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Herbal Mosquito Repellent: A Review

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Abstract: Mosquito-borne diseases such as dengue, malaria, and chikungunya remain a significant public health concern worldwide. While synthetic mosquito repellents like DEET and permethrin are widely used, their long-term application raises health and environmental concerns. Herbal mosquito repellents, derived from plant extracts and essential oils, offer safe, eco-friendly, and effective alternatives. This review focuses on identifying medicinal plants and essential oils with proven mosquito repellent and larvicidal properties, including neem (*Azadirachta indica*), tulsi (*Ocimum sanctum*), clove (*Syzygium aromaticum*), and lemongrass (*Cymbopogon citratus*). An extensive analysis of recent literature (2018–2025) was conducted to evaluate the efficacy, safety, and environmental benefits of these herbal ingredients. Based on the findings, several herbal oils were shortlisted for selection in future formulation studies. The insights from this review provide a strong foundation for developing safe, effective, and sustainable herbal mosquito repellent formulations.

Keywords: *Herbal Mosquito Repellents, Essential Oils, Medicinal Plant – Based Repellents Eco-Friendly.*

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I. INTRODUCTION

Mosquitoes are among the most common vectors responsible for transmitting serious diseases such as dengue, malaria, and chikungunya[35]. These diseases pose significant health risks and create a demand for effective preventive measures. One of the most widely used methods to protect against mosquito bites is the application of mosquito repellents. However, conventional chemical-based repellents often contain synthetic compounds like DEET, which can lead to skin irritation, allergies, and long-term environmental concerns[20].

Lissy S[1], Anusree P[2], Maria P. Mariadas[3], Mary Fena[4], Dept. of Pharmacognosy, St. Joseph's College of Pharmacy, Cherthala "Formulation and Evaluation of Herbal Mosquito Repellent Cream" Herbal formulations provide safe and eco-friendly alternatives to synthetic mosquito repellents. Mosquito-borne diseases such as dengue, malaria, and chikungunya are transmitted by *Aedes*, *Culex*, and *Anopheles* mosquitoes. This study focuses on formulating a herbal mosquito repellent cream using neem extract and essential oils of clove, tulsi, and lemongrass[32].

During the literature review, various medicinal plants with mosquito repellent and larvicidal properties were studied. Based on this review, several herbs were identified and selected for the present research considering their safety, availability, and effectiveness. This review helped in understanding the role of different herbal ingredients and supported the selection of suitable herbs for the formulation of a herbal mosquito repellent lotion[16].

The objective of this project is to formulate a herbal mosquito repellent lotion that combines these natural ingredients to create a product that is both effective and safe for regular use. This formulation aims to offer an eco-friendly and skin-friendly solution for mosquito protection, highlighting the potential of herbal alternatives in everyday health care[12].

➢ *Objectives*

- To compare the efficacy of herbal mosquito repellents with conventional synthetic repellents such as DEET, picaridin, and permethrin[20].
- To evaluate the mechanism of action through which herbal active compounds repel, inhibit, or disrupt mosquito behaviour[12].
- To explore consumer acceptance and market trends for herbal based mosquito repellent formulations[27].
- To study the phytochemical constituents responsible for mosquito repellent activity in herbs.
- To study the role of essential oils in enhancing mosquito repellent activity[25]
- To evaluate the compatibility of various herbal ingredients in repellent formulation[10]
- To review challenges and limitations associated with herbal mosquito repellents[2]

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II. MOSQUITO REPELLENT HERBS

➢ *Citronella Oil (Cymbopogon nardus)*

- *Introduction*

Fresh leaves of Cymbopogon nardus or Cymbopogon winterianus, which belong to the Poaceae family and include citronellal, citronellol, and geraniol as active constituents, are the biological source of citronella oil. A common natural mosquito repellant is citronella oil, an essential oil derived from the Cymbopogon species[26]. Citronella is a fragrant grass that is well-known for its citronellal, citronellol, and geraniol-rich essential oil. which, by concealing human scent, effectively deter mosquitoes. Natural repellant lotions, candles, and sprays frequently contain it.

- *Mechanism of Action*

Citronella oil works by interfering with the olfactory receptors of mosquitoes, which are responsible for detecting human body odor[33]. Its volatile compounds create a protective aromatic barrier, making mosquitoes unable to recognize human scent and thus preventing mosquito bites[16].

