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FORMULATION AND EVALUATION OF ECO-TWIST SEMISOLID MOSQUITO REPELLENT STICKS

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ABSTRACT

Purpose: The demand for plant-based mosquito repellents has grown due to concerns over the safety and side effects of synthetic agents. This study aimed to formulate and evaluate semi-solid stick preparations using *Lantana camara* and marigold oils for effective topical mosquito repellency. **Method:** Five formulations (F1–F5) were developed using stearic acid, cetyl alcohol, and natural oils in varying ratios. The sticks were evaluated for organoleptic characteristics, pH, washability, melting point, skin irritation, and physical stability. The best-performing formulation was selected based on an integrated assessment of these parameters. **Results:** All formulations exhibited a pleasant odor and yellow to dark-yellow color, with pH values ranging from 4.0 to 5.0 and no evidence of skin irritation. F3 emerged as the optimal formulation, showing a balanced melting point (76–81 °C), smooth non-greasy texture, good washability, and surface integrity. In contrast, F4 and F5 were overly sticky and less washable, while F1 and F2 lacked adequate oil content for long-lasting repellency. **Conclusion:** Formulation F3 demonstrated the best balance of efficacy, user acceptability, and physical stability, making it a promising candidate for a natural mosquito repellent stick. Further work is warranted to evaluate its repellency duration and performance under field conditions.

KEYWORDS: Mosquito repellent, *Lantana camara*, marigold oil, semi-solid twist-up stick, herbal formulation.

INTRODUCTION

Anopheles, Culex, and Aedes mosquito species carry a variety of infections that cause diseases like dengue, malaria, and yellow fever. By attaching the antibodies Immunoglobulin G (IgG) and Immunoglobulin E (IgE) to antigens, mosquito saliva stimulates an immunological response when the host's blood is consumed. These immunological responses often cause redness, pimples, itching, and pain. Furthermore, allergic reactions to the saliva of the mosquito can cause severe skin irritation after a bite. Mosquito management and personal protection from mosquito bites are currently the main strategies for controlling diseases spread by mosquitoes. This is possible by using people opposed to mosquito bites. The application of insect repellents can help achieve this. Mosquito repellent is a chemical that is applied to the skin, clothing, or other surface to prevent mosquitoes from landing or reproducing. In order to reduce human-mosquito contact, repellents are applied to the skin and other surfaces to stop mosquitoes from landing. By using mosquito repellents, mosquito-borne illnesses like dengue and malaria can be avoided or reduced.[1,2]

Mechanism of mosquito repellents

Mechanism of mosquito repellents: By detecting an increase in air carbon dioxide concentrations, mosquitoes often exploit the warm, humid convection rising from the human body as a means of contact. There are two main categories into which mosquito repellent chemicals fall.

1. The olfactory modality : In the olfactory mode, also known as transpiration repellence, mosquitoes' ability to detect humidity, which aids in their ability to discover living things, is inhibited; as a result, they are unable to locate people.
2. The tactile mode: At sub-lethal, mortal, or toxic doses, repellent substances act on the mosquito's nervous system, causing them to become confused and resist their behaviour before being knocked down by contact with the fabric surface. This mechanism, also known as direct-contact repellency, drives the insects away from the surface before they can suck blood.[14]

How mosquito repellents work

They form a barrier that is unappealing to mosquitoes and other pests. These products contain active substances that either release odours that repel insects or cover up scents that attract them. Repellants reduce the likelihood of getting bitten by keeping insects away from skin or

clothing. Although the formulae of various products vary, their basic objective is always the same: to provide protection from unwelcome insect encounters.[20]

Plant Description

The orange, white, and red flowers of L. camara can change in colour as the plant ages. L. camara is considered a plant with numerous medicinal uses since it contains phytochemicals such as triterpenoids, flavonoids, alkaloids, steroids, saponins, coumarins, tannins, and carbohydrates. The colour of marigold flowers ranges from yellow to red. The chemical components lutein, limonene, alpha-terpineol, and tagetenones are found in marigold.

Table no. 1: Taxonomy of L.camara and Marigold.

