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Herbal Remedies For Mosquito Control: A Comprehensive Review Of Plant-Based Repellents

[1]S. K. Budhawale, [2*]Dnyaneshwari Pawar, [3]D. V. Fajage, [2]Vishal Kindre

[1]Assistant Professor, Department of Pharmacology, Rajgad Dnyanpeeth's College of Pharmacy, Bhor, Pune

[2]Student, Rajgad Dnyanpeeth's College of Pharmacy, Bhor, Pune,

[3]Research Scholar, Department of Pharmacology, Rajgad Dnyanpeeth's College of Pharmacy, Bhor, Pune

Abstract: Mosquito-borne diseases continue to pose a significant global health threat, necessitating effective and sustainable methods for vector control. In recent years, there has been a growing interest in herbal mosquito repellents as an alternative to conventional chemical-based products. This review aims to provide a comprehensive assessment of the efficacy, safety, and potential applications of herbal mosquito repellents. Various herbal extracts and essential oils with documented mosquito-repelling properties are discussed, along with the bioactive compounds responsible for their effectiveness. Emphasis is placed on the ecological sustainability of herbal repellents, as well as their potential role in integrated vector management strategies. The review critically analyzes the existing evidence on the duration of protection, repellent efficacy against different mosquito species, and potential adverse effects on human health. Moreover, considerations are given to the environmental impact, feasibility of production, and cultural acceptance of herbal repellents in diverse settings. this review provides valuable insights into the current state of knowledge regarding herbal mosquito repellents. It contributes to the ongoing discourse on sustainable and eco-friendly vector control strategies, fostering informed decision-making among policymakers, public health practitioners, and the general public.

Index Terms - Efficacy, herbal mosquito repellents, sustainability, vector control.

I. INTRODUCTION

Mosquitoes, notorious for their blood-sucking habits, pose a significant threat to human well-being [1,2]. Various mosquito species, including those from the Anopheles, Culex, and Aedes genera, serve as vectors for pathogens responsible for diseases such as Dengue fever, Malaria, Yellow fever, Japanese Encephalitis, and numerous other infections [3]. Annually, mosquitoes are responsible for transmitting diseases to more than 700 million people, resulting in over one million reported deaths globally [4,5]. Consequently, the management of mosquitoes stands as a crucial public health priority worldwide.

Malaria stands as a leading cause of death, with a child succumbing to the disease every 30 seconds, and an annual occurrence of 300 to 500 million cases, as per WHO [6]. The primary preventive measure against illness transmission is avoiding mosquito bites, achieved through the use of repellents like lotions, creams, coils, sprays, and other similar products. Herbal formulations, recognized for their efficacy against various diseases, are increasingly gaining global popularity [7].

Mosquito bites not only trigger allergic reactions like itching and swelling but also serve as a means to transmit pathogens, particularly by the Ae. albopictus (Asian tiger mosquito), a carrier of dengue, Zika, and yellow fever viruses [8]. To prevent these diseases, mosquito control and personal protection against bites are crucial, with insect repellents being a common approach. Repellents fall into two categories: spatial and contact. Spatial repellents, like synthetic pyrethroids, diffuse through the air, inducing aversive behavior in mosquitoes. Contact repellents, including DEET and picaridin, inhibit mosquito responses to attractive odors

by direct action on olfactory receptors [9]. Although widely used, synthetic repellents like DEET raise environmental and health concerns. In contrast, natural essential oils offer advantages such as broad efficacy, multiple modes of action, low residue, and low toxicity, making them a promising alternative [10].

Essential oils (EOs) are volatile oils with distinct aromas found in aromatic plants, providing characteristic scents, flavors, or odors. Numerous EOs with mosquito-repelling properties have been identified, including citronella oil (widely used historically and still prevalent), as well as eucalyptus, clove, lavender, and lemon oils [11]. Despite neglect in modern times due to synthetic repellents, there's a renewed focus on researching and developing natural EOs as mosquito repellents, driven by the increasing demand for healthier and environmentally friendly alternatives [12].