- *Scientific Research*

According to scientific research, citronella oil works as a repellent by masking the smells of human skin and interfering with mosquito olfactory receptor neurons, which prevents host recognition. Significant repellency against Aedes and Anopheles species has been demonstrated in experimental assessments; however, the duration of protection is quite limited due to its high volatility unless combined with fixatives or controlled-release systems[5].

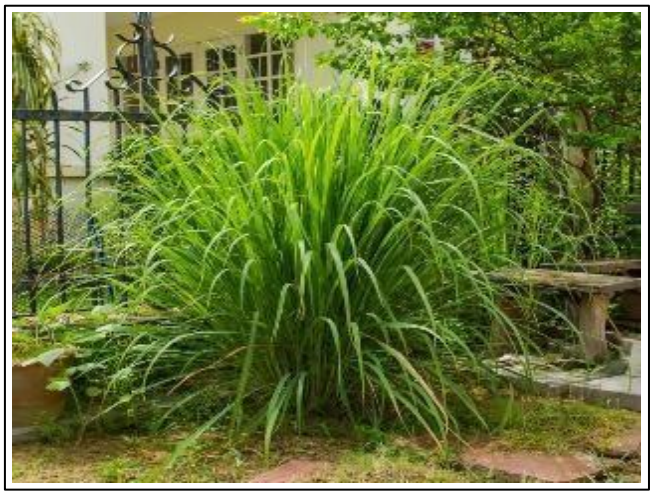

Fig 1 Citronella leaves

➢ *Neem Oil (Azadirachta indica)*

- *Introduction*

Azadirachta indica's leaves, seeds, and bark are the biological source; they belong to the Meliaceae family; their active constituents are azadirachtin, nimbin, and nimidin. Because of its antimicrobial and insect-repelling qualities, neem oil—which is derived from the seeds of Azadirachta indica—is extensively utilized in traditional medicine. Neem is a potent herbal repellent because this compound inhibits mosquito feeding and functions as an insect growth regulator and repellent[26]. a strong smell could be disagreeable and lower user compliance[4].

- *Mechanism of Action*

Neem oil shows a strong antifeedant and repellent effect on mosquitoes[12]. Azadirachtin disrupts the growth, reproduction, and feeding behavior of mosquitoes[12]. Its smell and bioactive molecules act as natural irritants, keeping mosquitoes away from the skin[17].

- *Scientific Research*

The plant is rich in bioactive compounds such as azadirachtin, nimbin, and salannin, which possess mosquito-repellent, antifeedant, and insect growth-regulating properties. Scientific studies have demonstrated that neem affects mosquito feeding behavior and disrupts hormonal balance, resulting in decreased biting activity and reproductive potential. Although neem-based formulations provide prolonged repellent effects, their strong odor and relatively slow onset of action may reduce user acceptability[16].

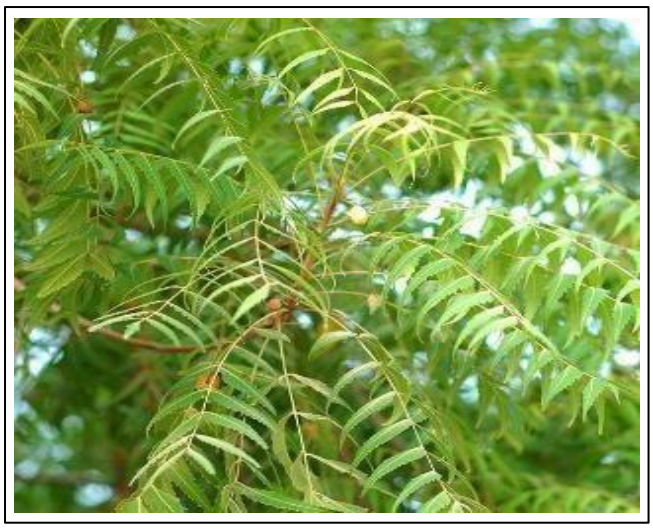

Fig 2 Neem Leaves

➢ *Lavender Oil (Lavandula angustifollia)*

- *Introduction*

Lavender oil is an essential oil obtained from the flowers of *Lavandula angustifolia* belonging to the family Lamiaceae and contains active constituents such as linalool and linalyl acetate. It is known for its pleasant aroma and significant mosquito-repellent activity, which is mainly attributed to its ability to mask human body odor and disrupt mosquito host-seeking behavior by interfering with olfactory receptors[4]. However, the repellent action of lavender oil is limited by its high volatility, resulting in a short duration of protection when applied alone[5].

