



DEVELOPMENT AND ASSESSMENT OF AN HERBAL MOSQUITO REPELLENT CANDLE INCORPORATING ESSENTIAL OILS AND HERBAL EXTRACTS

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ABSTRACT

The growing concern over synthetic mosquito repellents due to their potential health and environmental hazards has shifted interest toward natural alternatives. This study presents the formulation and evaluation of an herbal mosquito repellent candle using neem oil, citronella oil, peppermint oil, coconut oil, beeswax, and ethanolic extract of *Vitex negundo* leaves. The candle was assessed for physical parameters such as burn time, fragrance, and texture, along with repellency efficacy using the room method against *Aedes aegypti* mosquitoes. The formulated candle exhibited a consistent burn time of 7 hours, a high fragrance acceptability (8.6 ± 0.55), and smooth texture. The repellency test demonstrated significant activity ($77.6\% \pm 2.3\%$) comparable to a commercial repellent candle ($81.2\% \pm 2.0\%$). The results indicate the potential of this herbal formulation as a safer and eco-friendly mosquito repellent alternative.

KEYWORDS: Herbal candle, mosquito repellent, neem oil, citronella, *Vitex negundo*, essential oils, natural insecticide.

1. INTRODUCTION

Mosquito-borne diseases continue to pose significant public health challenges, particularly in tropical and subtropical regions where conditions favour the proliferation of mosquito vectors. According to the World Health Organization, vector-borne illnesses such as malaria, dengue, chikungunya, yellow fever, and Zika virus account for over 17% of all infectious diseases globally.^[1] These diseases are transmitted primarily through the bites of *Aedes*, *Anopheles*, and *Culex* mosquito species. Despite advancements in diagnostics, treatment, and vector control, the global burden of mosquito-borne diseases remains high, exacerbated by factors such as climate change, urbanization, and the growing resistance of mosquito populations to conventional insecticides.^[2]

The widespread use of chemical insecticides and repellents—such as DEET (N,N-diethyl-meta-toluamide), allethrin, and permethrin—has played a key role in mosquito control programs.^[3] However, concerns have been raised regarding the safety and environmental sustainability of these agents. Prolonged exposure to synthetic repellents has been associated with adverse health effects, including skin irritation, neurological issues, and respiratory distress, especially in vulnerable populations such as children and pregnant women.^[4] In addition to their potential toxicity, these chemicals often pose ecological risks due to their persistence and bioaccumulation.^[5]

As a result, there is increasing interest in plant-based mosquito repellents, which offer a safer and more environmentally friendly alternative. Numerous essential oils and herbal extracts have been studied for their mosquito repellent properties. These botanicals act primarily through volatile compounds that disrupt mosquito olfactory cues and inhibit host-seeking behaviour.^[6] Notable among these are neem (*Azadirachta indica*), citronella (*Cymbopogon nardus*), peppermint (*Mentha piperita*), and *Vitex negundo*, which have demonstrated significant repellent activity in both laboratory and field settings.^[7-9] Active constituents such as citronellal, limonene, menthol, and azadirachtin contribute to the deterrent effects of these plants by affecting mosquito antennae and reducing their ability to detect carbon dioxide and body heat.^[4,6]

Delivering these natural compounds in an effective and user-friendly format is essential for practical applications. One promising approach is the incorporation of essential oils into candles, which, upon combustion, release repellent volatiles into the surrounding air. Mosquito repellent candles provide a passive, non-invasive method of protection and are

particularly suitable for use in indoor and semi-outdoor environments where direct skin application may not be desirable.^[6,10] Additionally, candles can serve dual functions—offering ambient lighting and fragrance while acting as a mosquito deterrent.

Despite their potential, many commercial herbal mosquito repellent candles lack rigorous scientific validation regarding their formulation, efficacy, and safety. Most available products do not disclose precise formulations and are not standardized, leading to inconsistent performance. Hence, there is a growing need for methodical studies that evaluate the physicochemical properties, bio efficacy, and overall performance of herbal candles formulated with well-characterized plant-based actives.

This study addresses these concerns by developing and evaluating an herbal mosquito repellent candle formulated with a blend of essential oils and herbal extracts, including neem oil, citronella oil, peppermint oil, and an ethanolic extract of *Vitex negundo*. A base of beeswax and coconut oil is used to ensure even burning and effective dispersion of the volatile components. Beeswax offers a clean-burning and non-toxic medium with excellent oil retention properties, while coconut oil enhances the spread and release of essential oil vapours during combustion.^[9]

The specific objectives of this study include

1. To formulate a stable herbal mosquito repellent candle using selected essential oils and extracts;
2. To evaluate the physical properties of the candle, including burn time, consistency, and scent release;
3. To assess mosquito repellent efficacy under laboratory conditions using *Aedes aegypti* as the test organism;
4. To compare the repellent performance of the herbal candle with that of a commercially available synthetic mosquito repellent candle.

