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"CITRUS SHIELD: FORMULATING MOSQUITO REPELLENT STICK FROM ORANGE PEELS"

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Abstract: Controlling mosquitoes and taking precautions against mosquito bites are two of the most crucial ways to prevent the spread of infectious diseases. The main objective of this study was to use natural ingredients to create a mosquito-repellent coil. In this composition, limonene oil was used as pesticide. Following the extraction of these oils, the proper proportions of gum acacia, water, camphor, turmeric, and activated charcoal were added to serve as a binder. Over time, the coil base material's many chemicals might burn slowly, decreasing or releasing insects. An effective and safe method of mosquito repellent is the use of naturally occurring compounds. Its formulation, evaluation, and characterization were finished for safe and effective use.

Most of mosquito-repellent products and devices are made up of synthetic materials presented in the market which cause various harmful effects on human beings. The resistance can be developed by the mosquito due to continuous exposure at high doses. Hence, the present research work represents the development and evaluation of mosquito repellent sticks with the help of various herbal products such as starch powder, wood powder, charcoal powder, eucalyptus oil, coconut oil, lavender oil, lemongrass, and cinnamon oil, peppermint and citronella, neem oil making them ozone-friendly, financial effective, non-harmful.

Key Words: Orange Peels (Limonene Oil), Garlic Oil, turmeric, Camphor, Orange peel powder, Activated Charcoal, Gum Acacia.

I.INTRODUCTION

1.1 INTRODUCTION TO ORANGE PEELS:

Most vector-borne diseases come into action in the monsoon season. Most of the floodwater habitats during monsoon include floodplains across streams, containers that hold water and fill up after a rain, tree holes that collect rainwater, irrigated fields and meadows, and so on. In damp soil or containers above the water line, mosquitoes lay their eggs, which hatch when rain floods the soil or container. Heavy rains can provide ideal mosquito breeding conditions in arid regions. Heavy humidity and drought favours mosquito breeding. Common vectors nowadays seen are mosquitoes which can transmit the Chikungunya virus, dengue, malaria, Zika virus, and West Nile virus, to humans (1).

They also cause skin infections. Mosquito bites can cause staph bacteria to enter the skin, especially if the bite is itchy. The bacterium can lead to cellulitis, a skin infection that results in fever, red, inflamed skin, and skin

swelling (2). Even though many medicines and formulations are used for these diseases, certain people opt for natural remedies to prevent risk factors. Essential oil (limonene oil) obtained from orange peel has repellent potency against insects such as mosquitoes and shows antimicrobial activity against Staphylococcus aureus. Based on the literature study, Reactive oxygen species (ROS) and free radicals are involved in the pathogenesis of cancer, *D-Limonene*, a monoterpene present in citrus fruit, has been reported for its potential anticancer activities (4).

Figure: Limonene Oil

1.2 INTRODUCTION TO GARLIC OIL:

Garlic, known for its pungent aroma and culinary uses, has also been explored for its mosquito-repellent properties. Tuetun *et al*. (2004) evaluated the repellent properties of celery, a plant closely related to garlic, against mosquitoes under laboratory and field conditions. While the study focused on celery, garlic's repellent potential may stem from similar sulfur compounds present in both plants. Further research is warranted to investigate the efficacy of garlic-based repellents and their practical application in mosquito control [3].

Garlic contains sulfurs that are successful against mosquitoes. Marigolds possess an unpleasant smell that mosquitoes hate. However, there is no study about combining those three ingredients as a patch. [5]

Figure: Garlic Oil

1.3 INTRODUCTION TO TURMERIC:

Turmeric has been found effective in controlling certain agricultural and animal pests due to the presence of a variety of bioactive constituents that interfere with insect behavior and growth. Its products have been found active as insect repellents and insecticidal agents. The international literature reports on insect control properties of turmeric about the powder, the plant extracts, the essential oil, and certain bioactive constituents of the plant. [8]

Turmeric is one of most essential spices all over the world with a long and distinguished human use particularly in the Eastern civilization (Ravindran, 2007). It is a deep yellow-to orange powder that comes from the underground stems of the tropical perennial herb *Curcuma longa* of the family Zingiberaceae. [10]