Taxonomy	Lantana camara	Marigold
Kingdom	Plantae	Plantae
Sub kingdom	Tracheobionta	Tracheobionta
Super division	Spermotophyta	Spermotophyta
Division	Magnoliophyta	Magnoliophyta
Class	Magnolopsida	Magnolopsida
Subclass	Astderidae	Astderidae
Order	Lamiales	Asterales
Family	Verbenaceae	Asteraceae
Genus	Lantana	Tagetes
Species	Lantana camara	Tagetes erecta (African marigold) Tagetes patula (French marigold) Tagetes tenuifolia (Signet marigold)

It was investigated if lantana camara flowers may protect against Aedes mosquitoes. Coconut oil containing latana flower extract offered 94.5% protection against Aedes aliopictus and Aedes iegyptt. 1.9 hours was the average protection duration. Lantana flower extract can offer protection from potential Aedes mosquito bites for up to four hours. Marigold's capacity to repel different kinds of mosquitoes has already been the subject of numerous research. Lutein is one of its active ingredients. In order to increase the use of plant-based mosquito repellents, this study concentrated on the formulation, development, and repellence testing of pharmaceutical formulations based on the extracts of L. camara and marigold flowers.[16,21]

MATERIALS AND METHODS

Herbal drugs used

- **Lantana camara:** Fresh flowers of lantana camara belonging to family Verbenaceae are collected from college campus area and authenticated by Department of Botony, Y.C. Institute of Science, Satara.

Figure no. 1: *Lantana camara* plant.

- **Marigold:** Marigold oil brought from veda oils, Gurugram, Haryana, India.

Figure no. 2: Marigold oil.

Table no. 2: List of Chemicals Required.

Sr.No.	Materials	Suppliers
1)	Yellow bees wax	S.D.Lab Chemical Centre, Mumbai
2)	Cocoa butter	S.D.Lab Chemical Centre, Mumbai
3)	Carnauba wax	S.D.Lab Chemical Centre, Mumbai
4)	Lanolin	S.D.Lab Chemical Centre, Mumbai
5)	Glycerine	S.D.Lab Chemical Centre, Mumbai
6)	Methyl paraben	S.D.Lab Chemical Centre, Mumbai
7)	Propyl paraben	Research lab, Bombay
8)	Cetyl alcohol	S.D.Lab Chemical Centre, Mumbai
9)	Steric acid	Pallav Chemicals & Solvents, Boisar

Preparation of the *L.camara* flower extract

1. Collection and Cleaning
Collect fresh, mature Lantana camara flowers. Gently rinse with clean water to remove dust and insects. Pat dry with a cloth or air dry for a few hours to remove surface moisture

⇩

2. Drying
Spread flowers thinly on a clean tray. Shade dry for 2-4 days to reduce moisture. Do not sun-dry direct sunlight may degrade aromatic compounds.

⇩

3. Preparation
Lightly crush the flowers using a mortar and pestle. This increases surface area and helps oil penetration.

⇩

4. Oil Infusion
Place the crushed flowers in a clean, dry container. Add coconut oil in a 1:4 ratio (w/v)

⇩

5. Gentle Heating
Heat using a double boiler for 1 hour. Keep the temperature below 60°C to preserve floral volatiles and active compounds. Stir occasionally to ensure even extraction

⇩

6. Cooling and Filtration
Let the mixture cool to room temperature. Strain using muslin cloth or a fine strainer into a clean container. Squeeze or press the flower residue to extract all infused oil.

⇩

7. Storage
Pour the filtered oil into a dark glass bottle to protect it from light. Store in a cool, dry place for later use.

Figure no. 3: *L.camara* flowers and crushed *L.camara* flowers.

