



Formulation and Evaluation of Poly Herbal Mosquito Repellent Candle

Chougule AG, Kore VD, Jadhav SS and Awati SS*

Dr. Shivajirao Kadam College of Pharmacy, India

***Corresponding author:** Suhas S Awati, Professor, Dr. Shivajirao Kadam college of Pharmacy, Kasabe Digraj, Tal- Miraj, Dist Sangli, 416305, India, Email: awatiss@gmail.com

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Abstract

Herbal plants contain various biologically active compounds that are useful in various diseases. Uses of herbal ingredients are on demanding as they are safe, effective and not harmful. The burdens of diseases caused due to mosquitoes are on rise. Commonly known diseases caused by mosquitoes are malaria, dengue, chicken gunya, filariasis, yellow fever and Zika virus. Herbal Mosquito Repellent Candle study aims to develop an eco-friendly and effective alternative to chemical-based mosquito repellents. The research review for this study involves selection of suitable herbal raw materials, formulation and evaluation of candles efficacy in mosquito repelling activity. This research focuses on preparation and evaluation of a new mosquito repellent candle aimed at providing effective protection from mosquitoes. The candle is formulated using natural Herbal ingredients and essential oils such as Neem, Marigold, Lemongrass, Clove, Rosemary and Lavender oil which are known for their mosquito repellent activity, ensuring its safety. These herbal ingredients and oils were incorporated into melted wax. It helps as remedy for the mosquito-borne diseases. Formulated candle was tested in laboratory room temperature. The prepared candle is evaluated for its colour, fragrance, appearance, flammability test, burning time, irritancy test, stability, presence of smoke and its repellent activity. Burning test shows effectiveness because of natural ingredients and essential oils present in candle Candle was observed for its safety, efficacy and irritancy. it does not cause any irritation to skin or any allergic reaction. Herbal mosquito repellent candle is beneficial for repelling mosquitoes and human health also.

Keywords: Herbal; Mosquito; repellent; candle

Abbreviations: ORs: Olfactory Receptors; GRs: Gustatory Receptors; CO₂: Carbon Dioxide.

Introduction

Mosquitoes are among the most troubling blood-sucking insects affecting humans [1]. They are small insects that belong to the family Culicidae [2]. Species of mosquitoes

in the Anopheles, Culex, and Aedes genera are vectors for pathogens causing diseases like Dengue, Malaria, Yellow Fever, and many other infections [3]. Additionally, mosquitoes transmit Zika virus, Chikungunya, Japanese Encephalitis, Rift Valley fever, West Nile virus, and Lymphatic Filariasis. Mosquito-borne diseases are a significant health problem in tropical and subtropical regions worldwide, and controlling these diseases is becoming increasingly

challenging. Effective mosquito control is crucial given the rising incidence of mosquito-borne illnesses. Mosquitoes spread diseases by picking up a virus or parasite during a blood meal from an infected human or animal. The mosquito and the virus do not harm each other, but the virus multiplies within the mosquito. Subsequently, the mosquito transmits the virus to other humans when biting them. Mosquitoes are responsible for infecting over 700 million people annually, resulting in more than one million deaths worldwide [2,3]. Using mosquito repellents is an effective method to prevent these diseases. A mosquito repellent is a substance applied to the skin, clothing, or other surfaces to deter mosquitoes from landing or climbing on that surface. While traditional chemical repellents are effective, they often raise concerns due to potential health risks and environmental impact. Consequently, there is growing interest in natural, herbal alternatives that are safe and environmentally friendly. This project focuses on the formulation and evaluation of a herbal mosquito repellent candle. Candles offer a convenient and pleasant method of repelling mosquitoes. By incorporating natural herbal ingredients and essential oils known for their mosquito repellent properties, such as neem, clove, orange peel, lemongrass, marigold, rosemary, and lavender, we aim to create a formulation that is both safe and non-toxic.

Mosquito-Borne Diseases

Malaria: Malaria is caused by Plasmodium parasites transmitted through the bites of female Anopheles Mosquitoes [4]. Globally, malaria remains a critical concern, with approximately 249 million cases reported in 2022, leading to about 619,000 deaths. Pregnant women and children under five are particularly at risk. Malaria can lead to severe anaemia, cerebral malaria, and death if untreated.