Figure: Turmeric

1.4 INTRODUCTION TO CAMPHOR:

Mosquitoes are vectors of several life-threatening diseases, including malaria, dengue, Zika virus, and chikungunya. Traditional chemical-based repellents, such as DEET (*N-Diethyl-meta-toluamide*), are widely used but pose health and environmental concerns. Natural alternatives like camphor offer a promising solution with lower toxicity and biodegradability.[11]

Camphor (C10H16O) is a terpenoid with a strong aromatic odor and notable volatility. It exhibits antimicrobial, antifungal, and insect-repellent properties, making it a valuable compound in traditional and modern medicine. The volatile nature of camphor allows it to act as an effective spatial repellent against mosquitoes.[10]

Figure: Camphor

1.5 INTRODUCTION TO GUM ACACIA:

Binding agents or binders are useful in achieving various tablet mechanical strength and drug release properties for different pharmaceutical purposes. Binders are agents employed to impart cohesiveness to the granules. This ensures the tablet remains intact after compression as well as improving the flow qualities by the formulation of granules of derived hardness and size. The choice of a suitable binder for a tablet formulation requires extensive knowledge of the relative importance of binder properties for enhancing the strength of the tablet and also of the interactions between the various materials constituting a tablet. [14]

To hold various powders together to form a tablet is a binder, fillers usually do not have the good binding capacity, the binder is either added in a dry mix or mix in granulation or mix in granulating liquid, binder form matrix with fillers and drug embedded in it, on drying solid binder forms glue which holds the particles together, the wet binder is the most important binders are hydrophilic & most times soluble in water. [13]

The mechanical properties of binder film are important as well and a good tablet binder should be able to offer flexibility and plasticity and yield without rupturing to absorb the effect of elastic recovery. [14]

Figure: Gum Acacia

Lavender essential oil is a clear liquid, either colorless or slightly yellowish, derived from the aerial parts of the plant. It boasts a fresh, herbal aroma with a subtle camphorous note. The oil's chemical composition has been thoroughly studied, revealing over 300 distinct components**,** many of which exhibit significant biological activity. From a chemical perspective, essential oils are complex mixtures primarily made up of terpene compounds, along with derivatives of phenyl propane, and additional substances that include sulfur and nitrogen compounds, as well as acetylene derivatives. These components can have characteristics of hydrocarbons, alcohols, aldehydes, ketones, esters, and ethers.[13The primary components of lavender essential oil are linalyl acetate, which makes up an impressive 45.6% to 60%, and linalool, accounting for 30.8%.[12]

II.NEED OF THE STUDY

Aim:

To develop and provide an effective, safe, and eco-friendly mosquito repellent stick that protects individuals from mosquito bites and reduces the risk of mosquito-borne diseases.

Objectives:

1. **Effective Repellency** – To formulate mosquito repellent sticks using natural or chemical ingredients that effectively repel mosquitoes.

2. **Safety Assurance** – To ensure that the product is non-toxic, skin-friendly, and safe for humans and pets.

3. **Eco-Friendly Composition** – To incorporate biodegradable and environmentally sustainable materials.

4. **Long-Lasting Protection** – To enhance the duration of repellency to provide extended protection against mosquitoes.

5. **Affordable and Accessible** – To produce cost-effective repellent sticks that are affordable and accessible to a wide population.

6. **Aroma Enhancement** – To include pleasant natural fragrances that enhance user experience while repelling mosquitoes.

7. **Ease of Use** – To design a product that is simple to use and convenient for indoor and outdoor applications.

8. **Reduction of Mosquito-Borne Diseases** – To contribute to public health by minimizing exposure to diseases like malaria, dengue, and Zika virus.

9. **Market Availability** – To ensure proper distribution and availability of the repellent sticks in rural and urban areas.

10. **Sustainable Production** – To promote eco-friendly manufacturing processes that minimize pollution and waste.

III.MATERIALS & METHODS

The selection of plants was based on an analysis of several publications, their availability as essential oil-based insect repellents, experimental findings, and their uses.

3.1 MATERIALS

3.1.1 Content of the mosquito repellent

1. Limonene Oil: The rind of citrus fruits, including oranges, lemons, and limes, contains a substance called limonene. About 97% of the essential oils found in orange peels are contained in these peels.Its primary chemical form, d-limonene, is frequently used.