Identification Test

1. Test for Alkaloids

Sr. No	Test	Observation	Inference
1	Dragandorff's Test: 2 ml extract + Dragandorff's reagent	Orange-brown precipitate	Alkaloid present
2	Mayer's Test: 2 ml extract + Mayer's reagent	Cream-colored precipitate	Alkaloid present
3	Hager's Test: 2 ml extract + Hager's reagent	Yellow precipitate	Alkaloid present
4	Wagner's Test: 2 ml extract + Wagner's reagent	Reddish-brown precipitate	Alkaloid present

2. Test for Flavonoids

Sr. No	Test	Observation	Inference
1	Shinoda's Test: Powdered drug heated with alcohol, filtered. To the solution, magnesium turnings and conc. HCl added. Boiled for 5 minutes.	Red color	Flavonoid present

2	Alkali Test: 10% aqueous sodium hydroxide solution added to a small quantity of the test solution.	Yellow-orange color	Flavonoid present
3	Lead Acetate Test: Few drops of 10% lead acetate solution added to the test solution.	White precipitate	Flavonoid present
4	Acid Test: Few drops of concentrated sulphuric acid added to a small quantity of the test solution.	Yellow-orange color with H_2SO_4	Flavonoid present

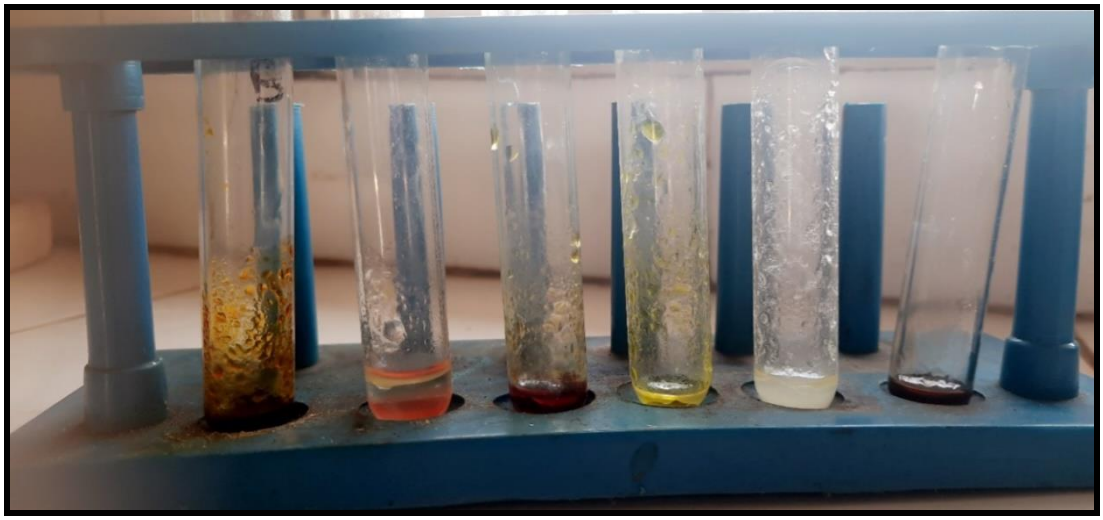

Figure no. 4: Identification test of Lantana camara extract.

Table no. 3: Table of formulation.

Ingredient(gm)	F1	F2	F3	F4	F5
Marie gold oil	2.0	2.2	2.4	2.6	2.8
Ghaneri flower	2.75	3.0	3.25	3.50	3.75
Bees wax	3.75	3.75	3.75	3.75	3.75
Cocoa butter	3.75	3.75	3.75	3.75	3.75
Carnauba wax	3.75	3.75	3.75	3.75	3.75
Lanolin	1.75	1.75	1.75	1.75	1.75
Glycerine	1.5	1.5	1.5	1.5	1.5
Methyl paraben	0.5	0.5	0.5	0.5	0.5
Propyl paraben	0.5	0.5	0.5	0.5	0.5
Steric acid	1.0	2.0	2.0	3.0	3.0
Cetyl alcohol	0.75	0.75	0.75	0.75	0.75

Method of Preparation

1. Preparation of the Oil Phase: In a clean, dry beaker, take the Yellow Beeswax, Carnauba Wax, Cocoa Butter, Cetyl Alcohol, Stearic Acid, Lanolin. Heat this mixture gently using a water bath at around 70–75°C until all solid components melt completely and a homogenous oil phase is formed.

⇩

2. Preparation of the Aqueous Phase: In another beaker, mix:Glycerine, Methyl Paraben, Propyl Paraben. Warm this aqueous phase to around 70°C (same as oil phase temperature to avoid sudden solidification upon mixing).

⇩

3. Emulsification and Mixing:Slowly add the aqueous phase into the oil phase with constant stirring to form a uniform semi-solid base. Maintain the temperature and stir gently until a uniform mixture is obtained.

