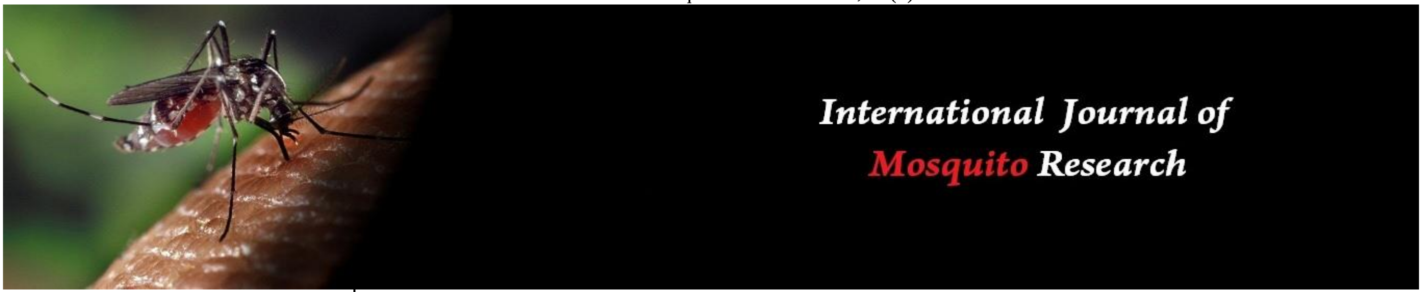

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Mosquito repellents derived from plants

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Abstract
Plant products have been put to use in a variety of contexts ever since ancient times. The development of chemical goods, on the other hand, led to a decline in the employment of these methods against pests. Recently, there has been a rise in concerns over public health and environmental security, which requires the identification of natural compounds that have the potential to be utilized against insect pests. Mosquitoes are major transmitters of illnesses and nuisance pests. The use of repellents lowers the risk of being bitten by a mosquito. At present, the use of synthetic pesticides to control insects and other arthropods presents several problems relating to the health of both humans and the environment. One option is to make use of natural products, which, in addition to being kind to the environment, are also very effective. Essential oils from plants belonging to a variety of species have been put through a battery of tests to determine the extent of their insect-repellent capabilities as a potentially useful natural resource. Among these compounds, are essential oils. The major emphasis of this review is going to be on the essential oils that have been shown to have repellent actions, as well as the significance of the synergistic effects that occur between the various components of these oils. Essential oils are volatile mixes of hydrocarbons that include a variety of different functional groups. Their ability to ward off pests has been connected to the presence of monoterpenes and sesquiterpenes in their composition. Nevertheless, in some contexts, the combined effects of these substances may have a synergistic boost to their efficiency. The plant families *Cymbopogon* spp., *Ocimum spp*., and *Eucalyptus spp*. are the most often listed as having potentially effective essential oils that may be utilized as insect repellents. A-pinene, limonene, citronellol, citronellal, camphor, and thymol are some of the individual chemicals that may be found in these mixes and have a high level of activity as a repellent. Last but not least, even though synthetic chemicals are still used as insect repellents more often than essential oils, these natural products have the potential to offer effective and safer insect repellents for both people and the environment. This is even though essential oils are more expensive than synthetic chemicals.

Keywords: Repellent, Essentail oils, Herbal repellent, pests, synergistic, and arthropods

Introduction
As a part of an overall integrated program to prevent diseases carried by mosquitoes, the use of repellents to protect people and animals from the bites of mosquitoes has long been acknowledged [1, 2]. Before recently, the use of natural goods such as plant extracts or oils was not typical for a variety of reasons. This has changed. Therefore, it is now quite simple to locate chemical compounds that exhibit features of repulsion and to employ these compounds as the active components of a product that acts as a repellent. However, the creation of natural active substances requires a significant amount of time and financial investment, which often results in the finished product being more costly than its artificial counterparts [3]. In the most recent few years, in response to a rise in public concern over the safety of several chemical items that were once used as insecticides or insect repellents, several institutions and researchers have begun the creation of natural active components, with a particular focus on plant sources [4]. Conducted experiments on red flour beetles to examine the repellant and growth-inhibiting properties of turmeric oil (*Curcuma longa*), sweet flag oil (*Acorus calamus*), neem oil (Azadirachta indica), and Margosan-O, which is a commercial pesticide based on neem. (Tenebrionidae). They discovered that the repellency of the oils and Margosan-O rose with increasing concentration. They also discovered that turmeric oil and sweet flag oil were effective in warding off insects for the first two weeks after application.

Additionally, they discovered that some essential oils, such as citronella and pennyroyal, have been used as insect repellents for centuries. Several essential oils, including citronella, camphor, tar, pennyroyal, and castor oils were used in several of the insect-repellent compositions that were mentioned [5, 6]. These formulations offered protection against insect bites that lasted for an extended period of time.

Mosquito-borne diseases

Infectious illnesses spread by mosquitoes are a significant challenge to human and animal health in every tropical and subtropical nation. Malaria, filariasis, yellow fever, Japanese encephalitis, and dengue fever are some of the illnesses that may be spread by mosquitoes [7].