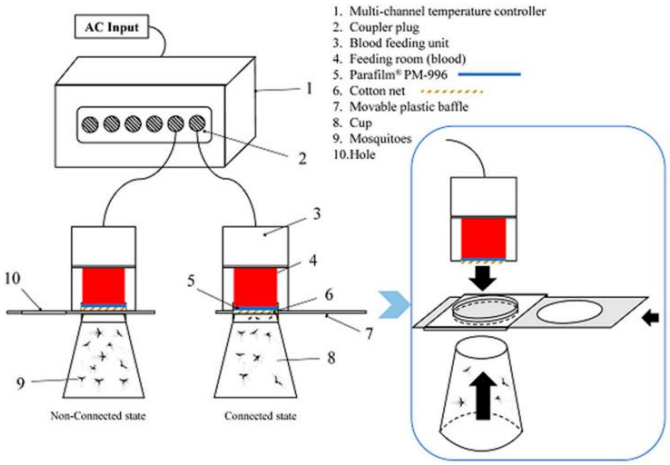


Fig. 1: Repellent activity test device

Numerous herbs and shrubs exhibit medicinal, therapeutic, and mosquito larvicidal properties. To address the environmental impact and harm to non-target organisms caused by synthetic solutions, plant-based insecticides have emerged as an alternative method for controlling various insect pests and vectors in recent times [13].

Frequent use of synthetic chemicals carries health and environmental risks. Phytochemicals in plants offer insect-repellent properties, acting as repellents, feeding deterrents, and poisons. Plant-based repellents are safe for humans and pets, posing no poisoning risk, and are environmentally friendly due to their easy biodegradability[14].

Natural substances are safer than artificial ones for human use. Phytochemicals from plants serve various roles, acting as larvicides, insect development regulators, repellents, and deterrents. Plant products have historically been employed globally to repel or eliminate mosquitoes. There is an urgent need to explore phytochemicals as insect repellents, given the carcinogenic and non-eco-friendly nature of many synthetic formulations [7]. The use of herbal products is rapidly increasing due to their environmental friendliness and high effectiveness. Numerous studies indicate that essential oils and other extracts from plants demonstrate superior properties compared to their synthetic counterparts [15].

Mosquito borne diseases:

In ancient times, mosquitoes have been reported as the source of various ailments affecting human. Comprising approximately 3500 species, mosquitoes are found beyond the tropical and subtropical regions of the world. The human disease causing pathogens are Anopheles (malaria), Aedes (yellow fever,dengue,chikungunya) and Culex (Japanese encephalitis). Over its life span a female mosquito repeatedly takes a blood meal as protein source to complete egg development. By injecting the saliva which may contain pathogens thus complete an obligatory life cycle phase and multiply in the mosquitos salivary glands. Over the years malaria have been considered as one of the leading cause of death in india. With an estimated 75 million cases and 0.8 million fatalities annually, the 1950s saw the greatest frequency of malaria in India, according to history.

Fig. 2: Ades aegypti

1.1 MALARIA

- One of the most widespread infectious illnesses in the world, malaria poses a serious threat to public health, especially in south Asia and Africa.
- An estimated 250 million cases of malaria are reported annually, with a million or more fatalities from the disease, primarily in children under five.
- The deadly parasites that cause malaria are called plasmodium parasites, and female Anopheles mosquitoes spread the disease [16].

1.1.1 Signs and symptoms of malaria:

- Fever and sweating
- Chills that shake your whole body
- Headache and muscle aches
- Fatigue
- Chest pain, breathing problems and Cough
- Diarrhea, nausea and vomiting

