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A review on medicinal plants having mosquito repellents activity

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Abstract
Mosquito-borne diseases pose significant public health challenges worldwide, emphasizing the urgent need for effective mosquito control measures. Traditional methods of mosquito repellency, particularly those utilizing medicinal plants, have gained attention due to their perceived safety, accessibility, and eco-friendliness. This review aims to consolidate existing literature on the efficacy of medicinal plants as traditional mosquito repellents, highlighting their active constituents, mode of action, and potential for integration into modern vector control strategies. A comprehensive search of scientific databases was conducted, identifying relevant studies published up to [insert date]. The review discusses key medicinal plants known for their mosquito-repelling properties, evaluates their effectiveness based on experimental evidence, and explores mechanisms underlying their repellent activity. Furthermore, challenges and opportunities associated with the utilization of medicinal plants in mosquito control are discussed, along with future research directions to optimize their efficacy and practical application.

Keywords: Medicinal plants, traditional repellents, mosquito control, active constituents, efficacy, mechanisms

Introduction
Mosquito-borne diseases, such as malaria, dengue fever, Zika virus, and chikungunya, continue to pose significant threats to public health globally, particularly in tropical and subtropical regions. The control of mosquito vectors remains a cornerstone in the prevention and management of these diseases. While synthetic insecticides have been widely used for mosquito control, concerns regarding environmental sustainability, development of insecticide resistance, and adverse effects on human health and non-target organisms have fueled interest in alternative approaches, including traditional methods utilizing medicinal plants.
Medicinal plants have been integral to traditional medicine systems for centuries, with many species renowned for their insect-repelling properties. These plants contain a diverse array of phytochemicals, including essential oils, alkaloids, terpenoids, and flavonoids, which contribute to their repellent activity against mosquitoes. This review aims to synthesize the current knowledge regarding the efficacy of medicinal plants as traditional mosquito repellents, shedding light on their potential role in contemporary vector control strategies.

Lavender (*Lavandula spp.*): Lavender, belonging to the Lavandula genus, is prized for its fragrant flowers and medicinal properties. Essential oils extracted from lavender contain compounds such as linalool and linalyl acetate, which exhibit insect-repelling properties. Lavender oil has demonstrated efficacy in repelling mosquitoes and other biting insects in laboratory studies. Its pleasant aroma and calming effects make lavender a popular choice for natural insect repellents. Further research is needed to optimize formulations and assess its efficacy in field conditions [1].

Basil (*Ocimum basilicum*): Basil, particularly *Ocimum basilicum*, is renowned for its culinary uses as well as its insect-repelling properties. Essential oils extracted from basil have demonstrated significant repellent activity against various mosquito species. Pavela (2015) reviewed the potential of essential oils from basil and other plants for the development of eco-friendly mosquito larvicides. The study highlighted the efficacy of basil essential oil as a larvicide and suggested its potential for use in mosquito control programs. While further research is needed to elucidate its repellent mechanisms and optimize formulations, basil shows promise as a natural mosquito repellent [2].

Catnip (*Nepeta cataria*): Catnip, also known as *Nepeta cataria*, contains nepetalactone, a compound that has been found to repel mosquitoes. Carroll *et al*. (2011) investigated the essential oils of catnip and their relaxing effects on mice. Although primarily studied for its effects on animals, catnip has also gained attention for its potential as a mosquito repellent. Its effectiveness against mosquitoes warrants further exploration, particularly in field studies to assess its practical utility in mosquito control [3].

Rosemary (*Rosmarinus officinalis*): Rosemary, a common culinary herb, possesses insect-repelling properties attributed to its essential oils. Maia and Moore (2011) discussed the efficacy of plant-based insect repellents, including rosemary oil, in their review paper. Rosemary essential oil contains compounds such as camphor and 1,8-cineole, which have shown repellent activity against mosquitoes. Incorporating rosemary oil into repellent formulations may offer a natural and eco-friendly alternative to synthetic insecticides [4].

Garlic (*Allium sativum*): 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 [5].

Lemongrass (*Cymbopogon citratus*): Lemongrass, specifically *Cymbopogon citratus*, is renowned for its citrusy aroma and medicinal properties. Essential oils derived from lemongrass have demonstrated potent mosquito-repellent activity due to their high citronella content. Moore *et al*. (2002) discussed the potential of plant-based insect repellents, including lemongrass oil, as alternatives to synthetic repellents. Lemongrass oil has shown promise in laboratory and field studies for its ability to repel mosquitoes effectively [6].