Figure: Limonene Oil

2. Garlic Oil: Garlic oil is a natural mosquito repellent due to its strong odor and sulfur compounds, which mosquitoes find unpleasant. It works by masking human scent and interfering with mosquitoes' ability to locate their hosts.

Figure: Garlic Oil

3. Turmeric: Turmeric (Curcuma longa) contains curcumin, a bioactive compound with strong insect-repelling properties. Studies suggest that turmeric can effectively repel mosquitoes due to its strong odor and natural antimicrobial properties.

Figure: Turmeric

4. Camphor: The main way that camphor works as a mosquito repellent is by interfering with the mosquito's olfactory senses.

Figure: Camphor

5. Orange Peel Powder: Orange peel powder is a natural mosquito repellent due to the presence of limonene, a compound known for its insect-repelling properties. Citrus scents naturally deter mosquitoes and other insects, making orange peels an eco-friendly alternative to chemical repellents.

Figure: Orange Peels Powder

6. Activated Charcoal: Activated charcoal is used in mosquito repellent sticks to reduce the emission of toxins. It can also be used as a binder in mosquito-repellent coils.

Figure: Activated Charcoal

6. Gum Acacia: Gum acacia, also known as gum Arabic, is a natural gum derived from the sap of Acacia trees. It has a wide range of applications across various industries As a thickening, emulsifier, or food stabilizer, gum acacia enhances the texture of food products without compromising other aspects like flavor.

Figure: Gum Acacia

3.2 METHODS

3.2.1 Rearing Mosquitoes

LARVAL MAINTENANCE

To raise mosquito larvae, use a 30 cm x 12.5 cm white enamel pan filled with about 500 first instar larvae of *Aedes* or *Anopheles* species. Start with 0.5g of oats, but you'll learn to estimate this amount. This method avoids dirty water caused by mixing yeast and oats since both types of larvae feed from the bottom. For water, use rainwater or tap water, but distilled water is best. If using rainwater from artificial containers, be cautious of bacterial growth, which may require aeration. Distilled water does not need aeration at any stage of larval growth.

Figure: Collection of Larvae

ADULT MAINTENANCE

When pupae emerge from the larvae, we carefully use a pipette to transfer them into a glass jar with a conical gauze net. This net, 16 cm wide and 19 cm tall with a 2.5 cm opening, prevents adult mosquitoes from drowning and ensures females lay eggs in designated bowls. We provide a 10% glucose solution for mosquitoes that haven't fed, using a small tube inside a larger one.

The smaller tube, covered with lint, acts as a wick to keep the solution moist. We clean the wick and change the glucose solution twice weekly. Mosquitoes need space to mate. A 30 cm^3 netting cage is ideal for species that mate in captivity. We maintain about 500 mosquitoes—250 males and 250 females—to ensure proper mating. Too many lead to high mortality, while too few result in inadequate fertilization.

Female mosquitoes require blood to mature their eggs. We use guinea pigs or chickens for *Aedes* and *Culex* spec*ies while Anopheles*, which prefer human blood, often struggle due to a lack of volunteers. They feed best from calm, sedated animals. When oats are sprinkled in the water, larvae quickly gather to feed. We avoid disturbing the bowl to prevent oats from clumping, which could trap and kill some larvae, ensuring successful rearing.

Figure: Maintenance of Larvae

CAGE TRANSFER

These larvae were placed in a net cage that cover to a glass chamber and supplemented daily with fish food. After the growth of larvae into mosquitoes are feed with sucrose solution and these are transferred to another cage. 13, 5-7 days old mosquitoes were placed in the net cage. The sticks were lighted and placed beside the mosquito net cage make sure that. The duration of exposure was hours. The behavior of the mosquitoes such as freely moving in the net, aligned on the net.

Figure: Cage Transfer

3.2.2 Formulation of Herbal Mosquito Repellent Stick

1. Limonene Oil Extraction:

1. Preparation of Raw Material

- Select fresh citrus peels (orange, lemon, lime, or grapefruit).
- Wash the peels to remove dirt, pesticides, or wax coatings.
- Chop or grind the peels into small pieces to increase surface area, making extraction more efficient.

2. Setting Up the Steam Distillation Apparatus

A typical steam distillation setup includes:

- **Boiler/Steam Generator**: Produces steam.
- **Distillation Flask**: Contains the citrus peels and allows steam to pass through.
- **Condenser**: Cools the vapor to convert it back into liquid.
- **Separator/Collection Flask**: Collects the condensed liquid and separates oil from water.

