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Development of Eco-Friendly Herbal Mosquito Repellent Candle

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ABSTRACT

Mosquito borne diseases like malaria, dengue, chikungunya and Zika virus are problems for public health all over the world. People usually use chemical mosquito repellents that have DEET in them. These can cause skin problems, breathing issues and pollute the environment. So people are looking for eco friendly mosquito repellent products. This study was done to make and test a mosquito repellent candle using natural things like neem powder orange peel powder, clove powder, beeswax and essential oils like lemongrass, lavender, rosemary and marigold oil.The herbal candles were made by melting the beeswax and adding the powders and essential oils to it. The candles that were made were checked for how they looked how they smelled how long they burned how smoke they made, if they caused irritation their melting point and how well they kept mosquitoes away. The results showed that the candles smelled nice looked smooth burned evenly and did not make smoke. One of the batches Batch D was the best in terms of how it looked and burned. The mosquito repellent candles worked well to keep mosquitoes away without causing skin problems.This study found that herbal mosquito repellent candles are an eco friendly alternative to chemical mosquito repellents. They are also biodegradable and cheap. These candles can be used at home to prevent borne diseases, like malaria, dengue, chikungunya and Zika virus and they do not have the bad effects that chemical repellents.

Keywords: mosquito repellent candle, mosquito, beeswax, neem powder, orange peel powder, eco-friendly mosquito repellent, essential oil

1. INTRODUCTION

As most people know, a mosquito is a small fly that belongs to the Culicidae family.

They are regarded as one of the most dangerous insects on Earth because they spread diseases and are responsible for taking millions of lives. For many years, illnesses carried by mosquitoes have been the main cause of sickness and death in humans.[1] One of the most worrying blood-sucking insects that affect people is the mosquito. Many species from the genera Anopheles, Culex, and Aedes are known to spread diseases, carrying pathogens that cause Dengue fever, malaria, yellow fever, Japanese encephalitis, and other illnesses.[2] In over 100 countries, nearly 40% of the world's population is at risk of infection. Globally, around 2500 million people get infected with various mosquito-borne diseases each year.[3]

Out of the more than 500 species of Anopheles mosquitoes known to science, more than 50 can spread malaria through the bite of an infected female mosquito. At present, vector management is the only suitable preventive measure available, and there is no effective prophylactic anti-malarial vaccine. Therefore, one of the most effective ways to reduce the occurrence of disease is to prevent mosquito bites.

Chemical mosquito repellant, such as those containing DEET (N,N-Diethyl-meta-toluamide), are widely used, but they can causes skin irritation, respiratory problems, and environmental pollution. As a result,there is an increasing demand for natural and eco-friendly mosquito control solutions.[4]A good way to prevent annoying mosquito bites, which can spread illnesses like Zika virus, chikungunya virus, dengue virus, and plasmodium, is to use mosquito repellents. There are many repellent products on the market, but they may vary in how well they work. In some less developed areas, people might not have easy access to effective repellents. Individuals who are more at risk of getting sick from diseases carried by insects may not have sufficient protection. Mosquito repellents are commonly used worldwide as a popular and practical way to stay safe. Some repellents, such as those containing DEET, can be costly and hard to find, while others may be quite effective. Additionally, some proven methods, like using mosquito nets, are not always regularly used by people in the community due to practical challenges.

When mosquitoes inject their saliva into a host's bloodstream, the antigens attach to IgG and IgE antibodies, triggering an immunological reaction. In addition to causing discomfort, itching, and redness, the reactions frequently result in bumps. Additionally, the saliva of the mosquite causes a very irritating, itchy rash. When humans come into contact with mosquitoes and develop an allergic reaction to their saliva, mosquito bites can also result in extremely painful skin inflammation.[5]

2. Mosquito Borne Disease

Malaria : malaria is caused by Plasmodium parasites, which are passed to humans through the bite of female Anopheles mosquitoes. It continues to be a major health problem worldwide, with about 249 million cases recorded in 2022, which caused nearly 619,000 deaths. Young children, especially those under five years old, and pregnant women are most vulnerable to the disease. Malaria can result in severe anemia.

Dengue:- dengue is transmitted by Aedes aegypti and Aedes albopictus mosquitoes.

Dengue fever is prevalent in many areas, particularly in parts of Africa and the Americas. In 2023, approximately 4.1 million suspected dengue cases were reported in the Americas, leading to 2,049 deaths and 6,710 cases of severe illness.[6]

Chikungunya :- chickengunya is caused by the Aedes aegypti and Aedes albopictus mosquitoes. In 2023, there has been a significant rise in chikungunya cases across the Americas. Within the first few months of the year, almost 214,000 cases were reported.