⇩

4. Addition of Active Ingredients:Once the base cools down to around 45°C, add:Marigold Oil, Ghaneri Flower Oil. Stir gently but thoroughly to ensure even distribution of the mosquito-repellent essential oils.

⇩

5. Molding:Pour the warm, uniform mixture into stick molds or suitable containers (like twist-up deodorant stick tubes) while still in a pourable state.

⇩

6. Cooling and Solidification: Allow the formulation to cool and solidify at room temperature. Label and store in a cool, dry place.[22,23]

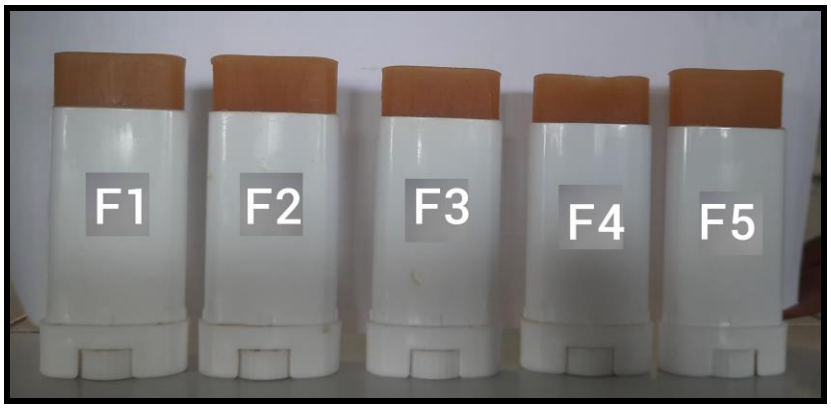

Figure no. 5: Formulations.

Evaluation Test

1. **Organoleptic properties:** Visual appearance: pay attention to texture, colour, and smell.[2]
2. **pH:** A digital pH meter or pH paper was used to measure the pH.[2]
3. **Spreadability**: Equipment for Testing Spreadability (Glass Slide Method): Place the insect repellent stick in the middle of the lower glass slide after weighing it to be around 1 gramme. To create a sandwich, carefully lay the upper glass slide over the sample. For five minutes, place a 500 g weight on top of the topmost slide. This aids in spreading the material evenly and getting rid of air bubbles. Once the weight has been removed, attach a thread to the upper slide and set a second 20g weight on the pan that is fastened to the thread. Because of the weight, let the top slide come off. Calculate how long it takes to slip a certain distance (t in seconds). Better application ease is indicated by a higher spreadability rating. Determine S=M. L/T, where T is the time in seconds, M is the weight attached to the top slide, L is the distance measured by material, and S is the spreadability.[2]
4. **Melting Point:** Since it indicates the upper limit of safe storage, the melting point should be determined. By filling a capillary, keeping it in the capillary apparatus, and first observing that the product melted gradually, the melting point of the prepared mosquito stick was ascertained using the capillary tube method. After a while, it was noticed that the product had melted completely. The aforementioned process was carried out three times, and the melting point ratio was noted in each formulation.[7]
5. **Human Patch Test for Skin Irritation:** Wash the volunteer's inner forearm with a light soap and water, then pat dry. On a cotton pad, apply 0.1–0.2 g of the insect repellent stick. Use a band-aid or surgical tape to secure the pad to the skin. For reference, clearly mark the region using a pen. Depending on the observation schedule, leave the patch on for two to twelve hours. Remove the pad at predetermined intervals (such as 30 minutes, 2 hours, or 12 hours) and check the skin for indications of discomfort. Note the response according to rash, itching, swelling, or redness.
6. **Testing for Stability:** Temporary Stability: Samples can be kept at ambient temperature, in the refrigerator (4°C), or at a high temperature (40°C). Track changes every week for a month. Examine the odour, pH, and appearance.
7. **Greasiness:** Assemble a group of qualified assessors, typically five to ten. Put a fixed quantity of the stick on a certain spot (forearm, for example). When applying and after, ask them to rate the texture. Make use of a scale, such as 0 to 5: 0 indicates smoothness

and lack of grit, 1–2 indicates little grit, 3 indicates moderate grit, and 4–5 indicates severe grit. Compile comments and average scores for analysis.

