



## Formulation and Evaluation of Safe Herbal Mosquito Repellent Roll-On and Liquid Spray

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### Abstract

Mosquitoes are widespread throughout the world and are major vectors of diseases such as malaria, dengue, and yellow fever. Given that there are currently no effective vaccines against viruses and parasites transmitted by arthropods, the development of potent and safe insect repellents is crucial. Many chemical-based mosquito repellents are available in the market, but they can be harmful to humans and the environment, and have been associated with many side effects. Knowledge of traditional repellent plants can be incredibly beneficial for the development of natural alternatives to chemical repellents. Plant oils may eventually prove to be a viable alternative to synthetic repellents because they are often safe, inexpensive, and readily available. In this study, we aimed to prepare mosquito repellents using natural ingredients. We selected several plants that have been shown to repel mosquitoes and designed two different formulations using neem, tulsi, and marigold as the main ingredients. We used various essential oils to formulate a roll-on repellent, which was evaluated for its aroma and skin irritation potential. Additionally, we prepared a herbal mosquito repellent spray using plant powders, and added essential oils to create a surface layer on the water.

**Keywords:** Mosquito Repellents; Natural Ingredients; Essential Oils; Traditional Repellent Plants; Vector-Borne Diseases

### Abbreviation

WHO: World Health Organization; DEET: N, N-diethyl-metatoluamide; EO: Essential Oils; pH: Potential of Hydrogen

### Introduction

Mosquito-borne diseases such as yellow fever, dengue hemorrhagic fever, epidemic polyarthritis, encephalitis, and malaria pose a worldwide threat. According to the World Health

Organization (WHO) [1], malaria alone causes over 3 million deaths each year. Various mosquito species from the Anopheles, Culex, and Aedes genera carry viruses that lead to ailments such as dengue fever, malaria, yellow fever, Japanese encephalitis, and other infections [2]. Malaria, with approximately two to three million new cases annually, is one of the leading causes of newborn, child, and adult mortality in India [3]. Dengue fever has seen a 30-fold increase globally in recent decades, making it the

fastest-spreading mosquito-borne viral disease [4]. These diseases are solely transmitted through mosquito bites, and no effective vaccines are available to control them. Avoiding mosquito bites is a key strategy for controlling or reducing the occurrence of these diseases [5]. While there are treatments available for malaria and other mosquito-borne diseases, prevention is always preferable. Currently, there are no specific medicines or effective vaccines to prevent the spread of these viruses. Thus, targeting mosquitoes is essential to halt the spread of neglected tropical diseases. Significant efforts have been made to develop effective larvicides and repellents against arthropods, resulting in the creation of mosquito repellents. Mosquito repellents are compounds that make surfaces unappealing to insects and can be applied to skin or other surfaces to deter mosquitoes from landing on them [6].

There are three complementary techniques for using odorants to control mosquito populations: “push” repellents that drive mosquitoes away, “maskers” that reduce human attractiveness, and attractants that lure mosquitoes into traps placed far from humans. Employing these methods may reduce the spread of disease by decreasing mosquito-human contact [7]. The majority of commercial repellents are made using chemicals such as N, N-diethyl-metatoluamide (DEET), allethrin, N, N-diethyl mendelic acid amide, and dimethyl phthalate. However, it has been determined that chemical repellents are not safe for public health due to observed toxic reactions, including allergies, dermatitis, and cardiovascular and neurological side effects when improperly used. The widespread use of synthetic repellents derived from chemicals for mosquito control has disrupted natural habitats, highlighting the need to study and develop environmentally safe, biodegradable, low-cost, indigenous vector control technologies that individuals and communities can use with minimal risk. Insect repellents can be a practical and cost-effective way to avoid mosquito-borne infections. Considering natural mosquito repellent products as an alternative to developing new eco-friendly repellents could provide a collaborative solution to reduce negative impacts on the environment and human health [8].

Numerous therapeutic herbs and essential oils have demonstrated various pharmacological properties, including the ability to repel mosquitoes and insects. Natural medicines are gaining popularity due to their perceived safety and fewer adverse effects compared to synthetic ones [9]. Throughout

history, natural products have served as important sources of bioactive compounds and will continue to play a significant role in the development of novel medications. Traditional plant-based repellents have been used for generations as a personal protective strategy against many *Anopheles* species. Utilizing traditional plant knowledge to develop novel natural repellents as an alternative to chemical-based repellents is highly valuable [10]. Therefore, mosquito control research is crucial to halt the spread of diseases transmitted by mosquitoes and to protect the environment from the use of chemical pesticides [11].

