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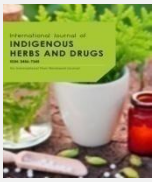

REVIEW ON PREPARATION AND EVALUATION OF HERBAL MOSQUITO REPELLENT

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Abstract

Mosquito-borne diseases such as malaria, dengue, chikungunya, Zika virus infection, lymphatic filariasis, and Japanese encephalitis remain major global health concerns, especially in tropical and developing regions. Although synthetic mosquito repellents like DEET and allethrin are commonly used, their long-term application has been associated with adverse health effects and environmental hazards. As a result, there is growing interest in herbal mosquito repellents that are safer, biodegradable, and environmentally friendly. This study focuses on the preparation and evaluation of herbal mosquito repellent sticks formulated using natural ingredients such as neem (*Azadirachta indica*), tulasi/holy basil (*Ocimum sanctum*), clove (*Syzygium aromaticum*), cinnamon bark (*Cinnamomum* species), camphor (*Cinnamomum camphora*), and eucalyptus oil (*Eucalyptus globulus*). Supportive materials such as charcoal, sawdust, and starch were also incorporated. These plant-based ingredients contain bioactive compounds known for their mosquito repellent, insecticidal, and larvicidal properties. The prepared dhoop sticks were evaluated for physical appearance, moisture content, smoke toxicity, irritation potential, mosquito repellent activity, ash value, smoke visibility, mosquito landing test, and user feedback. The findings suggest that herbal mosquito repellents offer advantages such as low toxicity, pleasant aroma, and environmental safety. However, limitations including shorter duration of protection and variable efficacy were observed. Further improvements in formulation and standardization may enhance their effectiveness and acceptance as sustainable alternatives to chemical repellents.

Keywords: Herbal Mosquito repellent sticks, Mosquito-borne diseases, Natural repellents, Neem, Tulasi, and Clove.

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Introduction

Mosquito-borne diseases continue to be a major global health concern, particularly in developing and tropical countries [1,2,12]. Diseases such as malaria, dengue fever, chikungunya, Zika virus infection, lymphatic filariasis, and Japanese encephalitis are transmitted by mosquitoes and account for significant morbidity and mortality each year [1, 6]. According to the World Health Organization (WHO), nearly half of the world's population is at risk of mosquito-borne infections, with India being one of the most affected countries due to its favourable climatic conditions for mosquito breeding [1,12].

Mosquitoes

Mosquitoes belong to the family Culicidae, and various genera are responsible for transmitting significant human diseases [1,6]. Mosquitoes are vectors for numerous pathogenic agents, making bite prevention crucial in disease control. Synthetic repellents such as DEET and picaridin are widely used but present environmental and health concerns,[7,8] prompting interest in natural alternatives [9,11]. Plant-based repellents long employed in traditional medicine are perceived as safer and biodegradable, and many contain bioactive compounds capable of deterring mosquito host seeking behavior [9,10].

Mosquito-Borne Diseases

These are transmitted by different mosquito species, each carrying specific pathogens. Malaria is spread by Anopheles mosquitoes such as Anopheles gambiae and Anopheles stephensi, and is caused by Plasmodium parasites [1],

including P. falciparum, P. vivax, P. malariae, P. ovale, and P. knowlesi, producing symptoms like fever, chills, and sweating. Dengue, transmitted by Aedes aegypti and Aedes albopictus, is caused by four types of dengue virus (DEN-1 to DEN-4) and leads to high fever, severe headache, joint pain, and rash [2]. Chikungunya, also spread by Aedes aegypti and Aedes albopictus, results from infection by the chikungunya virus and causes sudden fever, severe joint pain [3]. fatigue, and rashes. Zika virus infection is transmitted by the same Aedes mosquitoes [4], and presents with fever, rash, conjunctivitis, and joint pain. Yellow fever, carried mainly by Aedes aegypti, is caused by a flavivirus and is characterized by fever,[2]jaundice, bleeding, and possible organ failure. Lymphatic filariasis (elephantiasis) is transmitted by Culexquinquefasciatus in urban areas, Anopheles species in Africa, and Aedes species [5], in Pacific regions; it is caused by Wuchereriabancrofti, Brugiamalayi, and Brugiatimori, leading to lymphatic dysfunction and swelling of limbs. Japanese encephalitis, spread by Culextritaeniorhynchus and Culexgelidus [6], is caused by the Japanese encephalitis virus and results in brain inflammation, seizures, and coma.