Mosquitoes have been suspected of being the cause of a wide variety of diseases that afflict humans ever since prehistoric times. There are roughly 3500 different kinds of mosquitoes, and they may be found all throughout the globe, not only in tropical and subtropical areas. Anopheles (Which causes malaria and filariasis), Aedes (Which causes yellow fever, dengue, and chikungunya), and Culex are the three most important genera that transmit human disease-causing infections. (West Nile, Japanese encephalitis, filariasis). To get enough protein during her lifetime, a female mosquito must consume her host's blood many times. This is necessary for the completion of egg formation. By injecting the saliva, which may include diseases, into the animal that is serving as a host, the pathogens can successfully complete an essential step of their life cycle and then grow in the salivary glands of the mosquito. Because of this, the female mosquito is a prime candidate for transmitting a wide variety of blood-borne viruses and agents that cause debilitating illnesses in humans [8, 9].

Malaria has been recognized as one of India's main causes of mortality during the country's history (Table: 1). According to research, the decade of the 1950s in India had the greatest frequency of malaria, with an estimated 75 million cases and 0.8 million fatalities annually [10]. Anopheles mosquitoes are responsible for the spread of the protozoal parasites that cause malaria. These parasites are known as Plasmodium vivax Grassi and Feletti, Plasmodium malariae Felassi and Grassi, Plasmodium ovale Stephens, and Plasmodium falciparum Welch. Malaria is a potentially fatal disease. The presence of a large number of competent anopheline mosquitoes with a sufficient preference for human blood and an exposed human population with an adequate number of malaria carriers and susceptible individuals for the chain of infection to persist is necessary for any form of malaria to be considered endemic in a particular region, according to studies [11]. This is one of the requirements that must be met for any form of malaria to be considered endemic in a region. According to various reports, there are around 100 million cases of dengue fever and 500,000 cases of dengue hemorrhagic fever (DHF) per year throughout the world (Table: 2), with an average case fatality rate of approximately 5%. It is considered that population increase, uncontrolled urbanization in tropical and subtropical countries, the multiplication of breeding grounds for Aedes mosquitoes, and the absence of efficient mosquito control are potential factors for the worldwide comeback and spread of dengue fever and DHF outbreaks [12]. Encephalitis, which mostly affects children and adolescents in tropical regions, is one of the primary contributors to the development of acute encephalopathy. The Japanese encephalitis virus is transmitted by mosquitoes, which grow in close connection with pigs and other animal reservoirs, and it is determined that these mosquitoes mostly transmit the virus to malnourished children of low-income families living in rural areas [13].

Table 1: Countrywide Epidemiological Situation (1995 – 2021)

Year	Total Malaria Cases (million)	Deaths due to malaria
1995	2.93	1151
1996	3.04	1010
1997	2.66	879
1998	2.22	664
1999	2.28	1048
2000	2.03	932
2001	2.09	1005
2002	1.84	973
2003	1.87	1006
2004	1.92	949
2005	1.82	963
2006	1.79	1707
2007	1.51	1311
2008	1.53	1055
2009	1.56	1144
2010	1.60	1018
2011	1.31	754
2012	1.06	519
2013	0.88	440
2014	1.10	562
2015	1.17	384
2016	1.09	331
2017	0.84	194
2018	0.43	96
2019	0.34	77
2020	0.19	93
2021	0.16	90

Control of mosquitoes

The most effective method for eradicating these illnesses is to suppress mosquito populations that spread the disease and protect people from being bitten by mosquitoes. (Table: 2). According to studies, insect repellents play a significant part in avoiding the mosquito vector. This means that they discourage insects from flying to, settling on, or biting human and animal skin. The majority of the compounds that are employed as insect repellents are synthetic chemical repellents; however, these repellents have the drawback of not being safe for human usage, particularly in large doses, young children, and pets, since they may have skin irritation, heat sensitivity, rashes, or allergies [14]. Fogging is a short-term solution for reducing mosquitoes and similar pests, but it is essential when there is a risk to human health due to an abundance of insects or when people are engaging in an activity outside where they are unwelcome. A thermal fogger is used to create a pesticide fog or smoke by using the unit's internal coil to heat the fogging solution. Each gallon of this ready-to-use fogging solution includes 5% Piperonyl Butoxide and 0.5% Pyrethrins. Transdermal technology is another innovative method for preventing mosquito bites throughout the day and night by introducing a natural insect-repellent ingredient into the bloodstream. Vitamin B1, often known as thiamine, is the patch's active component since it is the most efficient naturally occurring mosquito repellant to date. The patch is effective because it releases a measured quantity of vitamin B1 into the bloodstream, which has been shown to repel female mosquitoes [15]. There are a wide variety of synthetic chemical mosquito repellents on the market, including creams, patches, coils, sprays, wipes, and liquids that evaporate when heated. Unfortunately, a large portion of these items harm humans and the planet.