- *Mechanism of Action*

Linalool exhibits a neurotoxic effect on mosquito nervous systems, reducing their movement and biting ability[5] [33]. Its strong aroma acts as a non-attractant, preventing mosquitoes from approaching the skin[13].

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- *Scientific Research*

Lavender essential oil, which contains high levels of linalool and linalyl acetate, has been scientifically studied for its mosquito-repellent properties. Research indicates that the oil releases aromatic compounds that disrupt mosquito olfactory and sensory mechanisms, thereby reducing host-seeking behavior. Owing to its gentle action and pleasant aroma, lavender oil is well suited for topical applications, especially for individuals with sensitive skin. Nevertheless, like many essential oils, its effectiveness is limited by rapid evaporation, resulting in a short duration of repellent activity[14].

Fig 3 Lavender Leaves

➢ *Lemongrass (Cymbopogon citratus)*

- *Introduction*

Lemongrass (*Cymbopogon citratus*), belonging to the family Poaceae, is an aromatic herb whose leaves are used as the biological source and contain active constituents such as citral, geraniol, and myrcene. It is well known for its strong citrus aroma and significant mosquitorepellent activity, primarily due to the presence of citral and geraniol, which act as natural repellents similar to citronella by masking human body odor and interfering with mosquito orientation and olfactory response[16 25]. However, the repellent effect of lemongrass oil is limited in duration because of the rapid evaporation of its volatile constituents[27].

- *Mechanism of Action*

The volatile compounds of lemongrass interfere with mosquito olfactory receptors, preventing them from detecting human body odor[25]. The presence of citral forms an aromatic shield on the skin, reducing mosquito landing and biting behavior[16].

- *Scientific Research*

Lemongrass oil is rich in active compounds such as citral and myrcene, which contribute to its mosquito-repellent activity. Scientific investigations have demonstrated that the strong aroma and volatile terpenoid constituents interfere with mosquito host-seeking mechanisms. Although lemongrass oil provides effective initial repellency, its high volatility results in rapid evaporation, thereby reducing the duration of protection and indicating the need for improved formulations to enhance long-term efficacy[33].

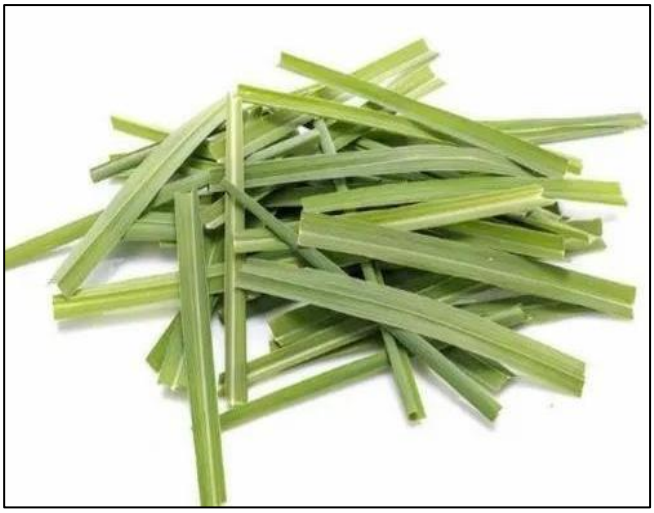

Fig 4 Lemongrass Leaves

➢ *Peppermint (Mentha piperita)*

- *Introduction*

Peppermint (*Mentha piperita*), belonging to the family Lamiaceae, uses its leaves and flowering tops as the biological source and contains active constituents such as menthol, menthone, and menthyl acetate. It is a well-known aromatic herb with a characteristic cooling effect and strong mosquito-repellent activity, mainly attributed to menthol and menthone, which repel mosquitoes while producing a cooling sensation on the skin[13 17]. The repellent action occurs by overstimulating and overwhelming the sensory receptors of mosquitoes, thereby interfering with their host-seeking behavior[33]. However, the effectiveness of peppermint oil is limited due to the rapid evaporation of its volatile components, resulting in a short duration of protection[27].

