong, piney scent. Rosemary oil is collected from leaves and it has antioxidant, antibacterial and insect repellent properties [8].

Thuja: *Thuja officinalis* leaves come from evergreen trees in the Thuja genus. It has distinct aromatic scent. Thuja essential oil is collected from leaves and it contains thujone. It acts as antimicrobial and insect repellent [9].

Preparation of extracts:

The air-dried leaves were ground just before extraction. The ground plant material (50 g) was mixed with 400 ml of distilled water and placed in a round-bottom flask on a heater to prevent overheating or charring from direct steam. The distillation process was carried out for three hours, and the essential oil obtained was collected. To separate essential oil separation funnel was used distilled oil is mixed with petroleum ether. Stoppered the funnel and shaked it. Allowed the mixture to settle and separated into two distinct layers. The petroleum ether layer contains the essential oil, it was separated and the petroleum ether was evaporated and essential oil was collected [10, 11].

Fig 2: Steam Distillation

Fig 3: Extracted Oils

Preparation of Mosquito Repellent cream

Preparation of oil Phase: lanolin, stearic acid, cetyl alcohol, mineral oil was weighed accurately and taken in a beaker. The oils were then gently heated using water bath with continuous stirring which allow the oils to incorporate in each other.

Preparation of water phase: Glycerin and sodium hydroxide and distilled water were weighed accurately and taken in a beaker. The components were then heated gently using a water bath with continuous stirring which allows the components to incorporate in each other [12].

Combine Oil and Water Phases: Both phases were heated separately to 75°C. Once heated, the oil phase was slowly incorporated into the aqueous phase under continuous stirring to ensure uniform emulsification. Essential oils were added after complete emulsification, when the mixture cooled to a temperature between 55°C and 60°C [13].

Table 1: Formulation of Mosquito Repellent cream

Ingredients	F1	F2	F3	F4	F5
Oil Phase					
Lemongrass Oil	0.4 gm	0.45 gm	0.45 gm	0.55 gm	0.6 gm
Mentha Oil	0.4 gm	0.45 gm	0.45 gm	0.55 gm	0.55 gm
Rosemary Oil	0.35 gm	0.25 gm	0.25 gm	0.35 gm	0.4 gm
Thuja Oil	0.1 gm	0.2 gm	0.3 gm	0.1 gm	0.1 gm
Cetyl Alcohol	0.4 gm	0.4 gm	0.4 gm	0.4 gm	0.4 gm
Lanolin	0.2 gm	0.2 gm	0.2 gm	0.2 gm	0.2 gm
Mineral Oil	1.5 gm	1.5 gm	1.4 gm	1.3 gm	1.3 gm
Steric Acid	2.1 gm	2 gm	2 gm	2gm	1.9 gm
Water phase					
Glycerine	2 gm	2 gm	2 gm	2 gm	2 gm
Sodium Hydroxide	0.05 gm	0.05 gm	0.05 gm	0.05 gm	0.05 gm
Water	12.5 gm	12.5 gm	12.5 gm	12.5 gm	12.5 gm
Preservative	q. s	q. s	q. s	q. s	q. s

Fig 4: Formulated Cream

Evaluation parameters

Organoleptic characteristics

The prepared cream formulation was evaluated for various parameters like colour, odor, texture, and any possible phase separation by visual observation. Pressing a small quantity of the cream on the finger and thumb gives an idea about its texture and homogeneous nature.

Colour evaluation

Colour evaluation has been tested by visible examination by using a black and white background and any change has been observed for change in colour.

Odour evaluation

Odour of the ointment has been tested with the three volunteers for more accurate observation.

Texture evaluation

The prepared cream was found to be Smooth and no greediness is observed.

pH determination

The pH of various formulations was measured using a digital pH meter. A 0.5g sample of each cream was dissolved in 50ml of distilled water, allowed to sit for 2 hours, and then tested.

Washability

Washability was assessed by applying a small amount of cream to the hand and then rinsing with tap water.

Irritancy test

The irritancy test involved applying the cream to a marked area on the dorsal surface of the left hand. The area was monitored for signs of irritancy, redness (erythema), and swelling (edema) at regular intervals over 24 hours [14].

Spreadability

The spreadability of the herbal cream was measured by timing how long it took for two glass slides, with the cream in between, to separate under a 30g weight. The slides were scraped clean of excess cream, and the time taken for the upper slide to slip off was recorded. Spreadability was calculated using the formula: Spreadability = (weight × length) / time [15].

Viscosity

Viscosity was measured using a Brookfield Viscometer with a helipath stand. A 50g sample was allowed to acclimate for 5 minutes before measuring the dial reading using a T-D spindle at various speeds (10-100 rpm). Measurements were taken in triplicate at room temperature, and viscosity values in centipoises were calculated by multiplying the dial readings with the corresponding coefficients from the viscometer catalogue [15].