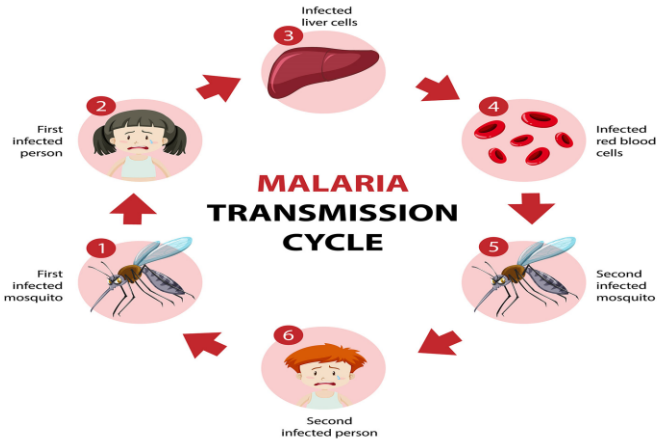


Fig. 3: Malaria Cycle

1.1.2 Treatment:

- It's important to start treating malaria as soon as possible.
- Malaria is treated with prescription drugs to kill the parasite.
- Arteminsnin drugs are best treatment for plasmodium falciparum malaria [17].

1.1.3 Disease Burden:

- According to the latest World malaria report, there were 249 million cases of malaria in 2022 compared to 244 million cases in 2021.
- In 2022, there were 608 000 malaria fatalities projected, compared to 610 000 in 2021.
- The WHO African Region is still responsible for an excessively large part of the world's malaria cases.
- Approximately 94% of all malaria cases and 95% of fatalities in 2022 occurred in the Region.
- Roughly 78% of malaria deaths in the region were in children under the age of five.
- Just over half of all malaria deaths globally occurred in four African countries: Mozambique (4.2%), Uganda (5.1%), Nigeria (26.8%), and the Democratic Republic of the Congo (12.3%).

1.2 DENGUE

- Dengue is a viral infection that spreads from mosquito to people.
- Each year up to 400 million people get infected with dengue and 40000 die from severe dengue.
- The largest number of dengue cases ever reported globally was in 2019. All regions were affected, and dengue transmission was recorded in Afghanistan for the first time [18].

1.2.1Causes

- The Aedes aegypti mosquito is the main vector that transmits the virus that causes dengue.

1.2.2 Signs and symptoms of dengue:

- Headache
- Muscle,bone or joint pain
- Nausea
- Vomiting
- Rash

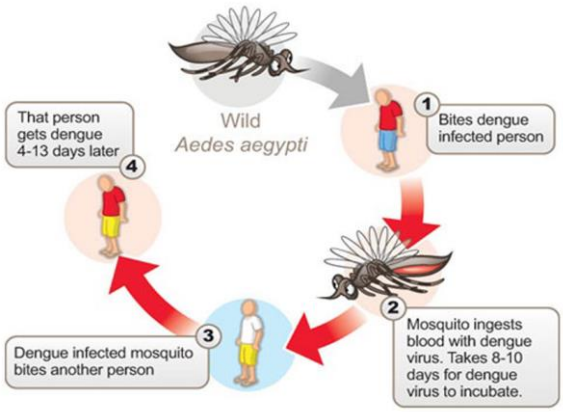


Fig. 4: Dengue Cycle

1.2.3 Treatment:

- There is no specific treatment for dengue.
- The focus is on treating pain symptoms.
- Acetaminophen (paracetamol) is often used to control pain [19].

1.2.4 Disease Burden:

- The incidence of dengue has grown dramatically around the world in recent decades, with cases reported to WHO increased from 505 430 cases in 2000 to 5.2 million in 2019.
- 2019 saw the highest number of dengue cases ever recorded worldwide.
- Every area was impacted, and Afghanistan had dengue transmission for the first time.
- Over twenty-five thousand of the 3.1 million cases recorded in the American Region were classed as serious. In Asia, Bangladesh (101 000), Malaysia (131 000), the Philippines (420 000), and Vietnam (320 000) all reported a significant number of cases.
- As of 2021, dengue still affects the following countries: Brazil, Colombia, the Cook Islands, Fiji, India, Kenya, Paraguay, Peru, the Philippines, the Reunion Islands, and Vietnam.

1.3 CHIKUNGUNYA

- People with chikungunya can be found in over 60 countries.
- Whilst 87% to 95% of people have severe arthralgia, which can last for years, it is rarely deadly [20].