- *Mechanism of Action*

Menthol produces a neurotoxic and irritant effect on mosquitoes, disrupting their sensory perception[33]. The strong mint aroma masks human scent and acts as a repellent barrier, preventing mosquito bites[17].

- *Scientific Research*

Peppermint oil, derived from Mentha piperita, is rich in menthol and menthone, compounds known for their insect-repellent properties. Research studies show that peppermint oil interferes with the nervous and sensory systems of mosquitoes, decreasing their landing and biting behavior. Its repellent effectiveness depends on concentration, with moderate to high levels of protection observed in controlled laboratory experiments[27].

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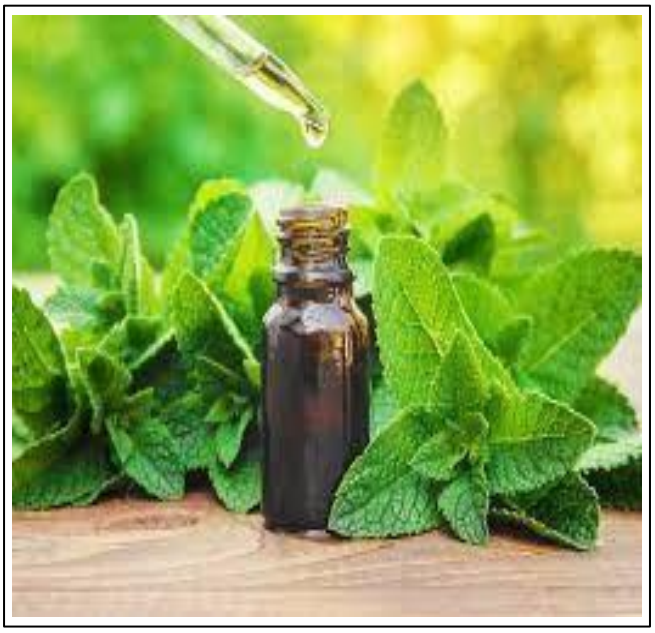

Fig 5 Peppermint

➢ *Basil (Ocimum basilicum)*

- *Introduction*

Basil (*Ocimum basilicum*), a member of the family Lamiaceae, utilizes its leaves and flowering tops as the biological source and contains active constituents such as eugenol, linalool, and methyl chavicol. It is a well-recognized medicinal herb widely used in herbal formulations due to its antimicrobial and mosquito-repellent properties[2] [25]. The repellent activity is mainly attributed to the presence of compounds such as eugenol and linalool, which produce a strong aroma that interferes with mosquito olfactory perception and significantly reduces mosquito landing behavior[15] [17]. However, the repellent effectiveness of basil essential oil is limited by the rapid evaporation of its volatile constituents, resulting in a short duration of action[27].

- *Mechanism of Action*

Eugenol acts on the nervous system of mosquitoes, reducing their biting activity[13]. Its essential oils produce a strong odor that acts as a natural deterrent, keeping insects away from the skin[17].

- *Scientific Research*

The study involved the formulation of a herbal mosquito repellent cream/lotion using selected essential oils and plant extracts, including citronella, lemongrass, peppermint, basil, thyme, clove, marigold, garlic, catnip, and eucalyptus. The oils were blended with a suitable base cream/emollient to achieve uniform consistency. The formulation process included heating, mixing, and homogenizing under controlled conditions. The final product was evaluated for physical properties (color, texture, odor, spreadability), stability, and mosquito-repellent efficacy using standard laboratory bioassays. Safety assessment was performed by observing potential skin irritation and allergenic reactions[2]

Fig 6 Basil Leaves

➢ *Thyme (Thymus vulgaris)*

- *Introduction*

Thyme (*Thymus vulgaris*), belonging to the family Lamiaceae, uses its leaves and flowering tops as the biological source and contains active constituents such as thymol, carvacrol, and *p*cymene. It is a well-known medicinal herb with documented antimicrobial, antioxidant, and mosquito-repellent properties, and has been shown to significantly reduce mosquito attraction and biting behavior[2]. However, the repellent efficacy of thyme is limited due to the high volatility of its active constituents, which results in a short duration of protective action[27].

