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Herbal Remedies for Mosquito-Borne Diseases

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ABSTRACT

Mosquito-borne diseases pose significant health risks worldwide, with millions of cases reported annually. In light of increasing insecticide resistance and environmental concerns associated with conventional mosquito control methods, there is a growing interest in exploring alternative approaches, including herbal remedies. This review focuses on the development of herbal mosquito repellents as a preventive measure against mosquito-borne diseases. We discuss the epidemiology and impact of common mosquito-borne illnesses such as malaria, dengue fever, Zika virus, and chikungunya, highlighting the urgent need for effective prevention strategies. Additionally, we explore the efficacy of various herbal ingredients known for their mosquito-repelling properties, such as citronella, neem, lemongrass, and eucalyptus. Furthermore, we examine the formulation and testing of herbal repellents, including their safety, duration of protection, and user acceptability. By synthesizing existing knowledge and ongoing research efforts, this review underscores the potential of herbal mosquito repellents as a sustainable and accessible solution for mitigating the burden of mosquito-borne diseases.

Keywords: *Herbal remedies, Herbal mosquito repellent, Larvicidal, Mosquito-borne diseases, Mosquito control, repellent, Public health, Traditional medicine*

1.INTRODUCTION

Mosquito-borne diseases pose a significant public health threat worldwide, particularly in regions with warm climates and stagnant water bodies, which serve as breeding grounds for these blood-sucking insects (1). These diseases are primarily transmitted through the bites of infected female mosquitoes, which inject pathogens into the bloodstream, leading to a range of illnesses. Common mosquito-borne diseases include malaria, dengue fever, Zika virus, chikungunya, yellow fever, and West Nile virus, among others (2). These diseases not only cause considerable morbidity and mortality but also impose a substantial economic burden on affected communities and healthcare systems.

In response to the challenges posed by mosquito-borne illnesses, various preventive measures and treatments have been developed, ranging from insecticide spraying and mosquito net distribution to the exploration of herbal remedies. While conventional treatments such as antimalarial drugs and vaccines have been effective to some extent, there is growing interest in exploring herbal alternatives due to their potential efficacy and fewer side effects. Herbal treatments harness the therapeutic properties of plants and natural compounds to combat mosquito-borne diseases, offering a promising avenue for research and development in the field of tropical medicine.

This paper aims to explore the prevalence and impact of mosquito-borne diseases, examine the traditional and herbal treatments utilized to combat these illnesses, and assess the potential benefits and challenges associated with integrating herbal medicine into mainstream healthcare strategies. By gaining a deeper understanding of the diseases caused by mosquitoes and the herbal remedies available, we can better inform public health interventions and empower communities to protect themselves against these debilitating illnesses.

1.1 MOSQUITO BORNE-DISEASES

The bite of an infected female mosquito spreads mosquito-borne illnesses. The most frequent mosquito-borne infections include malaria, Chikungunya, Zika, Dengue, West Nile, yellow fever, Rift Valley fever, lymphatic filariasis, and tick-borne encephalitis (3). Mosquitoes from the genera Aedes, Culex, and Anopheles are important vectors of the infections that cause these diseases and are found throughout Africa, Asia, South America, and Europe (4). Mosquito-borne infections affect over 700 million people worldwide, causing over one million fatalities (5).

MALARIA: - Malaria, transmitted by Anopheles mosquitoes, remains one of the most prevalent mosquito-borne diseases globally. Caused by the Plasmodium parasite, malaria infects millions, leading to fever, chills, and, in severe cases, organ failure or death (6). Malaria which is spread to humans by infected female Anopheles mosquitos, is one of the deadliest diseases (7). Malaria is prevalent throughout Africa's tropics, as well as Asia and South

America (8). In 2020, an estimated 241 million malaria infections were reported worldwide, with 627 thousand people dying, the vast majority of them were African children (9).

WEST NILE: - West Nile is a mosquito-borne disease caused by the West Nile virus, an enveloped, positive-strand ribonucleic acid (RNA) flavivirus from the Flaviviridae family (10). The virus causes most bird illnesses, particularly in crows and blue jays, but it can also infect humans, dogs, horses, and other species (11). Culex mosquitos, particularly Cx. quinquefasciatus, Cx. stigmatosoma, Cx. thriambus, Cx. pipiens, and Cx. nigripalpus, which infect a variety of avian and mammalian species, are the primary vectors of West Nile virus transmission (12). Culex mosquitoes are vectors for the West Nile virus, which can cause neurological diseases such as encephalitis or meningitis. While many infected individuals exhibit mild symptoms, severe cases can be life-threatening.