Marigold (*Tagetes spp*.): Marigold, belonging to the Tagetes genus, contains essential oils that possess insect-repelling properties. The presence of compounds such as limonene and β-ocimene contributes to its effectiveness against mosquitoes. Studies have shown that extracts from marigold plants can repel mosquitoes and other insect pests. Further research is needed to explore the full potential of marigold-derived repellents and optimize their formulations for practical use [7].

Geranium (*Pelargonium spp*.): Geraniums, particularly species within the Pelargonium genus, are known for their aromatic foliage and insect-repelling properties. Essential oils extracted from geraniums contain compounds such as citronellol and geraniol, which exhibit strong repellent activity against mosquitoes. While geranium-based repellents have shown promise in laboratory studies, additional research is necessary to assess their efficacy in field conditions and explore their potential integration into mosquito control programs [8].

Clove (*Syzygium aromaticum*): Clove, derived from the *Syzygium aromaticum* tree, is renowned for its culinary and medicinal uses. Clove essential oil contains eugenol, a compound known for its insecticidal and repellent properties. Studies have demonstrated the efficacy of clove oil in repelling mosquitoes and other biting insects. Its strong odor and potent repellent activity make clove oil a promising candidate for use in mosquito control, pending further research to optimize formulations and assess long-term effectiveness [9].

Thyme (*Thymus spp*.): Thyme, a member of the Thymus genus, is valued for its culinary and medicinal properties. Essential oils extracted from thyme contain thymol and carvacrol, compounds known for their insect-repelling and insecticidal properties. Thyme oil has shown efficacy in repelling mosquitoes and other insect pests in laboratory settings. Further research is needed to explore its potential as a natural mosquito repellent and develop formulations suitable for practical use [10].

Patchouli (*Pogostemon cablin*): Patchouli, derived from the *Pogostemon cablin* plant, is prized for its earthy aroma and medicinal properties. Patchouli essential oil contains compounds such as patchoulol and pogostone, which exhibit insect-repelling properties. While patchouli oil has been traditionally used as a fragrance and insect repellent, its efficacy in repelling mosquitoes warrants further investigation. Future research should focus on optimizing patchouli-based repellents and evaluating their effectiveness in field conditions [11]

Orange Peel (*Citrus spp*.): Orange peel, derived from various Citrus species, is rich in essential oils containing compounds such as limonene and citral, which exhibit insect-repelling properties. While primarily used for culinary purposes and as a source of essential oils, orange peel has also been traditionally utilized as a mosquito repellent. Its citrusy aroma and repellent activity make orange peel a potential candidate for inclusion in natural insect repellents. Further research is needed to optimize formulations and assess its efficacy in repelling mosquitoes [12].

Sandalwood (Chandan) (*Santalum album*): Sandalwood, scientifically known as *Santalum album*, is prized for its aromatic wood and medicinal properties. Essential oils extracted from sandalwood contain compounds such as santalol, which possess insect-repelling properties. Sandalwood oil has demonstrated efficacy in repelling mosquitoes and other biting insects in laboratory studies. Its soothing aroma and medicinal properties make sandalwood a potential candidate for inclusion in natural insect repellents. Further research is needed to optimize formulations and assess its efficacy in repelling mosquitoes [11].

Mechanisms of repellent action

1. **Interference with Mosquito Olfactory Receptors:** Many medicinal plants contain volatile compounds that interfere with the olfactory receptors of mosquitoes. These receptors play a crucial role in guiding mosquitoes towards potential hosts by detecting chemical cues such as carbon dioxide, lactic acid, and octenol. The volatile compounds emitted by medicinal plants may either block these receptors or mimic repellent signals, confusing the mosquitoes and deterring them from approaching [1].
2. **Disruption of Host-Seeking Behavior:** Certain phytochemicals present in medicinal plants have been found to disrupt the host-seeking behavior of mosquitoes. By interfering with the sensory pathways involved in locating hosts, these compounds can impede the ability of

mosquitoes to detect and locate humans or other animals for blood-feeding. This disruption in host-seeking behavior reduces the likelihood of mosquito bites and potential disease transmission [8].

3. **Masking of Attractant Cues:** Medicinal plants may emit odors that mask or camouflage the attractant cues emitted by humans, thereby making it difficult for mosquitoes to locate their hosts. By overpowering or concealing the scent of humans, these plant-derived odors create a barrier that repels mosquitoes and reduces their likelihood of landing and biting [11].
4. **Irritant or Toxic Effects:** Some phytochemicals found in medicinal plants possess irritant or toxic properties that deter mosquitoes upon contact. When mosquitoes come into contact with these compounds, they may experience irritation or discomfort, prompting them to avoid the treated area. Additionally, certain phytochemicals may have toxic effects on mosquitoes, leading to physiological disruptions that further deter their feeding activity [13].
5. **Variability in Mode of Action:** The mode of action of plant-based repellents can vary depending on the specific plant species and their bioactive constituents. While some plants may primarily act through olfactory interference, others may exert their repellent effects through multiple mechanisms, including both sensory disruption and physiological deterrence. This variability underscores the complex nature of plant-based repellency and the need for further research to elucidate specific mechanisms for different plant species [14].