Paraguay has been the most affected country, with a record high of 138,730 cases. Bolivia has experienced high levels of both dengue and chikungunya transmission. Other countries, including Uruguay and Argentina, have also seen their first instances of local transmission. The disease is characterized by severe joint pain and a sudden fever. The joint pain typically lasts for a few days but can persist for weeks, months, or even years in some cases.[7]

Zika virus: The Zika virus is a type of virus that spreads through the bite of infected mosquitoes. It usually causes mild symptoms in most people. However, it is a major concern during pregnancy because it can result in serious birth defects.

Yellow fever: Yellow fever is a severe viral illness that causes bleeding and is spread by infected Aedes and Haemagogus mosquitoes in tropical regions of Africa and South America.

Symptoms such as high fever, headache, yellowing of the skin and eyes (jaundice), nausea, and vomiting typically appear 3 to 6 days after infection. Although many people recover, about 15% of cases develop into severe and life-threatening conditions, including kidney failure, liver failure, and severe bleeding. There is no specific treatment for yellow fever, so vaccination is the main way to prevent it.

West Nile virus :- west nile virus is mainly spread by Culex mosquitoes. Most people who get infected experience mild symptoms, but in some cases, the infection can lead to serious neurological problems.

3. Life cycle of mosquitos [9,10]

The life cycle of a mosquito consists of four clear stages: egg, larva, pupa, and adult.

Egg:-

A female mosquito lays her eggs close to the surface of water. These eggs may be laid in groups or one at a time, depending on the type of mosquito. The time it takes for the eggs to become larvae depends on the surrounding environment and can vary from a few days up to several weeks. The eggs need to be in water to grow and develop properly.

Larva:-

Also called "wigglers" after they hatch, larvae are aquatic organisms. They go through four stages of growth, known as instars. They feed on organic materials such as bacteria and algae found in the water. They breathe air through a tube-like structure at the surface of the water.

Pupa: After the larval stage, mosquitoes become pupae, which are also called "tumblers" because they move around in the water.

Pupa :-

During this stage, the mosquito transforms into its adult form and does not eat. The duration of the pupal stage varies depending on the species and environmental conditions, lasting from a few days to a week.

Adult:-

After coming out of the pupal case, the adult mosquito places its wings and body on the water's surface before flying away. The lifespan of adult mosquitoes varies depending on the species and their environment, typically ranging from a few weeks to several months. Male mosquitoes usually feed on nectar and other substances from plants, whereas female mosquitoes consume blood to support the development of their eggs.

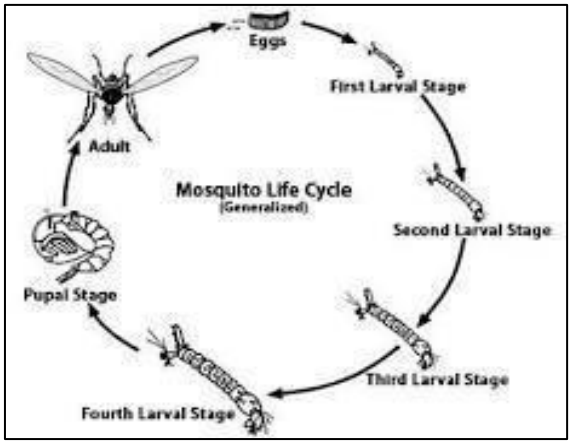


Figure no :-1 life cycle of mosquito

- **prevention and control of mosquito born disease:-**

Mosquito Nets: Use mosquito nets while sleeping, especially in areas where mosquito-borne diseases are common.

Eliminate Breeding Sites: Get rid of standing water where mosquitoes lay their eggs. Regular Cleaning: Keep gutters clear and free from blockages to prevent water buildup. Also, regularly clean water tanks, drains, and surrounding areas.

Clothing: Wear long sleeves and pants, particularly during times when mosquitoes are most active. Use clothing that has mosquito-repellent properties.

Vaccines and Medication: In areas where vaccines or medications are available for specific diseases such as malaria or dengue, follow the recommended schedule for vaccination or medication.

Mosquito Repellents: Mosquito repellents are products that help keep mosquitoes away from people or surfaces.They are applied to the skin, clothing, or other surfaces. These products work by making the treated area less attractive to mosquitoes, which reduces the chances of bites and helps prevent the spread of diseases like malaria, dengue fever, and Zika virus. Mosquito repellents come in various forms, such as sprays, lotions, creams, coils, or electronic devices.