DENGUE: - Dengue fever, transmitted by Aedes mosquitoes, has seen a dramatic increase in incidence over the past few decades. This viral infection manifests as flu-like symptoms, severe joint pain, and in severe cases, hemorrhagic fever or shock. Dengue fever is caused by the Dengue virus, a positive (+)-stranded ribonucleic acid (RNA) virus from the Flavivirus genus and the Flaviviridae family (13). The virus is mostly spread through the bites of infected female Aedes aegypti and Aedes albopictus mosquitos, as well as zoonotic agents with no recognized arthropod vector (14). The disease is the greatest cause of morbidity and mortality in the tropics and subtropics, with an estimated 10,000 fatalities and 100 million symptomatic infections per year in more than 125 countries (15)**.**

YELLOW FEVER: - Yellow fever is caused by the yellow fever virus. This flavivirus is prevalent in tropical Africa, South America, and North America. Yellow fever has the potential to create widespread epidemics in non-human primates as well as outbreaks in humans (16). Pathogens that cause the disease are primarily spread in Africa by Aedes albopictus and Aedes aegypti (17). Nonhuman primates are part of the sylvatic reservoir system (18). The disease is transmitted through two cycles: urban (humans and mosquitoes) and sylvatic (non-human primates and mosquitoes that live in forests) (19,20). Sylvatic cycles are responsible for the bulk of recorded instances in South America (21). In contrast, the intermediate cycle, which involves the transmission of yellow fever virus from monkey to human or human to human via mosquito bites, has only been recorded in Africa (22).

CHIKUNGUNIYA: -Chikungunya is caused by the Chikungunya virus, which is transmitted by arthropods (23). This virus is predominantly spread through the bite of infected Aedes (subgenus Stegomyia) mosquitos (e.g., Ae. aegypti, Ae. albopictus, Ae. Furcifer, and other Ae. furcifer-taylori members) (24). Chikungunya virus is endemic in tropical and subtropical Africa, as well as Southeast Asia, where nonhuman primates and Aedes spp. share transmission cycles (24). Chikungunya is another viral disease transmitted by Aedes mosquitoes, causing fever, joint pain, and muscle aches. Although rarely fatal, it can result in long-lasting joint pain.

RIFT VALLEY FEVER: - Infection with the Rift Valley fever (RVF) virus (Phlebovirus, family Bunyaviridae) is a disease that affects both domestic livestock (cattle, sheep, and goats) and humans (25). The disease is spread by mosquitoes or by direct contact with diseased animals and their products (26). Mosquito species such as Aedes vexans (Meigen), Cx. poicilipes (Theobald), and Cx. quinquefasciatus are the primary vectors of RVF (27). Rift Valley fever is also spread by genus Mansonia and Anopheles mosquitoes (28). RVF is most prevalent in sub-Saharan Africa, however the disease has lately been detected in the Arabian Peninsula and Saudi Arabia (29,30).

ZIKA VIRUS: - Zika virus, also transmitted by Aedes mosquitoes, gained international attention due to its association with congenital disabilities, particularly microcephaly in infants born to infected mothers. Symptoms include mild fever, rash, and joint pain. The Zika virus is caused by a flavivirus since 2007 (31). Outbreaks of Zika virus have been recorded in Micronesia and Brazil (32). Furthermore, between 2015 and 2017, about 6000 instances of symptomatic Zika virus disease were documented in the United States (33). The Zika virus, like other flaviviruses, is transmitted by mosquitos, especially of the Aedes (Stegomyia) genus, with species such as Aedes aegypti, Aedes africanus, Aedes hensilli, and Aedes albopictus implicated (34). Although viral isolation tests suggest that Aedes albopticus was the most likely vector in a 2007 Zika virus outbreak in Gabon, Africa's major Aedes species vector has yet to be identified (35). Other methods of Zika virus transmission include maternal-fetal transmission, sexual transmission, blood transfusions, organ transplantation, and laboratory exposure (36).

LYMPHATIC FILARIASIS: - Lymphatic filariasis (LF) is caused by microfilaria from Wuchereria bancrofti, Brugia malayi, or Brugia timor (37).Lymphatic filariasis is transmitted by various mosquito species from the following genera, depending on their geographical distribution: (i) Culex (ii) Anopheles (iii) Aedes (iv) Mansonia, and (v) Coquillettidia (C. juxtamansonia) (38,39). Lymphatic filariasis infects more than 120 million individuals worldwide (40). The disease is endemic in 73 countries, putting 1.1 billion people in Asia, Africa, the western Pacific, South America, and the Caribbean at danger of catching it (40).