8. **Wash off property:** On the palm's back, a tiny bit of stick was applied and uniformly distributed. After washing the hand under the water tap, it was checked to see if it still felt oily.[2]
9. **Surface anomalies:** Surface defects, such as the absence of crystal formation on surfaces or contamination by mould, fungi, etc., are used to study surface anomalies.[7]
10. **Weight Variation:** Weigh each of ten sticks separately. Determine the average weight. Examine each weight in relation to the average. ±5% deviance is the acceptance criterion.
11. **Test of Repellency:** Put a stick on the volunteer's arm. In the mosquito cage, place the treated arm (10–20 mosquitos). Note how long it takes for the first bite or five mosquito landings. Repeat with the untreated arm as the control.[13]

RESULT AND DISCUSSION

Table no. 3: Observations of evaluation test.

Test name	F1	F2	F3	F4	F5
Colour	Yellow	Yellow	Yellow	Dark Yellow	Dark Yellow
Odour	Pleasant	Pleasant	Pleasant	Pleasant	Pleasant
pH	4-5	4-5	4-5	4-5	4-5
Washability	Washable	Washable	Washable	Less Washable	Less Washable
Spreadability (g.cm/sec)	6.2	6.8	7.1	6.0	7.6
Melting point	82-86	81-85	76-81	70-75	75-78
Skin irritation test	No	No	No	No	No
Greasiness	Smooth	Smooth	Smooth	Smooth	Smooth
Stickiness	Sticky	Sticky	Sticky	More Sticky	More Sticky
Softness	Soft	Soft	Soft	More Soft	Soft
Edging stability	Smooth	No Smooth	Smooth	No Smooth	Smooth
Surface anomalies	No defect	Defect	No defect	Defect	No defect

The semi-solid mosquito-repellent sticks (F1–F5) were evaluated for their organoleptic properties, physicochemical parameters, and repellency performance. The aggregated observations are presented in Table 3:

Color and Odour: All formulations exhibited an appealing yellow to dark-yellow hue with a uniformly pleasant odor, indicating successful incorporation of L. camara and marigold oils

without any off-odours. The gradual darkening from F1–F5 correlates with increasing active-oil concentration.

pH: The pH of all sticks remained in the mildly acidic range (4–5), which is compatible with skin's natural pH and suggests a low risk of irritation.

Washability: Formulations F1–F3 were readily washable with water, whereas F4 and F5 exhibited reduced washability, likely due to higher lipophilic-oil content and elevated proportions of stearic and cetyl alcohol.

Spredability

The spreadability of the semisolid stick formulations (F1 to F5) was assessed to evaluate the ease with which the product can be applied over the skin. From the table 3, it is evident that formulation F5 exhibited the highest spreadability (7.6 g·cm/sec), indicating that it spreads more easily compared to the other formulations. This could be attributed to a higher content of softening agents or a lower concentration of waxy components, which reduces internal resistance. Formulation F3 (7.1 g·cm/sec) also demonstrated good spreadability, making it suitable for smooth application. In contrast, F4 had the lowest spreadability (6.0 g·cm/sec), suggesting a firmer consistency which might affect user compliance. In general, higher spreadability is desirable in topical preparations for better patient acceptance and uniform application. However, excessively high spreadability may compromise the formulation's integrity or lead to unintentional wastage. Therefore, F3 and F5 appear to offer an optimal balance between firmness and ease of spreading.

Figure no. 6: Spreadability test.

Melting Point: The melting points decreased progressively from F1 (82–86 °C) to F4 (70–75 °C), reflecting the softening effect of increased oil load. F3 (76–81 °C) strikes a balance between ease of application and structural integrity at elevated storage temperatures.