Need For the Herbal Mosquito Repellents

Mosquito-borne diseases such as malaria, dengue, and chikungunya continue to pose major health risks, especially in tropical regions. Synthetic repellents containing DEET, allethrin, and transfluthrin can cause respiratory issues, allergies, and environmental harm with prolonged use.[7,8] The toxic smoke from chemical-based coils increases indoor air pollution[38] and may lead to severe complications in sensitive populations. Herbal alternatives like Neem, Tulasi, Clove, Cinnamon, and Eucalyptus offer safe, eco-friendly mosquito-repelling action due to their active phytochemicals [13,17,19,22,27,30]. Herbal repellents are commonly formulated in forms such as coils, sticks, sprays, lotions, creams, and essential oil vaporizers. Among these, herbal mosquito repellent sticks and coils have gained interest due to their ease of preparation,[32] slow release of active ingredients, and low cost. This review summarizes medicinal plants with repellent effects, formulation components, preparation methods, and evaluation parameters to develop and evaluate an effective, economical, and environmentally friendly herbal mosquito repellents with good burning properties and repellent efficacy

Herbal Ingredients Used in Mosquito Repellents

Several herbal ingredients play important roles in mosquito repellent formulations due to their natural bioactive compounds and multifunctional properties.

Neem: (Azadirachtaindica) contains azadirachtin, which disrupts insect growth hormones and inhibits feeding [16,17], molting, and reproduction, making it effective as a mosquito repellent and larvicide while also offering antibacterial and wound-healing benefits.

Tulasi or Holy basil: (Ocimum sanctum) provides repellent action through essential oils like eugenol and linalool [20], that interfere with mosquito olfactory receptors, and it is also widely used for cough, cold, and immunity enhancement.

Clove: (Syzygium aromaticum) contains eugenol, which blocks mosquito nerve signaling and provides strong repellence along with analgesic and antiseptic uses [23].

Vasa or sweet flag: (Acorus calamus) exhibits repellent and knockdown effects through asarone [25, affecting the insect nervous system while also functioning as an expectorant and digestive stimulant.

Camphor: (Cinnamomumcamphora) releases volatile vapours that disturb mosquito respiration and cause neurotoxic effects, besides serving as a decongestant and pain reliever [26].

Cinnamon: (Cinnamomum verum) offers larvicidal and repellent properties due to cinnamaldehyde, which damages mosquito cell membranes, along with antimicrobial and digestive benefits [27].

Activated charcoal: Supports slow combustion and sustained vapor release in coils and also serves as an adsorbent and purification agent [28].

Saw dust or wood dust: Acts as a combustible carrier for uniform burning in mosquito coils [29].

Eucalyptusoil: (Eucalyptus globulus) contains eucalyptol that blocks mosquito odour receptors and aids respiration suppression, and it is also used as an antiseptic and inhalation therapy [30].

Starch: Functions as a binder without insecticidal activity, helping in coil or stick formation [31].

Rose oil: (Rosa damascena) provides mild mosquito repellency through aromatic terpenes while offering fragrance and skincare benefits [19].

Water: Is used mainly as a processing medium, providing moisture for dough formation without any insecticidal action.

Table 01: Herbal Ingredients Used in Mosquito Repellents

Ingredient	Mode of Action
Neem	mosquito feeding, growth and reproduction.[48]
Tulasi	interfere with mosquito olfactory receptors.[49]
Clove	exhibits strong repellent and neurotoxic effects on mosquitoes.[50]
Vasa / Sweet Flag	exerts insecticidal and repellent action via neuro-disruption.[51]
Camphor	act as mosquito irritant and disrupt sensory perception.[52]
Cinnamon	inhibits mosquito attraction and larval survival.[53]
Charcoal	allowing slow-burning release of repellent vapours.[54]
Saw Dust	Provides structural support and helps uniform burning in coils.[54]
Eucalyptus oil	Gives odors and interferes with mosquito olfaction.[55]
Starch	Used as a binder.[56]
Rose oil	Gives aroma and acts as a natural mosquito repellent.[50]
water	Solvent/binder for mixing ingredients

Evaluation Parameters

Physical Appearance: The prepared herbal mosquito repellent sticks were evaluated for their colour, odour, size, shape, texture, homogeneity, and physical state. These observations were made through direct visual and olfactory inspection [32].