Dengue: Dengue is caused by mosquitoes *Aedes aegypti* and *Aedes albopictus*. Dengue fever is widespread, particularly in the Americas and parts of Africa. In 2023, the Americas reported about 4.1 million suspected dengue cases, including 6,710 severe cases and 2,049 deaths. Brazil experienced the highest number of suspected cases, with over 2.9 million. In Africa, reported a significant dengue outbreak with 146,878 suspected cases and 688 deaths.

Severe dengue can lead to hospitalization and death, particularly among children and those with compromised immune systems.

Chikungunya: Chikungunya is caused by mosquitoes *Aedes aegypti* and *Aedes albopictus*. As of 2023, the Americas have experienced a significant increase in Chikungunya cases, with over 214,000 reported in the first few months alone. Paraguay has been particularly affected, recording its highest number of cases in history with 138,730. Other countries like Argentina and Uruguay have also reported local transmission for the first time, while Bolivia has seen high levels of both Chikungunya and dengue transmission. Chikungunya is

characterized by an abrupt onset of fever and severe joint pain. This joint pain typically lasts for a few days but can persist for weeks, months, or even years in some cases.

Yellow Fever: Yellow fever virus is transmitted to people primarily through the bite of infected *Aedes* or *Haematosis* species mosquitoes. As of 2023, yellow fever is either endemic in 34 nations in Africa and 13 countries in Central and South America, or has endemic areas in those regions. According to a study based on data from African sources, there were between 84000 and 160000 severe cases and 29000–60000 deaths from yellow fever in 2013.

These diseases are influenced by factors such as climate change, increased travel, and urbanization, which contribute to the spread of mosquito vectors. Efforts to control and prevent these diseases include improving surveillance, promoting preventive measures like the use of insect repellents and mosquito nets, and enhancing healthcare infrastructure to manage outbreaks effectively.

Mosquito species and diseases caused by them:

- *Aedes* Mosquitoes:

Species: *Aedes Aegypti*, *Aedes Albopictus*.

Diseases: Dengue fever, Zika Virus, Chikungunya, Yellow fever

- *Anopheles* mosquitoes:

Species: *Anopheles Funestus*, *Anopheles Gambiae*

Diseases: Malaria

- *Culex* Mosquitoes:

Species: *Culex Pipiens*, *Culex Quinquefasciatus*.

Diseases: West Nile Virus, Japanese Encephalitis, St. Louis Encephalitis, Lymphatic Filariasis.

- *Mansonia* Mosquitoes:

Species: Various Species

Diseases: Lymphatic Filariasis [5].

Lifecycle of Mosquitoes

The lifecycle of a mosquito consists of four distinct stages: egg, larva, pupa, and adult [5].

Egg: Female mosquitoes lay their eggs on or near water surfaces. Eggs can be laid singly or in clusters. The eggs require water to hatch, which can take from a few days to several weeks, depending on the environmental conditions.

Larva: Once hatched, the larvae, commonly known as “wigglers,” live in the water. They go through four growth stages called instars. Larvae feed on organic matter in the water, including algae and microorganisms. They breathe air through a siphon at the surface of the water.

Pupa: After the larval stage, mosquitoes enter the pupal stage, also called “tumblers,” because of their movement in the water. This is a non-feeding stage where the mosquito undergoes transformation into its adult form. The pupal stage lasts from a few days to a week, depending on temperature and species.

Adult: The adult mosquito emerges from the pupal case and rests on the water surface to dry its wings and body before flying away. Adult mosquitoes typically live for a few weeks to a few months, depending on species and environmental conditions. Female mosquitoes seek blood meals for egg development, while males generally feed on nectar and other plant juices.

The entire life cycle, from egg to adult, can take as little as 8-10 days under optimal conditions but may take longer depending on environmental factors (Figures 1-4).