2. HERBAL PLANTS USED IN COMBATING MOSQUITO-BORNE DISEASES

Several herbal plants have been traditionally used for their mosquito-repellent properties and, in some cases, for their potential in managing mosquito-borne diseases. While scientific research is ongoing to validate the efficacy of these plants, many communities have relied on these natural remedies for generations. Here are some herbal plants commonly used for mosquito control and prevention of mosquito-borne diseases:

2.1 LEMONGRASS

Fig. 1 – LEMONGRASS

Table No. 1- Pharmacogenetic study of lemongrass

Synonyms	East India lemongrass, Malabar, or Cochin Lemongrass.
Family	Poaceae
Biological source	Lemongrass oil is obtained from Cymbopogon flexuosus Stapf. (syn. Andropogonnardus var. flexuosus Hack.), belonging to family Poaceae. It contains not less than 75% of aldehydes calculated as citral.
characteristics	lemongrass are barbed wire grass,sillky heads ,cochin grass, oily heads
Chemical constituents	Monoterpenes :- Terpinolene, Limonene. Myrcene Terpenoids :- Grenial, Neral, Citral Phenolic Compound :- Terpinol, Geraniol, Borneol.
uses	1) Citral used for preparation of violet perfumes 2) Mosquito repellent 3) It also used in manufacturing of soaps, cosmetic and perfume. 4) It has antimicrobial, anti-inflammatory, and antioxidant properties.

Table No. 1

2.2 CYMBOPOGONNARDUS (CITRONELLA)

Fig. 2- CITRONELLA

Table No. 2- Pharmacogenetic study of citronella

Synonyms	Citronella grass, Nardus, Mana grass
Family	Poaceae.
Biological source	It is the oil obtained by the steam distillation of fresh leaves of Cymbopogonnardus (L.) Rendle
characteristics	It is a tall, tufted perennial, clump-forming tropical grass with narrow leaf blades. They grow to a height of 5-6 ft. The leaves are greyish green, flat, about 3 ft long, and I inch wide.
Chemical constituents	Citronella grass contains of volatile oil. The main chemical components of citronella oil are citronellic acid, geran-iol, nerol, citral, bormeol, camphene, citronellol, citronellal, dipentene., and limonene.

uses	1) Citronella grass is the source of the commercial citronella oil, 2) used in perfumery, 3) As an insect repellent. 4) Citronella oil is antiseptic, deodorant, tonic, insecticide, diaphoretic, bactericidal, and stimulant.

Table No. 2

2.3 TULSI

Fig.3- TULSI

Table No.3 – Pharmacognostic study of TULSI

Synonyms	Sacred basil, Holy basil.
Family	Labiatae
Biological source	Tulsi consists of fresh and dried leaves of Ocimum sanctum Linn., belonging to family Labiatae.
characteristics	It is much branched small herb and 30 to 75 cm in height. All parts of tulsi are used in medicine, especially fresh and dried leaves.
Chemical constituents	Tulsi leaves contain bright, yellow coloured and pleas-ant volatile oil (0.1 to 0.9%). The oil content of the drug varies depending upon the type, the place of cultivation and season of its collection. The oil is collected by steam distillation method from the leaves and flowering tops.
uses	1) The fresh leaves, its juice and volatile oil are used for various purposes. 2) The oil is antibacterial and insecticidal. The leaves are used as stimulant, aromatic, spasmolytic, diaphoretic 3) The juice is used as an antiperiodic and as a constituent of several preparations for skin diseases and also to cure earache.

Table No.3

2.4 CLOVE

Fig.4- CLOVE

Table No. 4 – Pharmacognostic study of clove

Synonyms	Citrus vulguris, Citrus biguradia, Seville orange peel.
Family	Rutaceae.
Biological source	The orange peel is the fresh or dried outer part of the pericarp of Citrus aurantiumLinn, belonging to family Rutaceae.
characteristics	It is a small tree with a smooth, greyish brown bark and branches that spread into a regular hemisphere. The leaves are oval, alternate, evergreen, size ranging from 3 to 4 inches long with a spine in the axil.
Chemical constituents	Bitter orange peel contains of I to 2.5% volatile oil. The principle component of volatile oil is 90% limonene and small quantities of aldehydes citral, citronellal, bitter amorphous glycoside like aurantiamarin and it's acid; hesperidin, isohesperidin, vitamin C.and Pectin.
uses	1) It is used as aromatic, stomachic, carminative, and flavouring agent, 2) it is used particularly in fish liver oil preparations and liver extract. 3) The oil is used chietly as a flavouring agent.

