

PLANT-BASED MOSQUITO REPELLENT PRODUCTS: A REVIEW FOR COMMUNITY ENTERPRISE

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Abstract

Mosquitoes are among the most important vectors of infectious diseases affecting humans, including malaria, lymphatic filariasis, dengue, chikungunya, yellow fever and Zika virus disease. Preventing mosquito from human contact is the most important component of personal protection and integrated vector management. Although synthetic repellents such as N,N-diethyl-meta-toluamide (DEET), picaridin and IR3535 are widely used, interest in plant-based repellents has increased because of their biological activity, renewable origin and potential for local production. Plant-derived repellents are obtained mainly from essential oils, fixed oils, extracts and purified phytochemicals. Important botanical sources include *Cymbopogon* spp. (citronella and lemongrass), *Azadirachta indica* (neem), *Ocimum* spp. (basil), *Eucalyptus* spp., *Syzygium aromaticum* (clove), *Mentha* spp., *Lantana camara*, *Carapa guianensis* and several other aromatic plants. A recent systematic review of studies published from 2020–2024 reported high repellency for several essential oils, although the authors emphasized that much of the evidence remains laboratory-based and that field validation is needed. Plant-based mosquito repellents have considerable potential as complementary personal-protection products, particularly where locally available botanical resources can be developed into affordable formulations. However, they should be considered as one component of integrated mosquito management rather than as a replacement for established vector-control interventions.

Keywords: Mosquito, Plant-based, Repellent, Essential oils, Botanical, Insecticides.

Introduction

Mosquitoes are medically important arthropods because they transmit a wide range of pathogens to humans (Meireles *et al.*, 2023). Major mosquito genera of public-health importance are *Anopheles*, *Aedes* and *Culex*. Depending on species and geographical distribution, these mosquitoes are responsible for the following vector born diseases; malaria, dengue, chikungunya, Zika, yellow fever, lymphatic filariasis and other infections. Therefore, reducing contact between humans and mosquitoes will be an important component of disease prevention (WHO, 2024). Personal protection against mosquito bites can be achieved through various physical barriers such as insecticide-treated nets, topical repellents, appropriate clothing, and other measures. The World Health Organization recognizes personal protection measures, including topical repellents, as supplementary components of vector control programmes (WHO, 2024). Synthetic repellents, particularly DEET and picaridin, have been extensively investigated and are widely used (Farina and Conti, 2024). However, continuing interest in botanical alternatives has been stimulated by concerns about environmental persistence, consumer preferences, the search for renewable resources and the need for locally available mosquito-control products. Plant materials contain numerous secondary metabolites capable of affecting mosquito host seeking, landing and biting behaviour (WHO, 2023). Essential oils have received particular attention because many aromatic plants produce volatile compounds with insect-repellent activity. A recent systematic review

involving 33 experimental studies published between 2020 and 2024 found substantial repellency among several plant essential oils. However, the review also noted that most available evidence was generated under controlled laboratory conditions rather than natural field conditions (WHO, 2019; Rabelo *et al.*, 2026). The purpose of this review is to examine the scientific basis, botanical sources, active constituents, formulations, efficacy, safety, limitations and future prospects of plant-based mosquito repellent products.

Mosquitoes and Their Public-Health Importance

Mosquitoes belong to the family Culicidae. Their importance as disease vectors is closely related to their blood-feeding behaviour, by the fact that female mosquitoes require blood meals for egg development, and during feeding they may acquire pathogens from infected hosts and subsequently transmit them to susceptible individuals (Cecilio *et al.*, 2025). *Anopheles* mosquitoes are the principal vectors of human malaria. Some species are also associated with transmission of lymphatic filariasis. Protection against *Anopheles* bites is particularly important in malaria-endemic regions. *Aedes aegypti* and *Aedes albopictus* are important vectors of dengue, chikungunya and Zika viruses. They commonly bite during daylight hours, making topical repellents and other personal protection measures potentially useful during outdoor activities. WHO recommends personal protection measures against mosquito bites as part of prevention of mosquito-borne diseases, while *Culex* species are involved in transmission of several pathogens, including lymphatic filarial parasites and viruses such as West Nile virus in appropriate epidemiological settings (WHO, 2024). Because mosquito behaviour differs among genera and species, the effectiveness of a particular botanical repellent cannot automatically be generalized from one mosquito species to another.