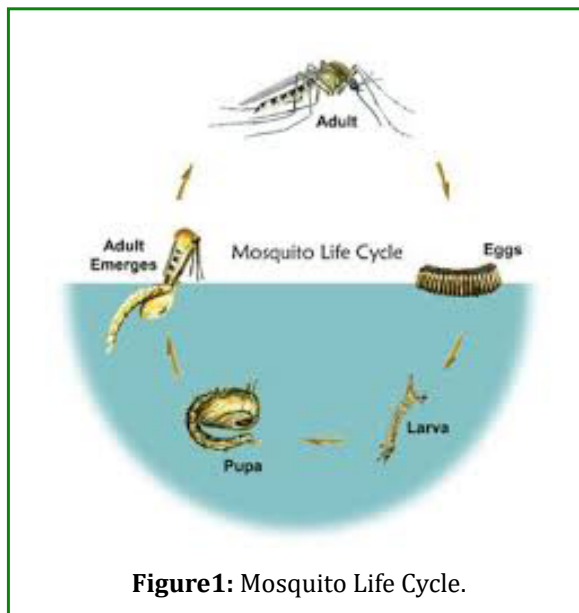


Figure1: Mosquito Life Cycle.

Prevention and Control of Mosquito-Borne Diseases

Mosquito Repellents: Use insect and mosquito repellents containing mosquito repellent and dying activity to prevent mosquito bites such as dhoop, candle, sticks, Coils, etc.

Mosquito Nets: Sleep under mosquito nets, especially in areas where mosquito-borne diseases are prevalent or mosquitoes are in more numbers.

Eliminate Breeding Sites: Remove standing water where mosquitoes breed.

Regular Cleaning: Keep gutters clean and unclogged to prevent water accumulation, regular clean water tanks, drains and surrounding areas.

Clothing: Wear long sleeves and pants, especially during peak mosquito activity times, and use mosquito-repellent clothing.

Vaccines and Medication: In areas where vaccines or medications are available for specific diseases like malaria or dengue, utilize them as recommended.

Mosquito Repellents

Mosquito repellents are substances designed to deter

mosquitoes from approaching or landing on surfaces, particularly human skin [1]. They are substances applied to skin, clothing or other surfaces. They work by making the treated area unattractive or offensive to mosquitoes, thereby reducing the likelihood of bites and potential transmission of mosquito-borne diseases such as malaria, dengue fever, and Zika virus. Mosquito repellents can be formulated as sprays, lotions, creams, coils, or electronic devices.

Types of Mosquito Repellents

Chemical Repellent: DEET, Picaridin, Ethyl butyl acetyl aminopropionate.

Natural Repellents: Oil of lemon eucalyptus, citronella, other essential oils (Lavender oil, Rosemary oil, neem oil)

Wearable Repellents: Repellent wristbands, Clip-On devices.

Spatial Repellent: Candles, Coils, Dhoops, Sticks, Electric diffusers and plug-Ins.

Mosquito Repellent Clothing: Permethrin-treated clothing.

Ultrasonic Repellents: Ultrasonic devices [6].

Mechanism of Action of Mosquito Repellence

Usually, mosquito repellents work by masking human scent or by using a scent which mosquitoes naturally avoids and find unpleasant [7]. Mosquito repellents function by targeting the olfactory receptors (ORs) and gustatory receptors (GRs) of mosquitoes. By disrupting these receptors, repellents make it difficult for mosquitoes to find and bite humans. Mosquitoes use their olfactory system to detect carbon dioxide (CO₂) and other human odors, which guide them to their hosts. Mosquitoes use heat sensors to detect body heat emitted by warm-blooded hosts. Repellents acting as contact irritants to discourage landing and biting [8].

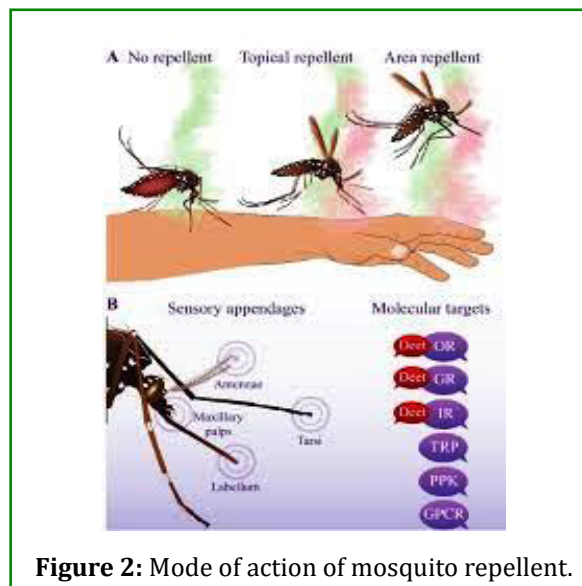


Figure 2: Mode of action of mosquito repellent.