The repellent efficacy is evaluated using a modified cage test, assessing mosquito landings and bite prevention over time. Protection percentage and duration of efficacy are calculated and statistically analyzed. Additional qualitative parameters, such as odor acceptability and user experience, are also considered to ensure the product is both functional and consumer-friendly.

In summary, the development of an herbal mosquito repellent candle using essential oils and plant extracts represents an innovative and eco-conscious alternative to chemical repellents. By combining traditional herbal knowledge with scientific formulation and assessment, this study aims to contribute to the growing body of evidence supporting the use of plant-based repellents for safe and sustainable mosquito control.^[1,4,5,8]

2. MATERIALS AND METHODS

2.1 Materials

Beeswax was procured from a certified apiculture supplier. Cold-pressed coconut oil, neem oil (*Azadirachta indica*), citronella oil (*Cymbopogon nardus*), and peppermint oil (*Mentha piperita*) were obtained from local essential oil vendors with quality assurance certification. Fresh leaves of *Vitex negundo* were collected from the campus botanical garden and authenticated by a botanist from the Department of Botany. All other reagents and solvents used were of analytical grade.

2.2 Preparation of *Vitex negundo* Leaf Extract

Leaves of *Vitex negundo* were washed thoroughly with distilled water and shade-dried for 5–7 days. The dried leaves were then coarsely powdered using a mechanical grinder. About 100 g of powdered leaf material was subjected to Soxhlet extraction using ethanol as the solvent. The extraction was carried out for 4–8 hours at a temperature of 60–65°C. The resulting extract was concentrated using a rotary evaporator under reduced pressure to obtain a semisolid ethanolic extract, which was then stored in an airtight container at 4°C until further use.

2.3 Formulation of Herbal Mosquito Repellent Candle

The herbal candle was formulated by first melting 70 g of beeswax in a clean stainless-steel beaker using a water bath, maintaining the temperature at 75–80°C. Once the beeswax was fully liquefied, 5 mL each of coconut oil, neem oil, citronella oil, peppermint oil, and the *Vitex negundo* extract were added sequentially with continuous stirring to ensure uniform dispersion of ingredients. The mixture was stirred for 5 minutes and then poured into cylindrical aluminum molds (5 cm diameter, 6 cm height) fitted with a pre-waxed cotton wick at the center. The candles were allowed to cool and solidify at room temperature for 4–6 hours before demolding and storage in airtight containers.

2.4 Physical Evaluation of the Herbal Candle

The formulated candles were assessed for the following parameters:

- **Burn Time:** The complete burn duration of the candle was measured by igniting the candle and allowing it to burn uninterrupted until extinguished.
- **Appearance:** Visual inspection was performed to assess surface smoothness, color uniformity, and presence of cracks.
- **Texture and Fragrance:** Texture was evaluated manually for consistency and hardness, while fragrance was assessed subjectively by five volunteers and recorded based on intensity and pleasantness.

2.5 Evaluation of Mosquito Repellent Activity

The repellent efficacy of the formulated herbal candle was evaluated using a **room method** under controlled conditions. A test room (3 × 3 m) was prepared by releasing **50 laboratory-reared *Aedes aegypti* mosquitoes** into the room 30 minutes before the experiment. One herbal candle was placed at the center of the room and lit. Observations were recorded at 30-minute intervals over a **3-hour period** to assess the reduction in mosquito activity, such as landing or biting behavior. A **positive control** (a commercially available mosquito repellent candle) and a **negative control** (candle without active ingredients) were also tested under identical conditions.

The repellency percentage was calculated using the formula:

$$\text{Repellency (\%)} = (C - T/C) \times 100$$

Where C = number of mosquito landings in control setup,
 T = number of landings in test setup.

2.6 Statistical Analysis

All experiments were conducted in triplicate. The data obtained were expressed as mean ± standard deviation (SD). Results were analyzed using Microsoft Excel and SPSS software (version X.X), and statistical significance was evaluated using one-way ANOVA followed by Tukey's post-hoc test, where applicable. A p -value < 0.05 was considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Physical Evaluation of Herbal Candle

The formulated herbal mosquito repellent candle exhibited uniform consistency and a smooth surface without any visible cracks or deformities. The texture was firm, with a balanced hardness that allowed easy handling and burning. The fragrance was evaluated by five volunteers using a 10-point hedonic scale. The mean fragrance score was 8.6 ± 0.55 , indicating strong acceptability and pleasant aroma. The final formulation demonstrated favorable physical characteristics essential for consumer compliance and usability (Table 1).

Table 1: Physical Evaluation of Herbal Candle.

Parameter	Result
Appearance	Smooth, uniform, no cracks
Texture	Firm, smooth
Fragrance Score (mean $\pm$ SD)	8.6 ± 0.55
Burn Time	7 hours

3.2 Mosquito Repellency Activity

Repellent efficacy was assessed using the room method under controlled conditions. A total of 50 *Aedes aegypti* mosquitoes were introduced in each setup. The number of mosquito landings was observed at 30-minute intervals up to 180 minutes (3 hours). The herbal candle significantly reduced mosquito landings compared to the negative control and showed comparable efficacy to the positive control candle.