3. Steam Generation and Distillation

- Heat water in the boiler to generate steam.
- Direct the steam into the distillation flask containing citrus peels.
- The steam causes the essential oil (limonene) to evaporate along with water vapor.

4. Condensation and Collection

- The vapor mixture passes into a condenser, where it cools down and turns back into liquid.
- The condensed liquid is collected in a separator, where the oil (limonene) floats on top of the water.

5. Separation of Limonene Oil

- Since limonene is hydrophobic, it naturally separates from the water.
- Carefully decant or use a separating funnel to extract the limonene oil.

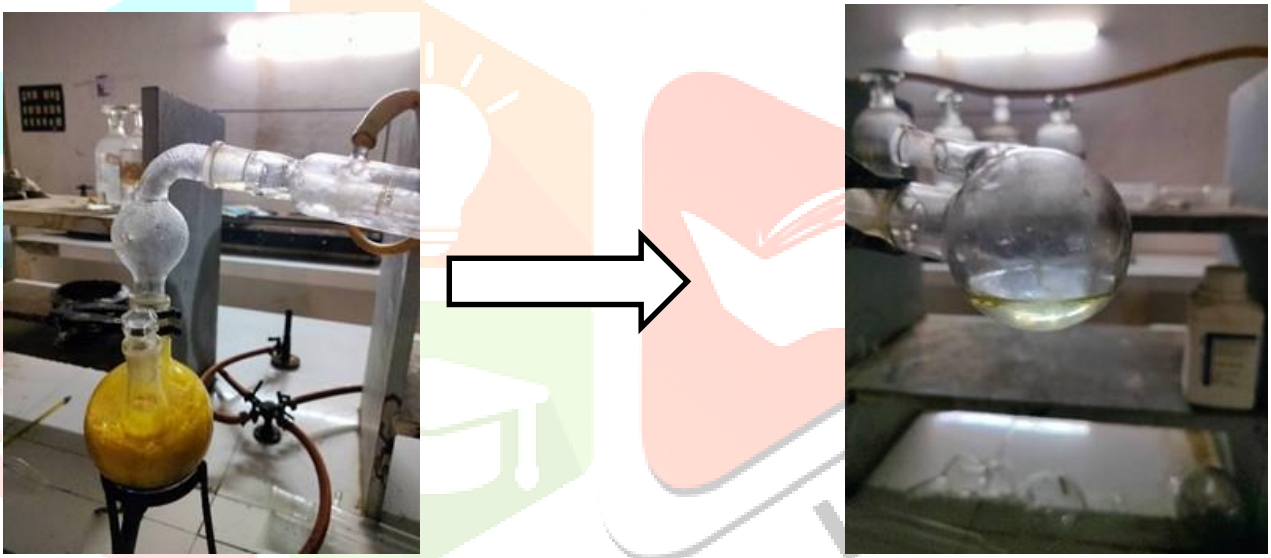

Figure: Extraction Process of Limonene Oil

2. Collection and measuring raw material:

- Collect and weigh all ingredients like Limonene Oil, Camphor, Garlic Oil, Turmeric, Orange Peel powder, Activated Charcoal & Gum Acacia.

3. Adding of raw material:

- Firstly, we have add 1 g starch powder in 10 mL of water and heat continuously to form the sticky gel formulation.
- After that add Turmeric, Orange Peel powder, Activated Charcoal & Gum Acacia. and camphor and mix properly.
- Add in beaker one by one and mix well then add the Garlic Oil, Limonene oil and water stir it, then add a suitable quantity of Gum acacia.

Figure: Adding Raw Materials

Sr. No.	Ingredient	Pictures	Quantity (g) or (ml)	Category
1	Limonene Oil		7.5 ml	Mosquito Repellent
2	Garlic Oil		2 ml	Mosquitoes Repellent
3	Turmeric		2 gm	Strong Aromatic as a Mosquito Repellent
4	Camphor		2 gm	Natural Insecticide
5	Orange Peel Powder		2 gm	Mosquito repellent

6	Activated Charcoal		2 gm	Reduces Emission of toxins
7	Gum Acacia		1 gm	Binding agent

Table: Formulation of Herbal Mosquito Repellent Stick

4. Consistency:

- Heat for five minutes.
- Thoroughly mix the ingredients, form the mixture into dough Once desired consistency is acquired turn off the flame then add lavender essential oil for fragrance and wait for 1-2 minutes at room temperature.