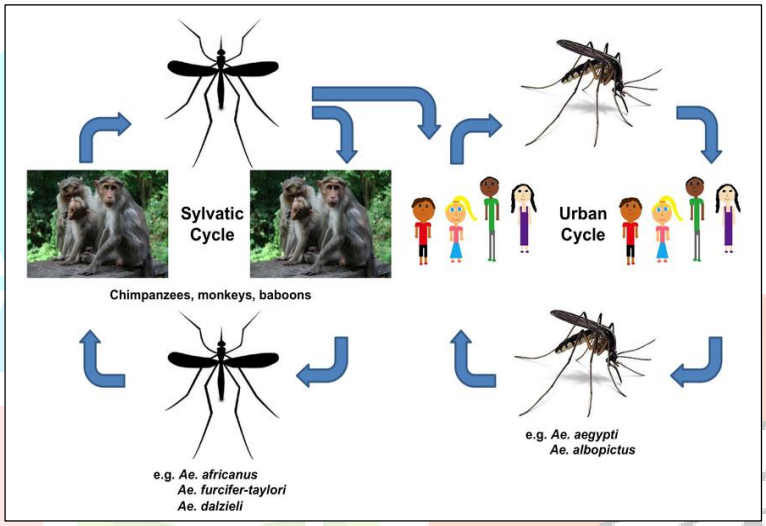


Fig. 5: Chikungunya Cycle

1.3.1 Causes

- Primary vectors are Aedes aegypti and Aedes albopictus, a more temperate-climate mosquito species.

1.3.2 Signs and symptoms of dengue:

- Acute-onset fever
- Severe arthralgia
- Headache
- Myalgia
- Conjunctivitis
- Nausea/vomiting [21]

1.3.3 Treatment:

- Rest
- Oral hydration to prevent dehydration
- Acetaminophen
- Nonsteroidal anti-inflammatory drugs (NSAIDs) Note: NSAIDs and aspirin should be avoided until dengue has been ruled out

- No interferon, ribavirin, intravenous immunoglobin, or antiviral medications (limited human data, inconsistent results, and potentially harmful effects) [22].

1.3.4 Disease Burden:

- As of June 7, 2023, there has been 281 recorded fatalities and 214,317 cases.
- Brazil (124 270), Paraguay (85 889), Argentina (1 336), Bolivia (1 233), and Thailand (453), have reported the bulk of instances. There have been confirmed deaths in Paraguay (256) and Brazil (25).

1.4 JAPANESE ENCEPHALITIS

- Japanese encephalitis was first documented in Japan in 1871.
- It primarily affects children, with more than 68,000 cases occurring with 13,600 to 20,400 deaths annually.
- Fifty percent of the incidence is in China, with 75% of cases being in children younger than 15 years [23].