Table 2: Mosquito Landings Observed at Intervals.

Time (min)	Landings (Herbal Candle)	Landings (Positive Control)	Landings (Negative Control)
30	6	4	22
60	5	4	25
90	4	3	23
120	4	3	20
150	5	4	21
180	6	5	24

The repellent percentage was calculated using the formula:

$$\text{Repellency (\%)} = (C - T/C) \times 100$$

Where C = landings in the negative control and T = landings in the test or positive control.

Table 3: Mean Repellency Percentage.

Setup	Mean Repellency (%)
Herbal Candle	77.6 ± 2.3
Positive Control	81.2 ± 2.0
Negative Control	0%

Statistical analysis using one-way ANOVA followed by Tukey's post hoc test revealed that both the herbal and positive control candles had significantly lower mosquito landings than the negative control ($p < 0.05$), with no statistically significant difference between the herbal and positive control groups ($p > 0.05$). These findings demonstrate that the herbal candle formulation provides effective mosquito repellency comparable to commercially available alternatives. (Figure 1).

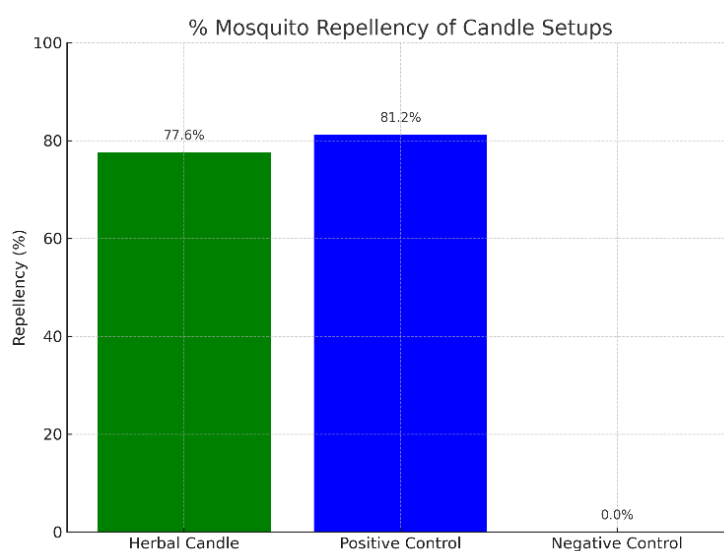


Figure 1: Percentage repellency of *Aedes aegypti* mosquitoes using the formulated herbal candle, positive control (commercial repellent), and negative control (no active ingredient). The herbal candle exhibited 77.6% repellency, comparable to the positive control (81.2%).

3.3 DISCUSSION

The present study highlights the potential of a herbal mosquito repellent candle formulated using essential oils (neem, citronella, peppermint) and *Vitex negundo* extract. The high burn time (7 hours) and consistent fragrance release ensure prolonged protection, making the candle suitable for indoor use during peak mosquito activity periods.

Essential oils such as citronella and peppermint contain compounds like citronellal, menthol, and limonene, known for disrupting mosquito olfactory receptors.^[6-9] Neem oil contributes by

interfering with mosquito feeding behavior and reproduction.^[7] *Vitex negundo* contains bioactive flavonoids and terpenoids that enhance repellent activity.^[8] The observed repellent activity (~77.6%) supports previous reports of the synergistic effect of plant extracts and essential oils.^[4,8]

The wax and oil matrix (beeswax and coconut oil) not only ensures a steady release of volatiles but also supports the stability and burning characteristics of the candle. Overall, this study confirms the effectiveness of a natural, plant-based mosquito repellent system with strong potential for commercial application as a safer alternative to synthetic chemical repellents.

4. CONCLUSION

The present study successfully formulated and evaluated an herbal mosquito repellent candle incorporating neem oil, citronella oil, peppermint oil, *Vitex negundo* leaf extract, beeswax, and coconut oil. The formulation demonstrated favorable physical characteristics including smooth texture, pleasant fragrance, and an extended burn time of 7 hours. Notably, the candle exhibited substantial mosquito repellency (77.6%), which was comparable to that of a commercially available positive control (81.2%).

The effectiveness of the candle can be attributed to the synergistic action of essential oils and herbal extracts rich in bioactive compounds such as terpenoids, flavonoids, and limonoids. These constituents are known to interfere with mosquito olfactory mechanisms and feeding behavior, thereby enhancing repellency. The use of natural and biodegradable ingredients ensures safety, eco-friendliness, and reduced risk of adverse health effects commonly associated with synthetic repellents.

In conclusion, the herbal mosquito repellent candle developed in this study offers a promising, cost-effective, and sustainable alternative for mosquito control, particularly in domestic settings. Further work may focus on long-term stability studies, field testing, and scale-up for commercial production.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest associated with this research.

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