1. **Types of Mosquito Repellents**:

Mosquito Repellent Gel: Insect repellents containing DEET are not recommended for individuals with urea cycle disorders, such as ornithine transcarbamylase (OTD) deficiency, as they can be harmful to these individuals.

Mosquito Liquid Repellent: To keep mosquitoes away, repellents are commonly used. These days, many people use liquid repellents to prevent mosquitoes from coming close. The bottle of liquid repellent contains the product, and it includes a graphite rod in the center. The repellent also has a heating coil. When the repellent chemical comes into contact with the heated rod, it produces a vapor that interferes with the mosquitoes' ability to sense their surroundings. The fumes from the repellent block the mosquitoes' chemosensors, making it hard for them to detect humans.

Mosquito Repellent Stick: Due to its repellent properties, mosquitoes are unable to use it.

People are searching for mosquito repellent sticks made from herbal plants that are low in toxicity and safe to use. Many plants found in regions with essential oils are known to be safe and effective as mosquito repellents.

Mosquito Repellent Lotion: Many studies have examined the advantages of using natural components to make mosquito-repellent lotions. One study investigated the effectiveness of lemon peel extract as a repellent against the Aedes aegypti mosquito. The findings indicated that a 5% concentration of lemon peel extract was effective in keeping Aedes aegypti mosquitoes away. Additional research on the use of lime peel extract showed that it could be up to 98% effective in repelling mosquitoes, particularly when using higher concentrations of essential oils from the peel.

Mosquito Repellent Spray: A mosquito repellent spray is a liquid or aerosol product applied to the skin or clothing to prevent mosquito bites. It typically contains an active ingredient like DEET, picaridin, or IR3535, which helps to keep mosquitoes away. This type of repellent spray can be purchased without a prescription from most pharmacies and grocery stores. It is important to follow the instructions on the product label when applying the spray to exposed skin and clothing. The spray should be reapplied as directed, especially after sweating or swimming.

2. Mode of action of mosquito repellent:

1. Mosquitoes detect humans by sensing lactic acid, carbon dioxide, and body odor.
2. Repellents work by interfering with the mosquito's sensory receptors.
3. DEET specifically blocks the receptors that mosquitoes use to sense lactic acid.
4. When these receptors are blocked, mosquitoes are unable to detect their host effectively.
5. Repellents also disrupt the mosquito's behavior when searching for a host.
6. Mosquitoes lose the ability to fly towards a human, especially against the wind.
7. As a result, the human becomes difficult for the mosquito to locate or detect.
8. After feeding on blood, mosquitoes exhibit a reduced response to lactic acid.
9. This leads to a temporary decrease in their host-seeking behavior.
10. Once they lay eggs, their sensitivity to lactic acid returns to normal.

❖ **Herbal Mosquito Repellant Candle :-**

A herbal mosquito repellent candle is a type of candle that uses natural ingredients to keep mosquitoes away. It is usually made from plant-based herbs and their essential oils, which are known for their ability to repel mosquitoes. These candles often contain natural waxes such as soy, beeswax, or palm wax. This serves as an eco-friendly alternative to chemical-based repellents, which have become increasingly popular. Chemical products are commonly used to control mosquito populations, but their synthetic ingredients can be harmful to the human body. Because of these health concerns, there is a rising demand for herbal-based mosquito repellents in the market.

Advantages of herbal mosquito repellent candles:

1. Herbal mosquito repellent candles are lightweight and not too tall, making them easy to use, carry, and place in different environments.
2. These candles include essential oils that help keep mosquitoes away, and they also give off a nice, pleasant scent instead of a strong or unpleasant odor.
3. They are made from natural materials and essential oils, which makes them safe to use and less likely to cause skin irritation or

allergic reactions.

4. They are eco-friendly because they are biodegradable, making them a good choice for the environment.

5. Herbal mosquito repellent candles are usually less harmful to other creatures compared to other types of repellents.

Disadvantages of herbal mosquito repellent candles:

1. The mosquito-repelling effect might not last as long as other repellent methods.

2. They may not work as well in open spaces or windy areas where the scent can spread quickly.

3. The essential oils in the candles can evaporate quickly, which may reduce their effectiveness.

4. If not made properly, the candles might not burn smoothly or consistently.

3. Selection of Appropriate Drug and Excipients

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

Table no 1 selection of drug and excipient

Ingredient	Synonym	Biological sources	Family	Chemical constituent	Uses
Beeswax 	Yellowwax, cera alba	Honeycomb of the honey bee, Apis mellifera Linn and other species of Apis.	Apidae	Ester of fatty acids and long-chain alcohols.	1) candle making 2) Lip balms and cosmetics 3) Ointments and creams 4) Waterproofing products 5) Herbal mosquito repellent candles
Neem powder [13] 	Nimba, Margosa	Neem is fresh or dry leaves and seed oil of Azadirachta Indica.	Meliaceae.	Azadirachtin, Nimbin Nimbidin ,Nimbidol, Gednin, Sodium Nimbinate.	1) Mosquito repellent 2)Antibacterial agent 3)Antifungal agent 4) Skincare products 5) Herbal medicines
Orange peel powder 	Cortrex Limonis	Lemon peel is outer part of pericarp of tye ripe fruit ofcitrus Limonis Burm.	Rutaceae.	23% sugar, 22% cellulose, 25% pectins, 11% hemicellulose, Vitamin C, Flavonoid.	1) Mosquito repellent products 2) Aromatherapy and fragrances 3) Food flavouring agent 4) Air fresheners[14]

Marigold oil 	Calendula, geranium, anemone.	Its genus of about50 species of annual herbs of Calendula Officinials.	Daisy.	Limonene, Terpinolene, (Z)-myroxide, Piperitone, Piperitenone, Piperitenone oxide and b - caryophyllene	1) Soothes rashes and soreness 2) Natural mosquito and insect repellent 3) Skin care and wound healing preparations 4) Antibacterial and antifungal applications
Clove powder 	caryophyllum, Laung	The dried, unopened flower of clove tree.	Myrtaceae	Eugenol acetate, Beta caryophyllene and alpha humulene	1) Natural mosquito repellent 2) Dental pain relief 3) Antibacterial and antifungal agent 4) Aromatherapy and perfumes 5) Herbal medicines
Lemongrass oil 	Fever grass, Cochin grass, Malabar grass,soft heads,oily heads	obtained from fresh Aerial part of Cymbopogon citratus.	Poaceae.	Citral Isoneral, Citonellal, Citronellol, Gerniol, Isogeranial, Geranyl acetate, Germacrene-	1) Perfumary Soap and cosmetic, also used as repellent. 2) Air fresheners and perfumes 3) Antibacterial and antifungal preparations 4) Stress relief and relaxation

Lavender oil 	Levenda, Foreign oil, Espliego.	It consists of fresh Flowering tops Levendula Officinalis, L. augustifolia.	Lamiaceae.	It consists of Volatile Oil contain linalyl acetate, linolool, cineol, terpin-4-ol.	1) Lavender is used in aroma by aromatic therapists to relieve fatigue, headache 2) Naturalmosquito repellent 3) Stress and anxiety relief 4) Herbal candles and air freshener.

Rosemary oil 	Romero, polar plant, Hoja de romeo.	It consists fresh and dry flower of rosmrinus officinalis.	Lamiaceae.	1,8 cineole (46.4%), Camphor (11.4%), Camphene (5.2%).	1) Natural mosquito repellent 2) Aromatherapy and stress relief 3) Hair care products 4) Memoryand concentration improvement

4. Aim and objective Aim:

The goal of creating a herbal mosquito repellent candle is to provide a natural, safe, and eco-friendly alternative to chemical-based repellents, which can effectively repel mosquitoes and lower the risk of diseases caused by mosquito bites.

Objectives:

1) To develop a mosquito repellent candle using herbal components such as orange peel, neem, lemongrass, or marigold oils.

2) To assess how well the herbal candle works in repelling mosquitoes both indoors and outdoors.

3) To guarantee that the candle is safe and non-toxic for people and the environment.

4) To minimize the harmful impact of synthetic mosquito repellents.

5) To produce a user-friendly and smoke-free mosquito repellent candle.

5. Methodology

A) Preparation of neem ,orange peel and clove extract :-

for the purpose of extraction we took 50 mL of coconut oil and added herbal powder into it.

Then we heated it slowly at temperature 50-60 ^{0}c for some time so that the medicinal properties of the herbs could mix properly with the oil.

that, we cooled the mixture and filtered it to remove the solid particles. The filtered oil obtained is called infused oil, which we used for candle preparation

Table no 2:-formulation table for herbal mosquito repellent candle

Sr no	Ingredient	Batch (A) (gm/ml)	Batch (B) (gm/ml)	Batch (C) (gm/ml)	Batch (D) (gm/ml)
1	Beeswax	12	8	15	15
2	Neem powder/extract	2	5	2	2
3	Orange peel powder/extract	1	2	2	1
4	Clove powder/extract	0.5	1	1	0.5
5	Rosemary oil	4-5 drop	4-5 drop	4-5 drop	4-5 drop
6	Marigold oil	5-6 drop	5-6 drop	5-6 drop	5-6 drop
7	Lemongrass oil	4-5 drop	4-5 drop	4-5 drop	4-5 drop
8	Lavender oil	2-3 drop	2-3 drop	2-3 drop	2-3 drop

6. Preparation of herbal mosquito repellent candle

Step 1: Measure and Weigh Beeswax

Use a weighing scale to accurately measure the required amount of beeswax for the formulation.