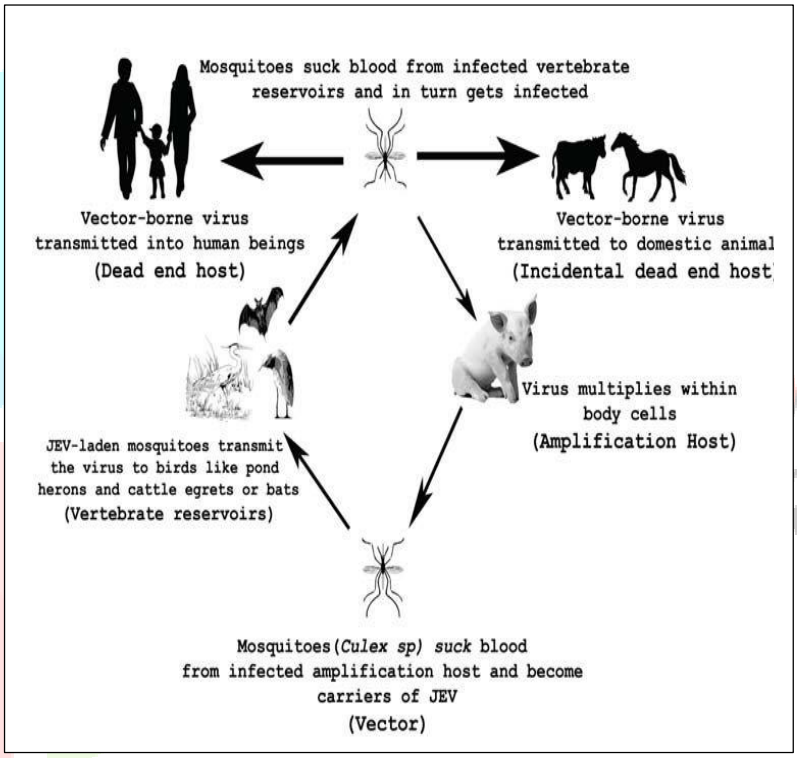


Fig. 6: Japanese encephalitis Cycle

1.4.1 Causes

- The Culex tritaeniorhynchus mosquito is the predominant vector, and most human outbreaks follow outbreaks in farm animals or agricultural rice and flood irrigation.

1.4.2 Signs and symptoms of dengue:

- Rapid-onset high fever
- Headache,
- GI symptoms
- Nausea/vomiting [24]

1.4.3 Treatment:

- Rest
- Oral hydration to prevent dehydration
- Acetaminophen
- NSAIDs, or nonsteroidal anti-inflammatory drugs, Note: Until dengue is ruled out, avoid using aspirin and NSAIDs.
  Absence of intravenous immunoglobin, ribavirin, interferon, and antiviral drugs due to insufficient human evidence, uneven outcomes, and possible side effects [22].

1.5 YELLOW FEVER

- It is endemic in 47 countries in Africa and South and Central America.
- Only 27,467 cases of yellow fever in Africa and 3988 cases in South America were officially diagonised 1985 to 2009, a significant underreporting according to the WHO [25].

1.5.1 Causes

- Yellow fever is an arbovirus transmitted by Aedes and Haemagogus mosquitoes.

1.5.2 Signs and symptoms of dengue:

- Myalgia
- Fever
- Headache
- Nausea
- Vomiting
- Poor Appetite [26]

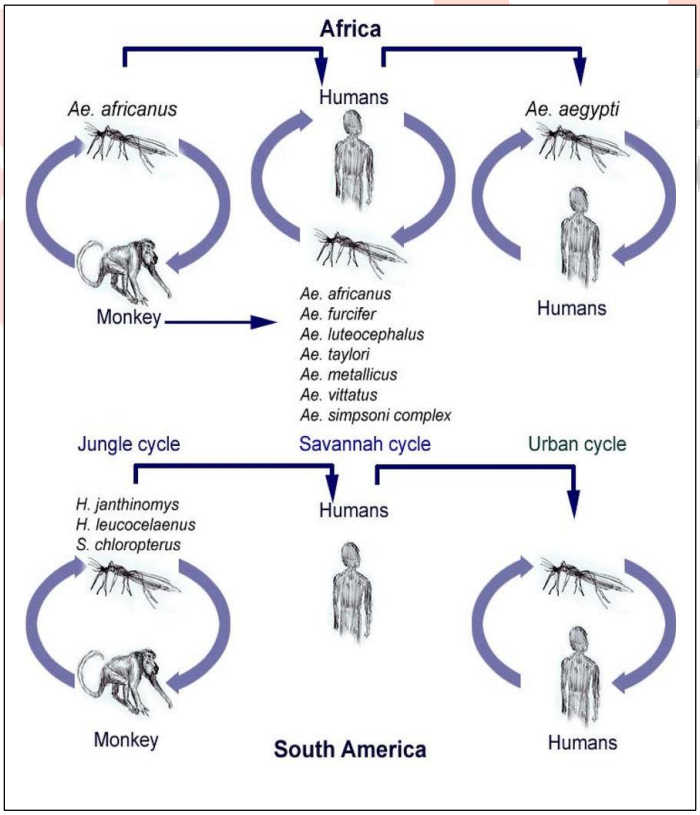


Fig. 7: Yellow fever Cycle

1.5.3 Treatment:

- Rest
- Oral hydration to prevent dehydration
- Acetaminophen
- Nonsteroidal anti-inflammatory drugs (NSAIDs) Note: NSAIDs and aspirin should be avoided until dengue has been ruled out
- No interferon, ribavirin, intravenous immunoglobin, or antiviral medications (limited human data, inconsistent results, and potentially harmful effects) [22].