### Essential oils and insect repellents

A substance that prevents arthropods from landing on or biting human skin is known as a repellent. Female mosquitoes are attracted to lactic acid and carbon dioxide in perspiration, which their antennae’s chemoreceptors can detect. Essential oils (EOs) are complex mixtures of plant-derived volatile organic chemicals that have been shown to have repellent effects. The monoterpenoids, sesquiterpenes, and alcohols found in EOs assist in explaining why they are repulsive. Various EOs containing constituents such as citronellol, citronellal,  $\alpha$ -pinene, and limonene have been found to have repelling properties. Recent studies have demonstrated that linalool, a naturally occurring terpene alcohol found in many flowers and spice plants, and eucalyptol, a natural organic substance, activate the odorant receptor neuron in a mosquito’s antennal sensilla. The odor-sensing-based repellent screen platform is a new approach for creating repellents or chemicals with novel modes of action against arthropods [4]. Repelling refers to the impact of a repellent on the sense of smell. The chemical used in repellents restricts the ability of insect humid sensory receptors to sense moisture by inhibiting this capacity, thereby making humans undetectable to insects [12].

### Herbal mosquito repellent roll-on

Essential oils are typically extracted through distillation, often using steam. Other techniques include cold pressing, resin tapping, wax embedding, solvent extraction, absolute oil extraction, expression, and wax extraction. Essential oils (EOs) are defined as volatile oils that have strong aromatic components and give a distinctive odor, flavor, or scent to an aromatic plant. Many natural EOs with mosquito repellent properties have been discovered and utilized [13]. They have various biological effects, such as antiseptic,

antibacterial, antiviral, and fungicidal properties. Additionally, their larvicidal activity, repellent effects, and insecticidal properties have been confirmed [14]. Roller bottles, which can be used to create customized blends, are a helpful tool for utilizing essential oils. The roller ball on top makes it easy to apply the precise amount to the desired area, as it delivers a portion of the mixture upon contact. Due to their size, they don't take up much space in your handbag or backpack.

**How to use an essential oil roller?**

The use of essential oils in roller bottles will save money because they last longer, and the dilution process doesn't harm the essential oils in any way; rather, it aids in getting the oils. As roller bottles are convenient to apply where they are needed and then massage them more thoroughly [15].



**Figure 1:** Illustrates Roll-on.

**Herbal mosquito repellent spray**

A larvicide is an insecticide used to control mosquitoes both inside and outside the home. It functions by inhibiting the turning of mosquito larvae into adult mosquitoes. The most effective technique for preventing mosquito breeding in water features is to clear the environment. Even a small amount of standing water can feed a significant number of mosquitoes because their larvae prefer shallow water. Therefore, water features deeper than two or three feet are less likely to be breeding habitats. However, the use of conventional pesticides in water sources comes with a number of risks for both the environment and people. Insecticide-

containing natural plant products have been tested recently to control a number of insect pests and vectors. Since mosquitoes breed in water, it is simple to control them in this environment, making larval mosquitoes an appealing target for pesticides [16]. A spray bottle is the most convenient method to apply this herbal formulation.



**Figure 2:** Illustrates of Spray.

**Material and Methods**

**Formulation and development**

Sr. No.	Chemicals	Supplier
1	Neem powder	Yogesh Pharmacy, Nanded
2	Tulsi powder	Yogesh Pharmacy, Nanded
3	Sandalwood powder	Yogesh Pharmacy, Nanded
4	Sandalwood oil	Shree Narayan Ayurvedic Pharmacy, Ahmedabad
5	Neem oil	Yogesh Pharmacy, Nanded
6	Peppermint essential oil	Spice Herbals and Amenities Pvt. Ltd.
7	Eucalyptus oil	Medizen Labs Private Limited
8	Rose essential oil	Natural biotech solutions
9	Lavender essential oil	ASG Mantra
10	Avocado carrier oil	Sheer Veda, Telangana

**Table 1:** List of chemicals.

Sr. No.	Equipment	Manufacturer
1	Electronic weighing balance	Dolphin Mumbai
2	pH meter	Equip-Tronics

**Table 2:** List of equipment. pH, Potential of Hydrogen.

Sr. No.	Ingredients	Quantity	
		In ml	In ml
1	Eucalyptus essential oil	0.4 ml	8 drops
2	Peppermint essential oil	0.5 ml	10 drops
3	Neem oil	0.5 ml	10 drops
4	Sandalwood oil	0.25 ml	5 drops
5	Lavender essential oil	0.25 ml	5 drops
6	Rose Essential oil	0.25 ml	5 drops
7	Avocado carrier oil	7.8 ml	

**Table 3:** Formula for roll-on.

**Procedure**

- Select a 10 ml roller bottle.
- Add the required amount of avocado carrier oil into the bottle.
- Add 0.4 ml of eucalyptus oil and 0.5 ml of peppermint oil to the carrier oil.
- Add 0.25 ml of lavender oil and rose essential oil to the bottle, respectively.
- Blend the oils well.