Step 2: Melt the Beeswax

Break the beeswax into small pieces and put them into a beaker. Heat the beaker slowly using a heating mantle until the beeswax is completely melted.

Step 3: Prepare the Herbal Mixture

Add the following ingredients to the melted beeswax:

- Neem powder or extract
- Orange peel powder or extract
- Clove powder or extract

Stir the mixture continuously to ensure that all the ingredients are well combined.

Step 4: Add Essential Oils

Mix the following essential oils into the beeswax mixture:

- Rosemary oil
- Lavender oil
- Lemon grass oil
- Marigold oil

Stir the oils for approximately 15 minutes to ensure they are fully incorporated into the beeswax.

Step 5: Pour into Mould

Carefully pour the prepared mixture into candle molds up to the desired height.

Step 6: Allow to Cool and Set

Let the candle cool at room temperature until it hardens completely.

Step 7: Remove from Mould

Once the candle has fully solidified, gently take it out of the mold. The herbal mosquito repellent candle is now ready to use.

Step 8: Pack the Candles

Place the finished candles into clean and dry containers or boxes. Store the packaged candles in a cool, dry place, away from direct sunlight.

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7. Result And Discussion:-

8. : Organoleptic characterization of herbal mosquito repellent candle

Sr no	parameter	Observation
1	Colour	Light green /dark green
2	Odour	Herbal aromatic smell
3	Texture	Hard and waxy
4	Surface	Non sticky and free from cracks
5	Burning	Burn evenly with less smoke
6	Appearance	Smooth and uniform
7	Shape	Desired mould shape

8.1. : Irritancy Test: The irritancy test showed that the prepared mosquito repellent candle did not cause any skin irritation when burned.

8.2. : Weight Variation: Four candles from each group were selected and weighed individually.

The weight of each group was recorded, and the average weight was calculated. Each individual weight was then compared to the average weight. The average weight was observed.

Candle no	Weight of individual (gm)
C1	15.1
C2	14.9
C3	14.7
C4	15.2
Average weight	14.9

8.3. : Burning Time: The burning time was observed using four candles, labeled as C1, C2, C3, and C4 respectively. The burning time was measured using a watch.





Candle no	Burning time	Application time	Efficacy
C1	20 min	6-7	Good
C2	15min	6-7	Poor
C3	25 min	6-7	Excellent
C4	35min	6-7	Excellent

8.4. Smoke Production: The herbal mosquito repellent candle was lit and observed during burning. The amount of smoke produced was assessed visually. The candle produced a minimal amount of smoke and burned evenly. No excessive or irritating smoke was noted during the test.

8.5. : Mosquito Repellent Activity

The herbal mosquito repellent candle was allowed to burn in a room for 30 minutes.

Throughout this time, there was a noticeable reduction in the number of mosquitoes and their level of movement. The nice herbal fragrance and the smoke released by the candle were found to be effective in keeping mosquitoes away.

8.6. : Melting Point

The herbal mosquito repellent candle, which is made with beeswax and essential oils, has a melting point that is roughly between 60°C and 65°C.

Result:- The herbal mosquito repellent candle was prepared successfully ,using natural ingredients like neem, orange peel, clove, and essential oils.The candle showed a pleasant smell, smooth appearance, proper hardness, and burned evenly with very little smoke.

It effectively helped in reducing mosquito activity and did not cause any skin irritation. Among all batches, Batch D showed the best results with good burning time, stability, and overall performance. Therefore, the prepared herbal candle can be considered a safe, eco-friendly, and cost-effective alternative to chemical mosquito repellents

Conclusion :- The prepared herbal mosquito repellent candle was found to be safe, effective, and eco-friendly. It was successfully prepared using natural ingredients such as neem, orange peel, clove, lemongrass oil, lavender oil, rosemary oil, and marigold oil. The candle showed good burning properties, produced very little smoke, and had a pleasant herbal aroma.

During evaluation, the candle did not cause any skin irritation and effectively reduced mosquito activity in the surrounding area. The study concludes that herbal mosquito repellent candles can be used as a safer and natural alternative to chemical mosquito repellents. These candles are easy to prepare,

cost-effective, biodegradable, and helpful in preventing mosquito-borne diseases like malaria, dengue, and chikungunya. Therefore, herbal mosquito repellent candles have good potential for household and public use**.**

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