Table No. 4

2.5 CITRUS SINENSIS (SWEET ORANGE)

Fig .5 – CITRUS SINENSIS

Table No. 5- Pharmacognostic study of citrus sinensis

Synonyms	Clove buds, Clove flowers
Family	Myrtaceae
Biological source	Clove consists of the dried flower buds of Engenia caryophyllus Thumb. belonging to family Myrtaceae
characteristics	Clove is reddish-brown in colour, with an upper crown and a hypanthium. The hypanthium is sub-cylindrical and tapering at the end. The hypanthium is 10 to 13 mm long, 4 mm wide, and 2 mm thick and has schizolysigenous oil glands and an ovary which is bilocular
Chemical constituents	Clove contains 14–21% of volatile oil. The other constituents present are the eugenol, acetyl eugenol, gallotannic acid.
uses	1) Clove is used as an antiseptic, stimulant, carminative, aromatic, and as a flavouring agent.

	2) It is also used as anodyne, antiemetic. Dentists use clove oil as an oral anaesthetic and to disinfect the root canals. 3) Clove kills intestinal parasites and exhibits broad antimicrobial properties against fungi and bacteria and so it is used in the treatment of diarrhoea, intestinal worms, and other digestive ailments.

Table No.- 4

2.6 EUCALYPTUS GLOBULES

Fig. 6 – EUCALYPTUS GLOBULES

Table No. 6 – Pharmacognostic study of eucalyptus globules

Synonyms	Dinkum oil, lemon gum tree, Blue gum tree
Family	Myrtaceae
Biological source	Eucalyptus oil is the volatile oil obtained by the hydro distillation of fresh leaves of eucalyptus globulus.
characteristics	Trichomes are absent, Presence of sunken Stomata, Epidermis is polygonal, Presence of schizogenous oil glands, both prismatic and spharides Calcium oxalate Crystal
Chemical constituents	Cineole (eucalyptol, 70-85%), Citronellal, Terpenes: - pinene, camphene, phellandrene, Polyphenolic acid:- caffeic acid, gallic acid, Flavonoids :- Eucalyptin, Ru
uses	1) Flavouring agent, 2) Expectorant, Cough, 3) Anti septic, Asthma, 4) Anti-microbial

Table No.6

2.7 CURCUMA LONGA (TURMERIC)

Fig.7- TURMERIC

Table No.7-Pharmacognostic study of turmeric

Synonyms	Saffron Indian; haldi (Hindi): Curcuma; Rhizoma cur-cumae
Family	Zingiberaceae.
Biological source	Turmeric is the dried rhizome of Curcuma longa Linn. (syn. Cdomestica Valeton)., belonging to family Zingiberaceae.
characteristics	The primary rhizomes are ovate or pear shaped, oblong or pyriform or cylindrical, and often short branched. The rhizomes are known as 'bulb' or 'round' turmeric. The secondary, more cylindrical, lateral branched, tapering on both ends, rhizomes are 4-7 cm long and 1-1.5 cm wide and called as 'fingers
Chemical constituents	Turmeric contains yellow colouring matter called as curcuminoids (5%) and essential oil (6%). The chief constituent of the colouring matter is curcumin I (60%) in addition with small quantities of curcumin II, curcumin II and dihydrocurcumin. The volatile oil contains mono- and sesquiterpenes like zing1berene (25%), a-phellandrene. sabinene. turmerone, arturmerone, borneol, and cineole Choleretic action of the essential oil is attributed to B tolylmethylcarbinol
uses	1) Turmeric used as aromatic, anti-inflammatory, stomachic, uretic, anodyne for biliary calculus, stimulant, tonic, carminative, blood purifier, antiperiodic, alterative, spice, colouring agent for ointments and a 2) common household remedy for cold and cough. 3) It is also used in menstrual pains. 4) Turmeric is primarily used as a treatment for anti-inflammatory, hepatoprotective, antitumor, antiviral, wound healing and anti-cancerous properties, and is also beneficial in treating gastrointestinal and respiratory disorders.