Concept of Plant Based Mosquito Repellents

A mosquito repellent is a substance that reduces the likelihood of mosquitoes landing on, probing or biting a treated person or surface (Iovinella *et al.*, 2022). Repellents do not necessarily kill mosquitoes, but they interfere with host-seeking behaviour and reduce the chances of mosquito having human contact. Plant based mosquito repellents are products in which the principal repellent ingredient originates from plants, which may contain; essential oils, crude plant extracts, fixed or vegetable oils, isolated phytochemicals, mixtures of botanical compounds or chemically modified derivatives of plant derived molecules (Rabelo *et al.*, 2026). Plant derived repellents can act through odour-mediated interference with mosquito host detection. Some compounds may interfere with olfactory receptors or other sensory mechanisms involved in locating hosts which may lead to moving away from a stimulus, inhibition of host attraction or interference with feeding (WHO, 2024).

The interest in plant based repellents has been revived seeing that the development of resistance, cross-resistance and possible toxicity hazards associated with synthetic insecticides and their rising cost in the markets (Shivaji *et al.*, 2024). Many synthetic chemicals are accepted and have been used for the purpose of mosquito repellency or killing. But, recently, commercial repellent products containing plant-based ingredients have gained increasing popularity among consumers, as these are commonly perceived as “safe” in comparison to long-established synthetic repellents. A report describes plant-based repellents for mosquitoes for personal protection measures. Based on the knowledge on traditional repellent plants obtained through ethnobotanical studies, the product developed offers high repellence as well as good consumer safety (Maia and Moore, 2011; Shukla *et al.*, 2018).

Currently, the scientific investigation of botanical repellents expanded with the identification of plant volatile compounds responsible for insect behavioural effects. Essential oils obtained from aromatic plants subsequently became important subjects of laboratory and field investigations. The modern research has therefore shifted from simple application of crude plant materials towards chemical characterization, identification of active compounds, standardized extraction, formulation development, controlled laboratory testing, human safety assessment, field evaluation and development of sustained release formulations. This progression is important because a plant may demonstrate biological activity in a laboratory while its crude extract may have inadequate stability, unpleasant odour, poor skin retention or inconsistent composition in a commercial product (Aidoo *et al.*, 2021; Iovinella *et al.*, 2022).

Major Plants Used in Mosquito Repellent Products

It was gathered from the studies conducted by Maia and Moore, 2011; Aidoo *et al.*, 2021; Iovinella *et al.*, 2022; Shibeshi *et al.*, 2024 that, the following are among the major plants used in mosquito repellent products.

1. *Cymbopogon* species

Cymbopogon, is commonly called lemongrass, oily heads, silky heads, cochin grass, fever grass, malabar grass, citronella grass or barbed wire grass, it is a genus of Australian, Asian, tropical island and African plants in the grass family (Figure 1). Some species particularly *Cymbopogon citratus* are commonly cultivated as culinary and medicinal herbs because of their scent, resembling that of lemons (*Citrus limon*). Citronella and related *Cymbopogon* species are among the best-known botanical sources of mosquito repellents. Their essential oils contain compounds such as citronellal, citronellol and geraniol. A major limitation of citronella oil is its volatility. Conventional citronella preparations may provide relatively short protection because their active components evaporate rapidly. Research has therefore investigated fixatives and chemical modification of citronellal to increase persistence. Recent work on citronellal derivatives demonstrated that modifying the volatility and physicochemical characteristics of natural repellent compounds can substantially extend protection.



Figure 1: An Image of *Cymbopogon citratus*

2. *Hyptis spicigera* Lam.

Hyptis spicigera is a plant with a strong aromatic smell. It stand erect and candelabra in shape. They produce quadrangular stem which bears simple opposite and decussate leaves. The leaves are lance in shape and are carried by a narrow stalk. The flowers are assembled in dense terminal

spikes. They consist of a calyx in tube with 5 narrow tines, it has four similar rounded lobes with a white corolla, four stamens and four free ovaries are at the base of a common style. The four seeds are ellipsoidal (Bourgeois, 2026) (Figure 2). Phytochemical screening and mosquito repellent potential of *Hyptis spicigera* was reported. The insecticidal and repellent activity observed may be attributed to bioactive phytochemicals; saponins and alkaloids, which are known to interfere with insect membrane integrity and behavioural responses. The traditional use of *H. spicigera* as a botanical mosquito repellent was suggested and demonstrated that increased plant concentration enhances efficacy (Muhammad *et al.*, 2026).