1.6 ZIKA VIRUS

- Zika virus is a Flavivirus first discovered in Uganda in 1952.
- Recent outbreaks include Micronesia in 2007 and Brazil in 2015.
- Between 2015 and 2017, there were about 6000 cases of the Zika virus that showed symptoms in the US [27].

1.6.1 Causes

- A Zika-infected mosquito bite is the most common method of transmission.

1.6.2 Signs and symptoms of dengue:

- Most Zika-infected individuals are asymptomatic
- After an incubation period of 3 to 12 days, 20% experience mild and self-limited symptoms, including low-grade fever, pruritic maculopapular rash (including palms and soles), joint pain, and nonpurulent conjunctivitis [28].

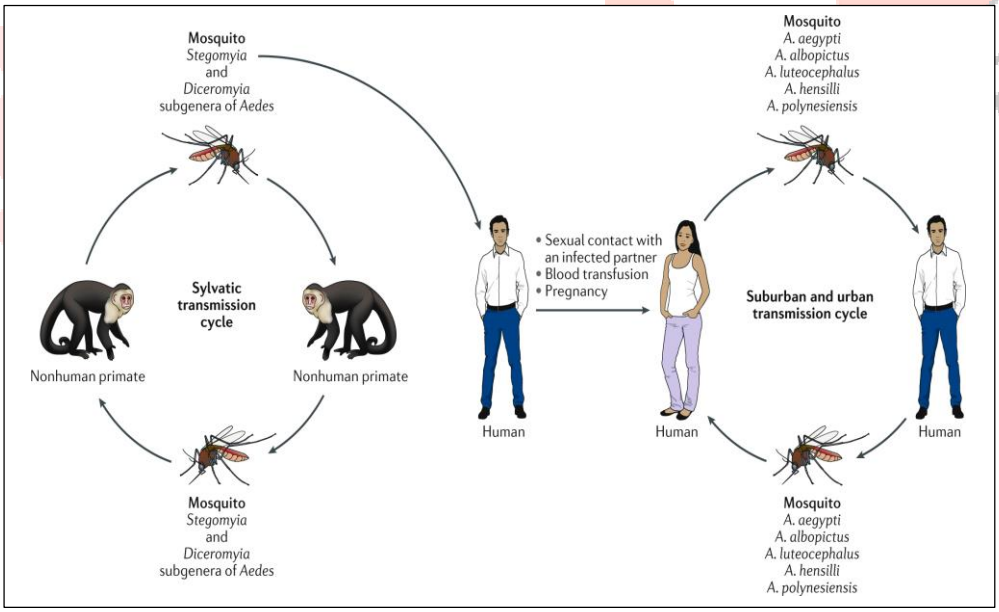


Fig. 8: Zika virus Cycle

1.6.3 Treatment:

- Rest
- Oral hydration to prevent dehydration
- Acetaminophen
- Nonsteroidal anti-inflammatory drugs (NSAIDs) Note: NSAIDs and aspirin should be avoided until dengue has been ruled out