Table No.7

2.8 PEPPERMINT

Fig.8 -PEPPERMINT

Table No. 8- Pharmacognostic study of peppermint

Synonyms	Brandy Mint.
Family	Labiatae.
Biological source	It is the oil obtained by the distillation of *Mentha piperita*, belonging to family Labiatae.
characteristics	The leaves are shortly and distinctly stalked, 2 inches long and 3/4 to 1.5 inches broad. The stems are 2 to 4 feet high, frequently purplish in colour. The plant has a characteristic odour and if applied to the tongue has a hot, aromatic taste at first and afterwards produces a sensation of cold in the mouth caused by menthol present in it.

Chemical constituents	The chief constituent of Peppermint oil is Menthol, along with other constituents like menthyl acetate, isovalerate, menthone, cineol, inactive pinene, limonene, and other less important bodies. Menthol separates on cooling it to a low temperature (–22°C). The flavouring properties of the oil are due to both the ester and alcoholic constituents, whereas the medicinal value is attributed only due to the alcoholic components.
uses	It is stimulant, stomachic, carminative, inflatulence, and colic; in some dyspepsia, sudden pains, for cramp in the abdomen and also in cholera and diarrhoea. Oil of peppermint allays sickness and nausea, as infant's cordial. Peppermint is good to aid in raising internal heat and inducing perspiration. It is also used in cases of hysteria and nervous disorders.

Table No. 8

2.9 ALOEVERA

Fig.9 – ALOEVERA

Table No. 9 – Pharmacognostic study of aloevera

Synonyms	Aloe, Musabbar, Kumari.
Family	Liliaceae.
Biological source	Aloes are the dried juice obtained by transversely cut leaves of various species of Aloe barbedensis Miller (known as Curacao aloes).
characteristics	It is usually opaque and varies in colour from bright yellowish or rich reddish brown to black. Sometimes it is vitreous and small fragments are then of a deep garnet-red colour and transparent. It is almost entirely soluble in 60% alcohol and contains not more than 30% of substances insoluble in water and 12% of moisture.
Chemical constituents	The most important constituents of Aloes are the three isomers of Aloins, Barbaloin, β-barboloin and Isobarbaloin, which constitute the so-called 'crystalline' Aloin, present in the drug at from 10 to 30%. Other constituents are amorphous Aloin, resin, emodin and Aloe-emodin. Barbaloin is present in all the varieties; it is slightly yellow coloured, bitter, water soluble, crystalline glycoside. Isobarbaloin is a crystalline substance, present in Curacao aloe and in trace amount in Cape aloe and absent in Socotrine and Zanzibar aloe.
uses	1) All the varieties of aloes have more or less purgative action. 2)improves digestion and does not lose its activity by repetition. 3) It mainly effects on colon and has much potent purgative activity than other anthraquinone glucosidal drugs. 4) Aloe gel is used in topical preparations and cosmetics. 5) It possesses good moisturising property, anti-inflammatory property, anti-wrinkle property, protective etc. The fresh gel has a role in burns and wounds.

Table No.9

2.10 ROSEMERRY

Fig. 10 – ROSEMERRY

3. Conclusion

scientific research on the efficacy of herbal plants in combating mosquito-borne diseases is ongoing, several plants have shown promise in laboratory studies and traditional medicine practices. Examples include neem (Azadirachta indica), citronella grass (Cymbopogon nardus), eucalyptus (Eucalyptus globulus), and lemongrass (Cymbopogon citratus), among others. These plants contain compounds with insect-repellent, larvicidal, or antiviral properties, making them potential candidates for the development of natural mosquito control products or complementary treatments.

While these herbal plants may provide some level of protection against mosquitoes, it's essential to note that their effectiveness can vary, and scientific studies are ongoing to better understand their potential. Additionally, personal preferences, skin sensitivities, and individual reactions should be considered when using herbal remedies for mosquito control. Integrating these plants into gardens, using their oils, or incorporating them into natural repellent formulations may contribute to holistic mosquito management strategies.

In conclusion, herbal plants represent a promising avenue for addressing mosquito-borne diseases, providing alternative solutions that align with the principles of traditional medicine and sustainable healthcare. Integrating traditional knowledge with modern scientific research can enhance our understanding of these plants' potential and contribute to the development of holistic approaches to mosquito control and disease management. As we continue to navigate the challenges posed by mosquito-borne illnesses, harnessing the therapeutic potential of herbal plants offers hope for more effective, accessible, and environmentally friendly solutions.

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