Challenges of plant based mosquito repellents

1. **Variability in Repellent Efficacy:** One of the significant challenges of herbal mosquito repellents is the variability in their efficacy. Different plant species and formulations may exhibit varying levels of repellency against mosquito vectors. This variability can be influenced by factors such as the geographical origin of the plants, extraction methods, and concentrations of active compounds. Ensuring consistent and reliable repellent efficacy across different formulations poses a challenge for product development and effectiveness [15].
2. **Standardization of Formulations:** Herbal mosquito repellents often rely on natural extracts or essential oils obtained from medicinal plants. However, achieving standardization in formulations can be challenging due to the complex chemical composition of plant extracts and variability in plant materials. Standardization involves ensuring consistent levels of active compounds in repellent products to guarantee efficacy and safety. Developing robust protocols for quality control and standardization of herbal formulations is essential but can be resource-intensive and technically demanding [16].
3. **Stability of Active Compounds:** Many active compounds in herbal mosquito repellents are sensitive to environmental factors such as light, heat, and air. This sensitivity can lead to degradation of active compounds over time, reducing the effectiveness of repellent products. Ensuring the stability and shelf-life of herbal formulations presents a challenge, particularly in regions with high temperatures and humidity. Strategies such as encapsulation, microencapsulation, and formulation optimization may be required to enhance the stability of active compounds and prolong the efficacy of herbal repellents [17].
4. **Regulatory Issues:** Herbal mosquito repellents are subject to regulatory requirements governing product registration, labelling, and marketing. Regulatory agencies often require extensive safety and efficacy data to assess the quality and performance of repellent products before approval for commercialization. Navigating regulatory frameworks can be complex and time-consuming, particularly for small-scale producers or traditional medicine practitioners. Lack of regulatory compliance may limit market access and consumer confidence in herbal repellents, hindering their widespread adoption [18].

Opportunities of plant based mosquito repellents

1. **Sustainable and Eco-friendly Alternatives:** Herbal mosquito repellents offer a sustainable and eco-friendly alternative to synthetic insecticides, which may have adverse effects on the environment and human health. By harnessing the repellent properties of medicinal plants, herbal formulations can reduce reliance on chemical pesticides and contribute to environmentally sustainable mosquito control practices. Additionally, cultivating and harvesting medicinal plants for repellent production can provide economic opportunities for local communities, supporting livelihoods and biodiversity conservation [11].
2. **Community Engagement and Empowerment:** Herbal mosquito repellents have the potential to empower communities by promoting traditional knowledge and practices related to plant-based medicine. Engaging local communities in the cultivation, processing, and utilization of medicinal plants for repellent production can foster a sense of ownership and cultural pride. Community-based initiatives for herbal repellent production and distribution can also enhance public awareness of vector-borne diseases and encourage community participation in mosquito control efforts [19].
3. **Integrated Vector Management:** Herbal mosquito repellents can be integrated into comprehensive vector management strategies alongside other control measures such as larvicides, insecticide-treated bed nets, and environmental management. Combining multiple interventions targeting different stages of the mosquito life cycle can enhance the effectiveness and sustainability of mosquito control programs. Herbal repellents can complement existing vector control tools, providing additional options for personal protection against mosquito bites, particularly in outdoor settings and during daytime biting periods [20].
4. **Research and Innovation:** Continued research and innovation in the field of herbal mosquito repellents present opportunities for optimizing formulations, identifying novel plant sources, and elucidating mechanisms of action. Advances in extraction techniques, formulation technologies, and bioassay methods can enhance the efficacy, safety, and scalability of herbal repellent products. Collaboration between scientists, traditional medicine practitioners, and industry stakeholders can drive innovation and facilitate the translation of traditional knowledge into evidence-based mosquito control solutions [13].

Conclusion

Medicinal plants represent a valuable source of natural compounds with potential utility as traditional mosquito repellents. Their diverse chemical composition and repellent

activity offer opportunities for the development of eco-friendly and sustainable alternatives to synthetic insecticides. However, further research is needed to elucidate the mechanisms of action, optimize formulations, and evaluate the long-term efficacy and safety of plant-based repellents. Collaboration between traditional medicine practitioners, entomologists, pharmacologists, and public health experts is essential to harness the full potential of medicinal plants in the fight against mosquito-borne diseases.

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