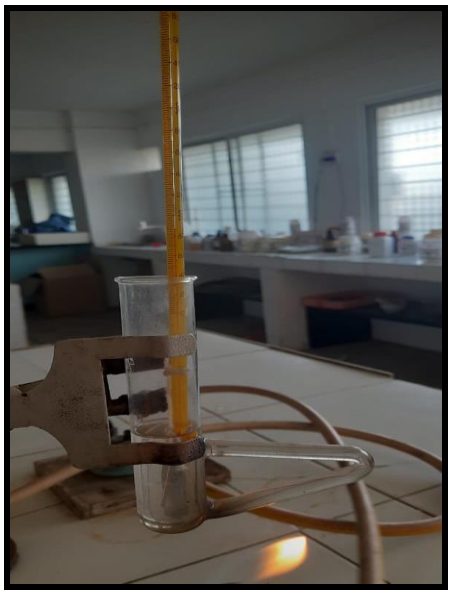

Figure no. 7: Melting point.

Skin Irritation and Safety: None of the formulations induced erythema, swelling, or itching in the human patch test, confirming that the selected excipients and botanical extracts are non-irritant under the test conditions.

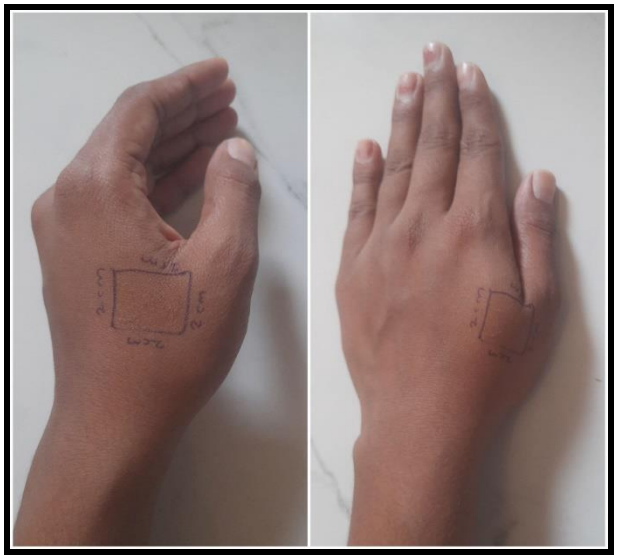

Figure no. 8: Skin irritation test.

Texture Attributes (Greasiness, Stickiness, Softness): All sticks felt smooth and non-greasy upon application. Stickiness and softness increased with higher concentrations of

active oils (notably in F4 and F5), which may enhance user comfort but could compromise residue and transfer resistance.

Edging Stability and Surface Anomalies: Formulations F2 and F4 showed minor surface defects (non-smooth edges and occasional crystallization), possibly due to phase separation during cooling. F3 maintained smooth edges and a defect-free surface, indicating optimal emulsion stability.

Figure no. 9: Stability test chamber.

Overall, formulation F3 emerges as the optimal prototype. It combines acceptable washability, a moderate melting point conducive to both tropical storage and user-friendly application, and defect-free appearance. The pH and safety profile of F3 align with dermal application requirements, while its textural attributes (smooth, non-greasy feel with moderate softness) are likely to promote consumer compliance. Formulations F4 and F5, despite higher active content, suffer from decreased washability and greater stickiness—traits that may discourage repeated use and increase the risk of residue staining on fabrics. Conversely, F1 and F2, though easy to wash off and structurally robust, contain lower levels of active botanical extracts, potentially limiting repellency efficacy duration. Future work should include quantitative repellency assays (e.g., measuring complete protection time against Aedes spp.) and accelerated stability studies under varied environmental conditions. Additional sensory panels can refine tactile properties, ensuring the final product meets both efficacy and consumer-acceptability benchmarks.

CONCLUSION

The present research successfully developed and evaluated semi-solid mosquito repellent sticks incorporating *Lantana camara* and marigold oils as natural active ingredients. This twist-up sticks are ecofriendly, easy to carry, pocket friendly. Among the five formulations tested (F1–F5), Formulation F3 demonstrated the most favorable combination of physicochemical stability, user-friendly texture, acceptable melting point, and aesthetic appeal, without causing skin irritation. It maintained a balance between effective incorporation of plant-based oils and desirable application properties such as smoothness, moderate stickiness, and good washability.

The study confirms that herbal-based repellents can be effectively formulated into semi-solid stick forms using suitable excipients, offering a safer, eco-friendly alternative to synthetic repellents. These findings encourage further development and testing of F3 for its repellency efficacy and long-term stability, with potential for commercial application in personal mosquito protection.

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