Moisture content: The initial weight of the freshly prepared dhoop sticks should be noted and record the final weight of the dried dhoop sticks [32].

Moisture content= Initial weight – Final weight × 100

Smoke toxicity test: A test of smoke toxicity was carried out in a chamber. Next grownup in the 30minutes following their discharge into the chamber, mosquitoes were exposed to the smoke from burning incense sticks. Every 10minutes, the mortality data were recorded. There were 12 mosquitoes employed in all.[35]

Irritation test: To Evaluate the Irritation potential of dhoop sticks. Burn the dhoop sticks and observe signs of irritation like coughing, sneezing or eye Irritation and record any observed effect [38].

Evaluation of mosquito repellent activity: The dhoop was burnt in the mosquito prone areas in the evening and night period [32]. For investigating mosquito repellent activity, the prepared incense sticks are checked for causal effect.

Burning on users: The test was done by giving mosquito dhoop to the persons living in the mosquito prone area to find out whether the effects like coughing, tears were observed or not [38].

Fume test: A fume test is used to identify the presence of specific compounds by detecting the colour and smell released while burning the product [41].

Mosquito landing test: This test involves counting the number of mosquitos that land in a persons exposed skin when they are in the vicinity of the dhoop. To perform this test, you can have a person sit in a room with the dhoop burning and count the number of mosquitos that lay on the person's skin for a specific period of time, Such as 5 min [37].

Suffocation Test: A suffocation potential assessment was conducted in a confined space to evaluate whether the smoke caused discomfort or hazardous conditions due to poor ventilation. This test ensured that smoke levels remained within safe inhalation limits [41].

Smoke Visibility Test: The density and visibility of smoke from the sticks were evaluated visually upon ignition. Observations were made on smoke spread, thickness, and irritation potential, compared across formulations [41].

Ash value Test: The dhoop was burnt completely and the ash was collected & weighed [32].

Feedback from 20 volunteers: The feedback on mosquito repellent incense stick was taken from 20 people and requested to evaluate the formulation [42].

Advantages of Herbal Mosquito Repellents

- Free from harmful chemicals.
- Gentle on skin and respiratory system.
- Safe around kids, pets and vulnerable groups.
- Eco-friendly and biodegradable.
- Pleasant fragrance.
- Repel multiple insects along with insects.
- Accessible, cost effective and easily homemade [39,40].

Limitations of Herbal Mosquito Repellents

- Shorter Duration of Protection.
- Variable Efficacy based on plant type and concentration of essential oils.
- Sensitive to Environmental Conditions.
- Need for Frequent Reapplication.
- Inconsistency and Lack of Standardization.
- Limited Regulatory Oversight.
- Not a Standalone Solution in High-Risk Areas [43,44].

Future Perspective

Advances in formulation technologies, Such as nanoemulsions, microencapsulation, and synergistic blends, hold promise for enhancing the performance of herbal repellents [45, 46] additionally, standardized testing protocols and rigorous field trials are necessary to validate efficacy and support regulatory approval for widespread use [47].

Conclusion

Herbal mosquito repellents offer a safe, eco-friendly, and promising alternative to conventional synthetic repellents, which often pose risks such as respiratory irritation, skin allergies, and environmental pollution. The increasing prevalence of mosquito-borne diseases like malaria, dengue, chikungunya, and Zika highlights the urgent need for effective yet non-toxic repellent solutions. Medicinal plants such as Neem, Tulasi, Clove, Eucalyptus, Camphor, and Cinnamon contain potent bioactive compounds that exhibit repellent, larvicidal, and insecticidal properties, making them valuable candidates for herbal formulations.

The preparation of herbal mosquito repellent sticks or dhoop is simple, cost-effective, and suitable for community-level or small-scale production. Comprehensive evaluation parameters-including physical appearance, burning properties, smoke toxicity, irritation potential, repellent activity, ash value, and volunteer feedback—ensure the quality and safety of the final product. Although herbal repellents have limitations such as shorter duration of protection and variability in potency, advancements in formulation techniques and standardized testing can significantly enhance their consistency and effectiveness.

Overall, herbal mosquito repellents provide a sustainable, user-friendly approach to mosquito control, with the potential to reduce dependence on harmful chemical repellents while promoting public health and environmental well-being.

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Informed Consent and Ethical Statement

Not Applicable

Author Contributions

All authors are contributed equally

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