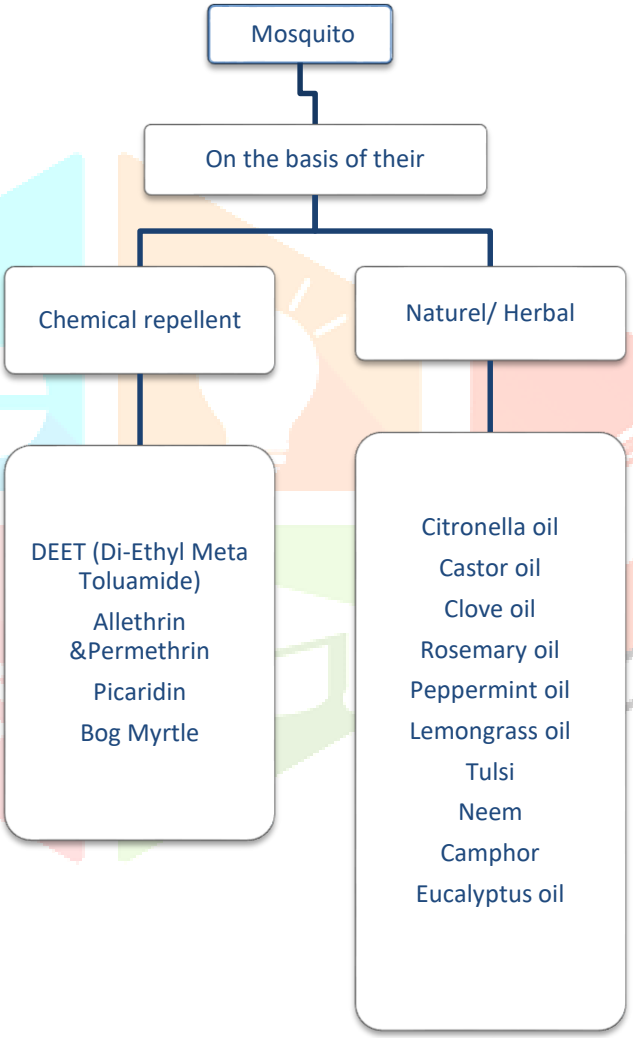
- No interferon, ribavirin, intravenous immunoglobin, or antiviral medications (limited human data, inconsistent results, and potentially harmful effects) [22].

Mosquito repellents

Anything that is used to apply clothing, skin or other surfaces that repel the mosquito from attracting and biting on that surface is known as mosquito repellentThe application of mana, vinegar, and plant oils on the body is one of the most traditional means of repelling mosquitoes. The first known technique for controlling mosquitoes is to burn plants or plant products to produce smoke.

Types of repellent

Mosquito repellents are classed in a variety of ways. Depending on their source, they are categorized as chemical or herbal repellents [7].



HERBS USED AS MOSQUITO REPELLANT [7]:

Lavender:

Fig. 9: Lavender

Lavender[29]	
Family	Lamiaceae
Synonym	Fabricia Adans
Biological Source	Obtained from the flowers *Lavandula angustifolia.*
Constituents	linalool, linalyl acetate, lavandulyl acetate, camphor

Rosemary:

Fig. 10: Rosemary

Rosemary[30]	
Family	Lamiaceae
Synonym	Rosmarinus latifolius mill
Biological Source	Oil of Rosemary is distilled from the flowering tops of leafy twigs of *Rosmarinus officinalis*
Constituents	Alpha Pinene, Camphor and borneol

Mint:

Fig. 11: Mint

Mint[31]	
Family	Lamiaceae
Synonym	Minthe
Biological Source	It is a fresh or dried leaves of *Mentha piperita L.*
Constituents	Menthol and methone

Neem:

Fig. 12: Neem

Neem[32]	
Family	Meliaceae
Synonym	Margosa
Biological Source	Neem consist of the fresh or dried leaves of *Azadirachta indica.*
Constituents	Azadirachtin, nimbolinin, nimbin, nimbidin, salannin and quercetin.

Tea tree:

Fig. 13: Tea tree

Tea tree[33,34]	
Family	Myrtaceae
Synonym	Melaleuca linarifolia
Biological Source	It consist of small tree leaves of camellia sinensis.
Constituents	Terpineol, p-Cymene, sabinene, limonene

II. CONCLUSION

In summary, the exploration of herbal mosquito repellents holds significant promise across health, environmental, and economic realms. Herbal alternatives offer a safer option, reducing health risks associated with chemical repellents. Emphasizing locally sourced plants promotes sustainable agriculture and preserves traditional knowledge. From an environmental perspective, herbal repellents prioritize eco-friendliness and align with biodiversity conservation.

Scientific validation is crucial for wider acceptance, ensuring reliable protection against mosquito-borne diseases. Economically, herbal repellents contribute to the growth of herbal medicine industries, meeting the rising demand for natural solutions and creating entrepreneurial opportunities. Overall, the study of herbal mosquito repellents harmonizes health, environment, and economics, providing a balanced approach to addressing vector-borne diseases and supporting global well-being. Ongoing research is vital to fully unlock the potential and benefits of herbal mosquito repellents on a global scale.

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