Figure 2: An Image of *Hyptis spicigera*

3. *Lantana camara*

Lantana camara also known lantana is a species of flowering plant in the verbenaceae family (Verbenaceae), native to the tropics of the Americas. It is a very adaptable species, that can inhabit a wide variety of ecosystems. Once planted into a habitat it may spreads rapidly between 45°N and 45°S and less than 1,400 metres (4,600 feet) in altitude. It has spread from its native range to around 50 countries (Wikipedia, 2026) (Figure 3). *Lantana camara* contains a complex mixture of secondary metabolites and essential-oil constituents. Recent experimental work has shown repellency against *Aedes aegypti*, *Anopheles gambiae* and *Culex quinquefasciatus*, although efficacy varied with mosquito species and concentration (Abbas *et al.*, 2024).



Figure 3: An Image of *Lantana camara*

4. *Azadirachta indica* (Neem)

Azadirachta indica, commonly known as neem, margosa, nimtree or Indian lilac, is a tree in the Mahogany family Meliaceae (Figure 4). It is one of the two species in the genus *Azadirachta*. It is native to the Indian subcontinent and to parts of Southeast Asia, but is naturalized and grown around the world in tropical and subtropical areas. Its fruits and seeds are the source of neem oil containing biologically active limonoids, including azadirachtin, nimbin and salannin. Neem derived preparations have demonstrated repellent, larvicidal, ovicidal and growth regulating effects against mosquitoes. A recent review described neem oil as a promising botanical mosquito-control agent and emphasized the importance of formulation in overcoming its instability under environmental conditions. Experimental studies have also investigated neem seed oil against *Anopheles* mosquitoes, supporting its potential as a botanical repellent (Aidoo *et al.*, 2021; Chatterjee *et al.*, 2023).



Figure 4: An Image of *Azadirachta indica*

5. *Ocimum* species

Ocimum is one of the genus among the aromatic annual and perennial herbs and shrubs in the family Lamiaceae, it is a native to the tropical and warm temperate regions of all 6 inhabited continents, with the greatest number of species in Africa. Its best known species are the cooking herb basil (*O. basilicum*) and the medicinal herb tulsi (holy basil) *O. tenuiflorum*. These species contains volatile compounds with insect-repellent properties. *Ocimum gratissimum*, commonly found in parts of Africa, has attracted interest because of its availability and traditional uses. A study conducted in eastern Nigeria evaluated formulations containing volatile oil of *O. gratissimum*. The researchers reported substantial reductions in mosquito biting, with efficacy varying according to oil concentration and the formulation base. This type of research illustrates the potential for locally available plants to contribute to the development of community oriented repellent products (Oparaocha *et al.*, 2010).



Figure 5: An Image of *Ocimum gratissimum*

6. *Eucalyptus* species

Eucalyptus is a genus of more than 700 species of flowering plants in the family Myrtaceae. Majority of *Eucalyptus* species are trees, often mallees, and a few are shrubs. Along with several other genera in the tribe Eucalypteae, including *Corymbia* and *Angophora*, they are commonly known as eucalypts or "gum trees". Species of *Eucalyptus* have bark that is either smooth, fibrous, hard, or stringy and leaves that have oil glands. The sepals and petals are fused to form a "cap" or operculum over the stamens, hence the name from Greek *eû* 'well' and *kaluptós* 'covered'. *Eucalyptus* oils contain compounds such as 1,8-cineole and other terpenoids. Several *Eucalyptus* derived oils have demonstrated mosquito repellent properties. The biological activity of *Eucalyptus* oil depends on species, chemotype, extraction method and concentration. Consequently, botanical identification and chemical characterization are important when comparing products (Wikipidea, 2026; Deng *et al.*, 2023).