Figure: Dough Formulation

5. Cooling:

- Then prepared mosquito repellents stick by hand roll method and dry at room temperature.

Figure: Cooling of Stick

IV.EVALUATION

4.1 PHYSICAL EVALUATION:

- The color and odour of the prepared soap were observed. with the naked eye keeping it on a white background.
- The order of the Stick Smoke was smelled.
- Texture Check by pressing Stick.

Sr. No.	Physical Parameter	Result
1	Color	Dark Green
2	Odour	Lemon Like
3	Texture	Solid

Table: Physical Evaluation

4.2. PHYSIOCHEMICAL EVALUATION:

4.2.1 Mosquitoes Repellent Activity Test:

To evaluate mosquito repellent activity, the formulated mosquito repellent stick was checked for its flammability, burning efficiency with respect to burning time, and comparatively effective repellent activity.

Figure: Death Mosquito

4.2.2 Flammability Test:

The flammability test of this stick was evaluated to check its consistent combustibility. After that, the time taken to burn the stick.

Figure: Flammability of Mosquito Repellent Stick

4.2.3 Smoke Toxicity Test:

the smoke produced and its harmful effects such as infuriation, struggle of breath, and running of nose and eye were observed and recorded.

4.2.4 Feedback from 20 volunteers:

The feedback on mosquito repellent incense stick was taken from 20 people and requested to evaluate the formulation.

4.2.5 Ash Weight:

It is carried out by Weighing the ash that forms after ignition of the repellent stick on weighing balance.

V.RESULT

PHYSICAL & PHYSIOCHEMICAL DATA

Sr. No.	Parameters	Result
1.	Color	Dark Green
2.	Odor	Lemon Like
3.	Texture	Solid
4.	Mosquitoes Repellent Activity	8 min
5.	Flammability Test	10 min
6.	Smoke Toxicity Test	Non-Toxic
7.	Health Impact Testing	No
8.	Ash Weight	0.12 gm

BEHAVIOUR OF MOSQUITOS ON IGNITION

Sr. No.	Areas	Observation	Remarks
1	Houses	Mosquitoes escaped	Less irritation and mosquitoes repelled
2	Hostel	Mosquitoes escaped	No irritation or allergic reaction. Mosquitoes repelled
3	Cage	Mosquitoes dead	Mosquitoes dead

FEEDBACK FROM 20 PEOPLE

Parameters	Excellent	Good	Average	Poor
Product elegance	15	5	_ _ _	_ _ _
Mosquito repellency	15	3	_ _ _	2
The odor of the incense stick	13	5	1	1
Allergy	_ _ _	_ _ _	_ _ _	_ _ _

VI.CONCLUSION

This study successfully developed a mosquito-repellent stick using a natural base. The stick formulation in this investigation produces impressive results. Plant essential oil provides a significant repellent effect against a variety of mosquito species. Based on the study's findings, we can say that it is safe for human usage and a useful tool for preventing diseases spread by mosquitoes. The sticks's formulation may offer a practical, cost-effective, and convenient means of preventing diseases spread by mosquitoes, including dengue and malaria. [16]

The goal of the current study was to create and assess a polyherbal insect-repellent Stick. This study uses various plant essential oils to build a polyherbal insect-repellent Stick. We found that plant essential oils outperform plant extracts in terms of repellency when used in this mixture. The flammability test, color, texture, aroma, and mosquito repellency of the created Stick were all assessed. Since the essential oils in this Stick are made from herbal plants, it is safe to use and have no negative side effects. [17]

A complete literature survey was find out previous preparation of mosquito repellent sticks. The essential oils have mosquito repellent activity such as eucalyptus oil, citronella oil, neem oil, lavender and coconut oil, lemongrass and peppermint oil, cinnamon oil, etc selected and prepared stick by using a binder. The sticks were subjected to evaluation and the result was very satisfactory. [13] The feedback on results was also satisfactory when given to 6 panels of people. The stick was also tested for allergic symptoms and the result was obtained that no such allergic symptoms as coughing, sneezing, or constricted breathing were reported. Hence the outcome is signified by the mosquito repellent activity.

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