Polyherbal Mosquito Repellent Candle

A polyherbal mosquito repellent candle is a type of candle designed to repel mosquitoes using natural ingredients. It is typically made from plant-based natural herbs and their essential oils known for their mosquito repellent properties. These candles also commonly use natural wax like soy, bees wax or palm wax. This is eco-friendly alternative to chemical repellents and has become popular. Chemical-based products are commonly used to control mosquitoes, but their synthetic components make them toxic to the human body. Due to these toxicity concerns, there is a growing demand for the development of herbal-based mosquito repellents in the market [9].

Advantages of herbal mosquito repellent candles:

- Herbal mosquito repellent candles are lighter in weight, height hence is easy to use, handle anywhere and transport.
- They contain essential oils used for repellent properties which impart a pleasant fragrance over strong scent.
- They contain natural ingredients and natural essential oils hence they are safe and less likely to cause irritation to skin or allergic reactions.
- They are Eco-friendly as they are biodegradable.
- Herbal mosquito repellents are generally less toxic to non-target organisms.

Materials and Methods

The selection of the plants was based on their availability as raw materials, scientific evidence and folkloric use as mosquito repellents.

Neem

Biological Name: *Azadirachta indica*

Family: Meliaceae

Uses: Neem is used for its mosquito repellent activity. The main active ingredient of Neem is Azadirachtin. Azadirachtin has been shown to inhibit larval, pupal and adult moults and reproduction of both plant feeding and aquatic larvae like mosquitoes. Neem is one of the safest methods to keep mosquito away from body. The effectiveness of neem will last approximately 3hrs and repel 70% of the mosquitos [8].

Lemongrass

Biological Name: *Cymbopogon citratus*.

Family: poaceae.

Uses: Lemongrass, also known as *Cymbopogon citratus* which contains Citronella oil, musk scents that attract mosquitoes such as carbon dioxide and lactic acid found in human. In other words, by applying repellent with Citronella oil ingredients, it actually blocks the scents being sensed by mosquitoes [10].

Marigold

Biological Name: *Calendula Officinalis*

Family: Daisy

Uses: The primary active constituents in marigold petals (*Tagetes* species) that contribute to them mosquito repellent activity is alpha-terphenyl and linalool marigold flower petal extract shows 100% mortality of mosquito larvae. The French marigold flowers were proven to have excellent mosquito repellent property [8].

Orange

Biological Name: *Citrus reticulata*

Family: Rutaceae

Uses: Orange peels can repel mosquitoes because mosquitoes do not like the smell of fragrances. Orange peel has been found to be an effective mosquito repellent. It contains essential oils, such as limonene, which have mosquito repellent qualities [11].

Clove

Biological Name: *Syzygium aromaticum*

Family: Myrtaceae

Uses: The clove contains eugenol, phenol, and beta – linalool has high mosquito repellent activity against mosquitos. Eugenol is the main bioactive compound of clove. The phenolic acid and gallic acid are the compound found in higher concentration for repellent mosquito activity [11].

Rosemary Oil

Biological Name: *Rosmarinus officinalis*

Family: Lamiaceae

Uses: Rosemary oil is effective as a mosquito repellent primarily due to its active constituents, particularly 1,8-cineole (also known as eucalyptol) and camphor. These compounds have insect-repelling properties [11].

Lavender Oil

Biological Name: *Lavandula aungustifolia*, *Lavandula officinalis*

Family: Lamiaceae

Uses: Lavender oil is known for its mosquito repellent properties, primarily due to its active constituents, linalool and linalyl acetate. These compounds contribute to its effectiveness in deterring mosquitoes [5].

Lemon Oil

Biological name: *Citrus limonium*

Family: Rutaceae

Uses: Lemon eucalyptus contains chemicals that repel mosquitoes and kill fungus. People use lemon eucalyptus oil to repel mosquitos [8].

Preparation of Poly Herbal Mosquito Repellent Candle

The beeswax taken and precisely weighed it. Beeswax chopped into small bits and melted in a beaker using a heating mantle. Once the Beeswax has melted appropriately, begin mixing neem, clove, and orange peel powders in a beaker while stirring constantly. Stirred the lemongrass and marigold juices into the beaker. Next, added lemon, lavender and rosemary oils. Filled a mould with thread that is the right size with the aforementioned mixture. Let the mould cool until it reaches room temperature. Taken the candle removed from the mould after three to five hours (Tables 1-3) [12].