Figure 6: An Image of *Eucalyptus* Tree

7. *Syzygium aromaticum* (Clove)

Syzygium aromaticum are the aromatic flower buds of a tree in the family Myrtaceae. They are native to the Maluku Islands, or Moluccas, in Indonesia, and are commonly used as a spice, flavoring, or fragrance in consumer products, such as toothpaste, soaps, or cosmetics. Freshly harvested cloves are available throughout the year owing to different harvest seasons across various countries. Clove essential oil is rich in eugenol, a phenylpropanoid associated with insecticidal and repellent activity. Experimental research has demonstrated strong repellency of clove oil against *Aedes* mosquitoes under laboratory conditions. Phytochemical analysis of essential oil showed the presence of eugenol (major compound), saponins, alkaloids, flavonoids, glycosides, tannins and steroids. The essential oil of *Syzygium aromaticum* possesses various biological activities such as antibacterial, antifungal, antiviral, anticancer, acaricidal, insecticidal, antioxidant, antidiabetic, cardiovascular and anti-inflammatory. However, high concentrations of essential oils may not necessarily be appropriate for direct skin application because efficacy and dermal tolerability must be considered simultaneously (Kahkahi, 2025; Wikimedia, 2026).

8. *Mentha* species

Mentha, also known as mint is a genus of flowering plants in the mint family Lamiaceae (Figure 8). It is estimated that 18 to 24 species exist, but the exact distinction between species is unclear. Hybridization occurs naturally where some species' ranges overlap, thereby producing many hybrids and cultivars. The genus *Mentha* possesses commercial values owing to its aromatic species. Despite its traditional applications in food flavoring, *Mentha* spp. such as *Mentha piperita* (peppermint), *M. aquatica* (water mint), *M. spicata* (spearmint), and *M. arvensis* (wild mint) are widely used for treating not only cold and fever but also gastro-intestinal and cardiovascular disorders as folk medicines. It has revealed a plethora of biological traits viz. antimicrobial, antioxidant, anticancer, anti-ulcer, anti-diabetic, insecticidal, and anti-inflammatory activities. Peppermint and related *Mentha* species contain volatile constituents such as menthol and menthone. Several *Mentha* essential oils have demonstrated repellent activity against mosquitoes and are being investigated as potential botanical ingredients (Eftekhari *et al.*, 2021; Abbas *et al.*, 2023).



Figure 8: An Image of *Mentha piperita*

Mechanisms of Action

The precise mechanisms differ according to the active compound and mosquito species. Major mechanisms proposed for botanical repellents alters the ability of mosquitoes to locate hosts using carbon dioxide, body odours, heat and other sensory cues. Volatile plant compounds may interfere with mosquitoes's olfactory host detection mechanisms, so that mosquitoes will not be able to detect their hosts. Some botanical compounds can activate or inhibit mosquito's olfactory receptors to interact with mosquito sensory receptors and alter behavioural responses to human odours. Some times, strongly aromatic compounds may interfere with the mosquito's ability to detect human odour cues. Certain plant compounds such as volatile substances induce mosquitoes to move away from treated surfaces or areas. At sufficiently high concentrations, some botanical compounds may produce knockdown or mortality rather than simple repellency due to toxic or neuro physiological effects (Mustapa *et al.*, 2023; Daniel *et al.*, 2025; Teshome *et al.*, 2026).

Types of Plant Based Mosquito Repellent Products

Plant derived mosquito repellents can be formulated into several product categories as follows;

1. Creams and Lotions

Creams and lotions can be formulated using essential oils and plant extracts into an appropriate dermatological base that will deter mosquitoes and other biting insects and bugs. The repellent products can be use for topical application only. The advantages of this product is direct application to exposed skin, relatively easy dosing portability and potential for controlled release.

2. Oils

Essential oils may be diluted in suitable carrier oils. However, undiluted essential oils may be inappropriate for direct skin use because concentrated oils can cause irritation or sensitization.

3. Sprays

Plant based sprays can be applied to exposed skin, clothing or environmental surfaces depending on product formulation and regulatory approval.

4. Gels

Gel formulations may improve skin adherence and permit gradual release of volatile components.

5. Soaps

Botanical oils may be incorporated into soaps. However, the brief contact period during washing means that soap formulations should not automatically be assumed to provide prolonged post washing repellency.

6. Candles and Spatial Repellents

Plant derived volatile substances may be incorporated into candles, diffusers or other spatial emission devices. Their efficacy depends on environmental conditions, air movement, formulation and mosquito behaviour.

7. Treated Materials

Botanical repellents may also be incorporated into fabrics, clothing or other materials designed to reduce mosquito contact.