- *Mechanism of Action*

Thymol and carvacrol exhibit potent neurotoxic effects on mosquitoes, impairing their mobility and biting behavior[13]. These compounds disrupt insect sensory pathways, preventing them from detecting human scent[33].

- *Scientific Research*

Thyme oil, which is rich in the active constituents thymol and carvacrol, has been extensively studied for its mosquito-repellent properties. Scientific research indicates that these compounds exert neurotoxic effects on mosquitoes, disrupting their normal nervous function and inducing strong avoidance behavior. Due to this potent activity, thyme oil remains effective even at relatively low concentrations. However, the use of higher concentrations may lead to skin irritation, which necessitates careful formulation for safe topical application[29].

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Fig 7 Thyme Leaves

➢ *Clove (Syzygium aromaticum)*

- *Introduction*

Clove (*Syzygium aromaticum*), a member of the family Myrtaceae, is obtained from the dried unopened flower buds and contains active constituents such as eugenol, caryophyllene, and acetyl eugenol. It is an aromatic spice rich in essential oil and is widely recognized for its antiseptic and strong mosquito-repellent activity[17 25]. The repellent effect of clove oil is mainly due to eugenol, which interferes with mosquito odor receptors and helps in masking human scent; therefore, it is often used in combination with other essential oils to enhance efficacy[15 27]. However, the repellent action of clove oil may be limited because of the volatility of eugenol, and excessive use can lead to skin irritation, burning sensations, or allergic reactions[17].

- *Mechanism of Action*

Eugenol produces a toxic and irritant effect on mosquitoes, affecting their nervous system and reducing biting attempts[13 14]. Its strong aroma masks human body odor, making it difficult for mosquitoes to locate the host[33].

- *Scientific Research*

Clove oil, which is rich in eugenol, has been widely studied for its mosquito-repellent properties. Research shows that it effectively interferes with the nervous system of mosquitoes, reducing their landing, biting, and feeding behavior. Its strong repellent activity makes it comparable to some synthetic repellents, though improper use may cause skin irritation[12].

Fig 8 Cloves Oil

➢ *Marigold (Tagetes erecta)*

- *Introduction*

Marigold (*Tagetes erecta* or *Tagetes patula*), belonging to the family Asteraceae, utilizes its flowers and leaves as the biological source and contains active constituents such as limonene, ocimene, and linalool. It is a commonly grown flowering plant known for its natural insecticidal and mosquito-repellent properties, which are mainly attributed to the presence of pyrethrumlike compounds and terpene constituents such as linalool that effectively repel mosquitoes[2 19]. The characteristic aroma of marigold interferes with insect olfactory receptors, thereby reducing mosquito attraction and landing behavior[33]. However, marigold exhibits moderate and short-lasting repellent activity, particularly under outdoor conditions, due to the volatile nature of its active compounds[14].

- *Mechanism of Action*

The aroma compounds in marigold disrupt mosquito sensory receptors and act as natural repellents, keeping insects away from treated areas[11]. Some components also show mild insecticidal activity[24].

- *Scientific Research*

Marigold (Tagetes spp.) contains terpenoids and pyrethrin-like compounds that act as natural mosquito repellents. Studies indicate that its volatile compounds interfere with mosquito olfactory receptors, reducing landing and biting activity. Although marigold is traditionally used for mosquito control, its repellent effect is moderate and is often improved when combined with other herbal ingredients[19].

Fig 9 Marigold

➢ *Garlic (Allium sativum)*

- *Introduction*

Garlic (*Allium sativum*), belonging to the family Amaryllidaceae, uses the bulb as its biological source and contains active constituents such as allicin, diallyl disulfide, and ajoene. It is a medicinal plant traditionally valued for its antimicrobial and mosquito-repellent properties, mainly due to sulfur-containing compounds like allicin that release a strong odor capable of repelling mosquitoes[19 25]. The repellent

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action of garlic is associated with its ability to alter human body odor and create an unfavorable environment for insects by interfering with their sensory perception[33]. However, the mosquito-repellent effect of garlic is short-lived because sulfur compounds degrade rapidly, and its strong odor may also cause skin irritation in some individuals[27].