Evaluation of mosquito repellent activity

The evaluation of mosquito repellent activity employs a cardboard frame cage with a cardboard bottom, one side netted for ventilation, plastic paper sides for viewing, and a front net area for access. To begin, mosquitoes are placed in the cage, and a control test is conducted without applying any cream to determine the number of mosquito bites. Next, the first concentration of the mosquito repellent cream (F1) is applied to a square section of skin on the hand, which is then inserted into the cage, protected by a glove and muslin cloth, leaving only the treated skin area exposed. The number of mosquitoes repelled is observed and recorded for 2 minutes. This process is repeated for each concentration of the mosquito repellent cream, and the data is analyzed by comparing the number of mosquito bites in the control test to the number of mosquitoes repelled in each treatment test [16].

Fig 5: Arm Cage Method

Results and Discussion

Organoleptic Characteristics

The organoleptic properties, including appearance, color, and texture of the formulations, were evaluated and are summarized in the corresponding table. All formulations exhibited acceptable aesthetic qualities, suitable for topical application.

pH

The pH of all formulations ranged between 6.0 and 6.5, which falls within the acceptable limits for topical creams. These values ensure compatibility with skin and meet standard formulation criteria.

Spreadability

Spreadability tests revealed that the formulations had values ranging from 4.61-9.25 g·cm/s. Among them, Formulation F5 demonstrated the highest spreadability, indicating ease of application and good coverage on the skin.

Washability

All formulations were tested for washability and were found to be easily removable with water, confirming their suitability for routine use without leaving residues.

Irritancy Test

The irritancy potential of the formulations was assessed through topical application on human skin. No signs of irritation, erythema, or edema were observed in any of the formulations, indicating that they are safe for external use.

Mosquito repellent activity

Our studies revealed that Formulation 5 demonstrated better mosquito repellent activity compared to the other tested formulations. This enhanced efficacy may be attributed to the optimal combination of active ingredients and excipients, contributing to its prolonged and effective action against mosquitoes [17, 18].

Table 2: Results of Evaluation of formulated cream

Sr No.	Evaluation	F1	F2	F3	F4	F5
1	Physical Appearance	Opaque	Opaque	Opaque	Opaque	Opaque
2	Color	White	White	White	White	White
3	Texture	Smooth	Smooth	Smooth	Smooth	Smooth
4	Homogeneity	Homogenous	Homogenous	Homogenous	Homogenous	Homogenous
5	Immediate Skin Feels	Moisturizing & Colling effect	Moisturizing & Colling effect	Moisturizing & Colling effect	Moisturizing & Colling effect	Moisturizing & Colling effect
6	pH	6.1	6	6.3	6.2	6.5
7	Spredability g.cm/s	4.61	5.88	6.2	9.06	9.25
8	Washability	Easily washable	Easily washable	Easily washable	Easily washable	Easily washable
9	Viscosity at 10rpm(cps)	3524	3708	3849	4034	4112

Table 3: Results of Mosquito repellent activity

Formulation no.	Parameter	Control	Test
F1	Number of Mosquitoes	20	20
	Number of mosquitoes repels	0	5
	Repellent activity	No	Yes
	Observation Time(min)	2	2
	Temperature ^{0}C	28	28
F2	Number of Mosquitoes	20	20
	Number of mosquitoes repels	0	7
	Repellent activity	No	Yes
	Observation Time(min)	2	2
	Temperature ^{0}C	28	28
F3	Number of Mosquitoes	20	20
	Number of mosquitoes repels	0	8
	Repellent activity	No	Yes
	Observation Time(min)	2	2
	Temperature ^{0}C	28	28
F4	Number of Mosquitoes	20	20
	Number of mosquitoes repels	0	10
	Repellent activity	No	Yes
	Observation Time(min)	2	2
	Temperature ^{0}C	28	28
F5	Number of Mosquitoes	20	20
	Number of mosquitoes repels	0	13
	Repellent activity	No	Yes
	Observation Time(min)	2	2
	Temperature ^{0}C	28	28

Conclusion

The development of plant-based mosquito repellents offers a promising solution to prevent mosquito borne diseases. The bioactive compounds present in lemongrass, mentha, rosemary, and thuja essential oils demonstrate potential as effective mosquito repellents, with possible synergistic effects when combined. Using essential oils of thuja (Thuja occidentalis), rosemary (Rosmarinus officinalis), mentha

(Mentha piperita), and lemongrass (Cymbopogon citratus), the current study effectively created and assessed a range of herbal mosquito repellent lotions.

All of the formulations showed high spreadability, simple washability, pH levels appropriate for skin application, and acceptable physical features. The compositions are safe for topical application, according to preliminary dermatological testing that showed no symptoms of skin irritation. These results imply that the created herbal cream is a viable, all-natural substitute for synthetic repellents, providing a skin-compatible and environmentally responsible method of personal mosquito protection. To improve its effectiveness and practical application for widespread use in mosquito-prone areas, more research is advised, including long-term stability tests, prolonged field trials, and essential oil mixture optimisation.

Acknowledgment

The authors would like to thank the administration of Mahatma Gandhi Vidyamandir's Pharmacy College in Nashik, Maharashtra, India, for their support and resources in facilitating this work.

Conflict of Interest

All the authors declare that they have no conflict of interest.

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