Sr. No.	Ingredients	Quantity
1	Neem Powder	4 gm
2	Orange Peel Powder	2 gm
3	Clove Powder	4 gm
4	Lemon grass juice	4 ml
5	Marigold juice	4 ml
6	Rosemary oil	8-10 drops
7	Lavender oil	8-10 drops
8	Lemon oil	5-7 drops
9	Bees wax	50 gm

Table 1: Quantity of Materials.



Figure 3: Formulation of polyherbal mosquito repellent candle.

Result and Discussion

Result

Organoleptic test: This test was done visualising the formulation to evaluate the texture, colour and Fragrance.

Colour: colour of formulation was found to be green.

Fragrance: Fragrance of formulation was found to be satisfied.

Texture: Formulation texture was found uniform [12].

Irritancy test: It found that prepared mosquito repellent candle did not cause any irritation to skin by burning candles [13].

Uniformity of mass: Five candles of each group were selected and weighed individually. The weight of individual group was noted. Average weight was calculated, and the individual Weights were compared with the average weight. Average weight was observed 44.32 [7].

Candle No.	Weight of Individual Candle	Average Weight	Length (cm)	Width (cm)
C1	44.24	44.32	11.2cm	2.2cm
C2	43.83		11cm	2.2cm
C3	45.87		11.5cm	2.2cm
C4	44.39		11.6cm	2.2cm
C5	44.3		10.9cm	2.2cm

Table 2: Uniformity of Mass.

Burning time: Burning time visualized using 3 candles named as C1, C2, C3 respectively their Burning time is calculated using watch [7,12].

Candle No.	Burning Time	Application Time	Efficiency
C1	35 min.	6-7 pm	Good
C2	40 min.	6-7 pm	Good
C3	40 min.	6-7 pm	Good

Table 3: Burning Time and Efficiency of Candle.

Mosquito repellent activity net Test: Test conducted using small net. 10 mosquitoes are collected in net and checked for its activity for 5 minutes. Out of 10 mosquitoes 4 mosquitoes were died and 2 repels. The dying percentage of candle for mosquitoes is 40 % and repelling percentage is 20 % [8].



Figure 4: Mosquito repellent activity net Test.

Flammable test: The prepared candle was tested for flammability to explore mosquito repelling habits, and burned Quality with respect to burning time and subsequently its Spotting process effectiveness flammability test for candle was conducted to verify its apparent flammability in the laboratory [14].

Discussion

On basis of evaluation test studies and observations, it's found that the candle was done successfully using various try outs. Formulated candle was tested in laboratory room temperature. By burning a herbal mosquito repellent candle, with adequate number of mosquitoes, the burning efficiency and time, flammability rate and mosquito repellent activity of candle was assessed. This test shows effectiveness because of natural ingredients and essential oils present in candle such as Neem, Marigold, Lemongrass, Clove, Rosemary and Lavender oil which are known for their mosquito repellent activity. These herbal ingredients and oils were incorporated into melted wax. The mixture was poured into suitable mold. Candle was observed for its safety, efficacy and irritancy.

Conclusion and Outcomes

Conclusion

The prepared herbal mosquito repellent candle is made using natural herbal ingredient, it does not cause any irritation to skin or any allergic reaction. The herbal mosquito repellent candle is very easy to use and handle as it is light in weight. Herbal mosquito repellent candle is beneficial for repelling mosquitoes and human health also. It concludes that used herbs and essential oils was very safe and effective to use as mosquito repellents.

Outcomes

Effective Mosquito Repellent: The herbal candle proved to be effective in repelling mosquitoes, providing a safer alternative to chemical repellents.

Non-Toxic and Safe: The use of natural ingredients ensures that the candle is non-toxic and safe for humans and pets, making it suitable for both indoor and outdoor use.

Eco-Friendly: The project reinforced the viability of creating environmentally friendly products that do not harm the ecosystem.

Aromatic Benefits: The inclusion of essential oils not only enhances the mosquito-repellent properties but also provides a pleasant fragrance and potential therapeutic benefits.

Practical Application: The candles are easy to prepare and can be used in homes.

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