- *Mechanism of Action*

Garlic releases sulfur-containing compounds that act as strong irritants to mosquitoes[13]. These compounds interfere with mosquito sensory receptors and create an unpleasant odor barrier, preventing them from approaching[33].

- *Scientific Research*

Garlic contains sulfur compounds like allicin that act as natural mosquito repellents. Studies show that these compounds modify human scent, reducing mosquito attraction. Although effective, the strong odor of garlic limits its suitability for use in topical repellent formulations[4].

Fig 10 Garlic

➢ *Catnip (Nepeta cataria)*

- *Introduction*

Catnip (*Nepeta cataria*), belonging to the family Lamiaceae, utilizes its dried leaves and flowering tops as the biological source and contains nepetalactone as the major active constituent, along with citronellol, geraniol, limonene, and caryophyllene. It is a perennial aromatic herb traditionally recognized for its insect-repellent properties, and scientific studies have demonstrated that catnip essential oil exhibits strong mosquito-repellent activity, in some cases comparable to or even exceeding that of certain synthetic repellents[20 23]. However, the repellent effectiveness of catnip oil is limited by the high volatility of nepetalactone, resulting in a relatively short duration of protective action[27].

- *Mechanism of Action*

Nepetalactone interferes with the olfactory receptors of mosquitoes, disrupting their ability to detect human attractants such as carbon dioxide and lactic acid[33]. It acts as a behavioral repellent, causing avoidance rather than toxicity, thereby preventing mosquito landing and biting 20 23.

- *Scientific Research*

Catnip contains nepetalactone, a compound known for its potent mosquito-repellent properties. Research indicates that nepetalactone effectively disrupts mosquito olfactory signaling, sometimes showing greater efficacy than DEET in laboratory studies. However, its limited stability and availability constrain its broader application[13].

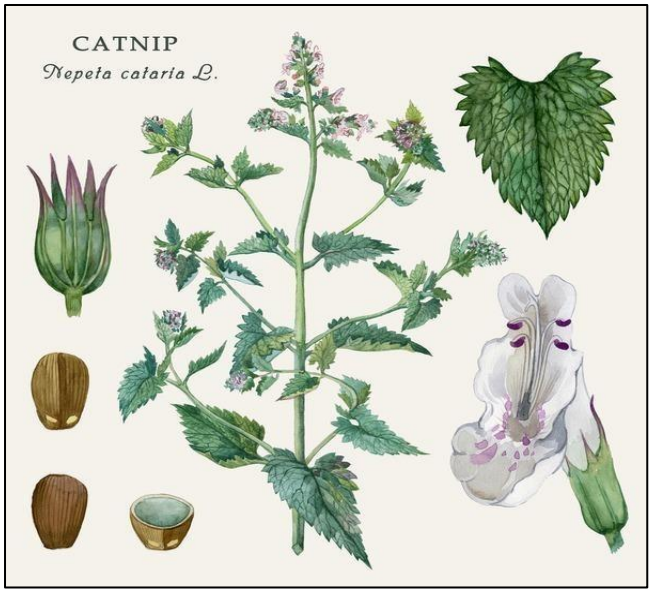

Fig 11 Catnip (nepeta calaria)

➢ *Eucalyptus (Eucalyptus globulus)*

- *Introduction*

Eucalyptus (*Eucalyptus globulus*), a member of the family Myrtaceae, utilizes its fresh or dried leaves as the biological source and contains active constituents such as 1,8-cineole (eucalyptol) as the major component, along with α-pinene, limonene, terpineol, and citronellal. It is a widely used medicinal plant known for its fragrant essential oil, which exhibits strong mosquitorepellent activity and is commonly incorporated into topical formulations as a natural alternative to chemical-based repellents[25]. However, the repellent effect of eucalyptus oil is short-lived due to the rapid evaporation of its volatile constituents, which limits the duration of protection[27].

- *Mechanism of Action*

Eucalyptus oil repels mosquitoes by covering up the scent of humans and triggering their odorsensing receptors, resulting in confusion and avoidance behaviour [25 33]. The volatile compounds in the oil disrupt the sense of smell in mosquitoes, making it harder for them to recognize and bite humans. (Maia & Moore, 2011).