Innovation for Community Business Opportunities

Community business opportunities for plant based mosquito repellents can be an important as innovation of ideas, particularly in Nigeria and other tropical communities where mosquito exposure is common. Plant based repellents can create opportunities across cultivation, processing, formulation, packaging, distribution, retail and community education. However, they should be developed as safe, properly tested products, not simply marketed because they are “natural.” WHO recognizes repellents as personal-protection tools, while also noting that evidence for community level disease impact from topical repellents is limited and that high, consistent use would be needed. The table 1, below summerised the opportunities and possible business one can engage within his community to serve based on their demands.

Table 1: Community Business Opportunities

Opportunity	Possible community business
Cultivation of repellent plants	Farmers can cultivate neem, lemongrass, citronella, basil/ <i>Ocimum</i> , eucalyptus and other suitable aromatic plants for sale to processors.
Essential oil production	Small enterprises can process suitable plant materials through distillation or other appropriate extraction methods and sell standardized oils to manufacturers.
Repellent creams and lotions	Community entrepreneurs can manufacture properly formulated topical products using validated botanical active ingredients.
Mosquito repellent sprays	Plant derived formulations can be developed as household or personal use sprays, subject to safety and regulatory requirements.
Repellent soaps	Local soap manufacturers can develop botanical products incorporating appropriate mosquito repellent ingredients.
Repellent candles and spatial products	Businesses can investigate botanical volatile ingredients for candles, diffuser and other spatial repellent products. WHO has specific guidance for evaluating spatial repellents.
Repellent-treated fabrics	Tailors and textile businesses could potentially produce treated clothing or fabrics, provided the treatment is scientifically validated and appropriately regulated.
Packaging and labelling	Local printing and packaging businesses can supply bottles, tubes, sachets, labels and cartons for repellent manufacturers.
Distribution and retail	Pharmacies, supermarkets, health shops, market traders and community retailers can distribute approved products.
Contract	Small businesses could specialize in extraction or formulation and

Opportunity	Possible community business
manufacturing	manufacture products for other brands.
Community pest control services	Trained operators could provide mosquito management services using approved products as part of an integrated approach.
Research and testing services	Universities and laboratories can provide plant identification, phytochemical analysis, mosquito bioassays, formulation testing and quality control services.
Community health education	Trained community workers can provide education on mosquito bite prevention and correct product use.
Agricultural value addition	Farmers can sell plant material rather than raw crops alone, creating additional value through drying, processing and extraction.
Export opportunities	Standardized botanical oils and finished products may eventually provide opportunities for regional or international markets if they meet applicable quality and regulatory requirements.

Conclusion and Recommendations

Plant-based mosquito repellents represent a promising component of personal protection against mosquito bites and the diseases transmitted by mosquitoes. A wide range of aromatic and medicinal plants contain bioactive compounds, particularly essential oils and their constituents, that demonstrate repellent activity against important mosquito species. Plants such as *Cymbopogon* spp., *Ocimum* spp., *Azadirachta indica*, *Eucalyptus* spp., *Mentha* spp., and *Syzygium aromaticum* have received considerable attention because of their potential to provide effective mosquito-bite protection. Their production can also create opportunities for local cultivation of medicinal and aromatic plants, essential-oil extraction, formulation of creams, lotions, sprays, soaps and spatial repellents, as well as small-scale entrepreneurship and employment, particularly in developing communities.

However, the classification of a mosquito repellent as “plant based” or “natural” does not automatically guarantee safety, effectiveness, or long lasting protection. Many botanical repellents have relatively short duration of activities because their volatile constituents evaporate rapidly. For communities in mosquito-endemic regions, including Nigeria, plant-based repellents may provide opportunities for local value addition and entrepreneurship while contributing to personal protection from mosquito bites. Nevertheless, they should be considered as part of an integrated mosquito-control strategy rather than as a replacement for proven public-health interventions such as insecticide-treated nets, indoor residual spraying, environmental management and other appropriate vector-control measures.

Future research should focus on identifying highly effective plant-derived compounds, improving formulation stability and duration of protection, developing controlled-release and microencapsulated products, establishing standardized quality-control procedures, evaluating long-term safety, and conducting well-designed field studies under real-life conditions. Greater collaboration among researchers, local communities, agricultural producers, manufacturers, regulatory authorities and public-health institutions will be important for translating promising laboratory findings into safe, affordable and commercially sustainable products.

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