**Figure 3:** Herbal mosquito repellent roll-on.

Sr. No.	Ingredients	Quantity
1	Neem powder	5 gm
2	Tulsi powder	5 gm
3	Sandalwood powder	5 gm
4	Marigold petals	5 gm
5	Peppermint essential oil	0.25 ml
6	Eucalyptus essential oil	0.25 ml
7	Lavender essential oil	0.25 ml
8	Rose Essential oil	0.25 ml
9	Distilled water	Upto 100 ml

**Table 4:** Formula for liquid spray.

**Procedure**

- Weigh the neem powder, tulsi powder, sandalwood powder, and fresh marigold petals according to the formula.
- Add about 100 ml of distilled water to the mixture.
- Mix the solution thoroughly, allow it to cool, and then filter it.
- Once the solution has completely cooled, add 0.25 ml of eucalyptus oil, 0.25 ml of peppermint oil, and 0.25 ml of rose essential oil.
- Transfer the solution to a spray bottle for easy application.



**Figure 4:** Herbal mosquito repellent spray.

## Results

### Evaluation of Roll on

The evaluation of the roll-on produced the following results.

#### Physical analysis

- **Color:** Light yellow
- **Odor:** Fragrant.

#### Skin irritation test

The roll-on was applied to the skin and checked for irritation every hour. It was found to be non-irritating and was absorbed quickly. No redness or irritation was observed on the skin.



**Figure 5:** Skin irritation test.

### Roll on evaluation strips

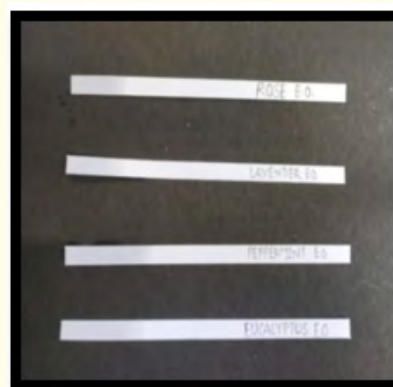
#### Fragrance testing strips

The fragrance testing strips were used to evaluate the aroma of both the essential oils and the final formulation. Unmarked strips were dipped into the oils for a few seconds before being removed. The strips were then held 3-5 inches away from the nose and a quick smell was taken. It was found that the oils were fragrant and non-toxic.

Mouillettes are strips or squares of plain absorbent paper used for testing scent formulations and specific fragrance components. They can either be dipped into your perfume or have perfume blend dropped or sprayed onto the strip. Drop individual oils onto the squares to see how the blend will smell before using it as a blending blotter [17]. Tester blotter strips, or Tester Blotters are small fragments of pH-neutral absorbent board that are used to test various scents and odours [18].



**Figure 6:** Fragrance testing strips.



**Figure 7:** Evaluation of essential oils.



**Figure 8:** Evaluation of formulation.



**Figure 10:** Surface layer uniformity.

### Evaluation of herbal spray

- **Physical appearance**
- **Color-** Yellowish orange
- **Odor-** Aromatic.
- **pH.**

The pH of the liquid spray was measured using a pH meter after diluting the liquid with distilled water. The pH was found to be 5.15 at 25°C.



**Figure 9:** Illustrates pH.

### Surface layer uniformity

The surface layer uniformity of the liquid was tested to determine whether the essential oils in the formulation formed a layer on the surface of water. To conduct this test, contaminated water was placed in a beaker, and the spray solution was added to the surface. The surface was then observed to determine if a layer formed on the water’s surface.

### Conclusion

Overall, the study aimed to develop and evaluate herbal mosquito repellents, including dhoop sticks, roll on, and liquid spray, to address the issue of mosquito-borne diseases. The use of plant essential oils has shown promise in providing mosquito repellent activity. The formulations were found to be safe, non-toxic, and cost-effective, making them a viable alternative to chemical-based mosquito repellents. The results indicate that the formulated herbal roll on and liquid spray are effective in repelling mosquitoes, and can help maintain a mosquito-free environment. The formulations are eco-friendly and less toxic, and insects are less likely to develop resistance to them. The study highlights the potential of herbal mosquito repellents as a safe and efficient alternative to chemical-based mosquito repellents, contributing to a healthier society.

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### Conflict of Interest

The statement regarding the absence of conflicts of interest regarding the investigation is clear and appropriate.

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