- *Scientific Research*

Eucalyptus oil, especially lemon eucalyptus oil containing p-menthane-3,8-diol (PMD), is a well-studied mosquito repellent. Research shows that PMD disrupts mosquito olfactory receptors, offering long-lasting protection often comparable to DEET, making eucalyptus a promising plant-based repellent for commercial applications[26].

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Fig 12 Eucalyptus (Eucalyptus globulus)

III. DISEASE

Although mosquitoes are small, the diseases they carry can have a major impact on human health. A single bite from a mosquito can transmit dangerous germs that lead to serious illnesses such as malaria, dengue, and chikungunya[18 35]. These diseases can make people very ill and are widespread in many regions around the world. Preventing mosquito bites is one of the best ways to stay healthy and safe[35]. There are three main types of mosquitoes: 1) Aedes mosquito, 2) Anopheles mosquito, and 3) Culex mosquito[36].

➢ *Disease Caused by these Mosquitoes:*

- *Aedes Mosquito: These Mosquitoes are Active Mostly During the Day[18 35].*

Table 1 Aedes Mosquito: These Mosquitoes are Active Mostly During the Day[18 35].

Disease	Symptoms
Dengue	High fever, severe headache, muscle and joint pain, rashes, low platelets
Chikungunya	Severe joint pain, fever, rashes, fatigue
Zika Virus	Fever, rash, joint pain, red eyes; dangerous in pregnancy (causes birth defects)
Yellow Fever	Fever, jaundice, muscle pain, headache

- *Anopheles Mosquito: These Mosquitoes Typically Bite at Night[35].*

Table 2 Anopheles Mosquito: These Mosquitoes Typically Bite at Night[35].

Disease	Symptoms
Malaria	High fever (comes and goes), chills, sweating, headache, anemia
Lymphatic (Elephantiasis) filariasis	Swelling in legs, arms, or genitals, fever

- *Culex Mosquito: These are Common in Areas with Dirty Water[18 35].*

Table 3 Culex Mosquito: These are Common in Areas with Dirty Water[18 35].

Disease	Symptoms
Japanese Encephalitis	Fever, vomiting, confusion, seizures (affects brain)
West Nile Virus (not common in India)	Fever, body aches, fatigue; severe cases affect brain
Filariasis (also spread by Culex)	Swelling of body parts (due to blocked lymph vessels)

IV. PREVENTIONS AND CAUSES

Effectively preventing mosquito-borne diseases involves both personal protective measures and environmental strategies to reduce mosquito activity and breeding. Some prevention methods include[17 33]:

➢ *Preventions*

- Apply mosquito repellent lotions, sprays, or patches on exposed skin[35].
- Wear long-sleeved shirts and full-length pants, especially during times when mosquitoes are most active[36].
- Sleep under mosquito nets in areas where mosquitoes are prevalent[35].
- Avoid letting stagnant water accumulate in flower pots, buckets, coolers, tyres, or other containers[35].
- Educate people about the risks associated with mosquito-borne diseases and how to prevent them[35].

Among these prevention strategies, using mosquito repellent lotion is one of the most convenient and practical options[35]. This project focuses on creating and highlighting the importance of a herbal mosquito repellent lotion made from citronella oil, a natural essential oil that has strong mosquito-repelling properties[18].

➢ *Causes*

- Stagnant water in open containers, drains, and water tanks promotes mosquito breeding[36].
- Poor sanitation and improper waste disposal increase mosquito populations.
- Warm and humid climatic conditions Favor mosquito growth and survival[35].
- Lack of awareness and preventive measures against mosquito bites[18].
- Increased urbanization and overcrowding leading to unhygienic conditions[35].

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V. CONCLUSION

This review offers a detailed analysis of various herbal ingredients and essential oils used as mosquito repellents. Through a thorough review of scientific literature, several medicinal plants and oils with proven repellent and larvicidal effects were identified and compared. The review emphasizes the effectiveness, safety, and environmental benefits of herbal repellents compared to chemical alternatives. Based on the findings, certain essential oils and herbal extracts were selected for their effectiveness, availability, safety, and suitability for topical use. This review serves as a basis for choosing appropriate herbal oils for the final formulation of a herbal mosquito repellent product. The insights gained from this study will guide the formulation, evaluation, and development of an effective and safe herbal mosquito repellent.

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