Table 2: Methods of mosquito control

Chemical methods	Non-chemical methods	Biological methods
Synthetic repellents: DEET, Permethrin Natural repellents: Neem oil, Citronella oil	Physical method: Medicated net, Nonmedicated net, Mosquito traps Mechanical methods: Electric mosquito zapper, Mosquito magnet	By populating waterways with fish that prey on mosquito larvae, we may reduce their numbers.

Essential oils as green pesticide

The term "Green Pesticides" is used to describe any pest management product that is kind to the environment and effective against pests. They are preferable to synthetic pesticides because of their low toxicity, low environmental impact, and compatibility with natural ecosystem components.

Aromatic plants produce essential oils, which are complex, volatile, naturally occurring chemicals with a strong odor. They have a density typically lower than that of water and are liquid, volatile, seldom colored, lipid-soluble, and soluble in organic solvents. Among higher plants, there are 17,500 species with aromatic properties, and of the 3,000 or so essential oils identified, only around 300 have any real economic significance outside of their pesticidal uses in the pharmaceutical, cosmetic, and perfume sectors. Essential oils have several uses in nature, including protecting plants from herbivores by lowering their hunger and killing insects and pathogens. In addition to luring in beneficial insects that help spread pollen and seed, they may also drive away pests. For novel uses in human health, agriculture, and the environment, it is crucial to have a deeper knowledge of the mechanism of biological action of natural compounds like essential oils, despite their widespread usage and familiarity with us as smells. Some of them are complementary to or viable substitutes for synthetic chemicals used in the chemical industry [15].

Several natural items have been studied for their potential to deter mosquitoes, including *Zanthoxylum armatum* (Rutaceae), *Azadirachta indica* (Maliaceae), and *Curcuma aromatica* (Zingiberaceae), according to the referenced literature. Other plants that have been found to have repellent action against land leeches include *Callistemon rigidus* (bottle brush), *A. indica* (neem), and *Z. armatum* (timur). The effectiveness of mosquito repellent mats and lotion made from neem oil has been tested. Artemisia vulgaris benzene and methanol extracts have been found to have efficacy against *Aedes aegypti*. A Chinese insect repellent called Quelling was tested against mosquitoes; it was made from a combination of lemon grass and eucalyptus oil. *Vitex negundo* essential oil was used to deter *Aedes aegypti* mosquitoes. It has also been observed that the blooms of *Lantana camara* (Vervanaceae) are effective in deterring Aedes mosquitoes =. The essential oils of the following plants can be found in many commercially available plant-based insect repellents: citronella (*Cymbopogon nardus*), cedar (*Juniper virginiana*), eucalyptus (*Eucalyptus maculata*), geranium (*Pelargonium reniforme*), lemon-grass (*Cymbopogon excavatus*), peppermint (*Mentha piperita*), ne (*Neonotonia wightii*) [17].

Mode of action of essential oils

Essential oils are often generated in plants as secondary metabolites and are complex combinations of volatile chemical molecules. They are made up of oxygenated molecules and hydrocarbons (Terpenes and sesquiterpenes). (Alcohols, esters, ethers, aldehydes, ketones, lactones, and phenols). Different types of essential oils have been demonstrated to be very effective as insect repellents. Essential oils and extracts from the genera Eucalyptus and Cymbopogan have a long history of usage as excellent insect repellents, as reported in the literature. Many essential oils with mosquito-repellent properties have similar ingredients, including the metabolites monoterpenes such -as pinene, cineole, eugenol, limonene, terpinolene, citronellol, citronellal, camphor, and thymol. The monoterpenoids and sesquiterpenes in various essential oils are often responsible for their repellent effects [18]. The majority of monoterpenes are cytotoxic, meaning they have a negative effect on plant and animal tissue. This has a knock-on effect on respiration, photosynthesis, and cellular membrane permeability. Due to their brief half-lives and alarming effects, pheromones serve as chemical signals for insects and other animals. The hairs of mosquito antennae, according to the aforementioned literature, are both temperature and moisture sensitive. The molecules of the repellent bind to the olfactory receptors of the female mosquito, interfering with the mosquitoes' ability to identify their hosts by scent [19].

Mosquito host-seeking behavior

Mosquitoes that are effective in finding and feeding from hosts can do so without the host being aware of their presence. Mosquito development and reproduction depend on the precise management of these stages. When thinking about host-seeking behavior, it's vital to take into account the female mosquito's life cycle traits [20].

In general, the following steps [21–23] are outlined in the literature on mosquito host-seeking behavior: "[Appetizer hunting]" "[Activation" "[Orientation" "[Attraction" "[Acceptance by the host" Mosquitoes' hunger and endogenous circadian cycles change in tandem with the amount of time they go without food, which in turn affects their propensity to look for food. It is considered a random or aimless search that ends when a host stimulus is encountered. The word "activation" describes this one-time process. There is ample evidence to suggest that carbon dioxide acts as a host cue for both activation and orientation. Activation may also be influenced by signals from the host's environment besides carbon dioxide. Interspecies variation is likely to blame, especially between mosquito species that prefer human blood and those that prefer animal blood. Mosquitoes have a programmed flying habit called optomotor anemotaxis that causes them to lift off and fly for a long time after being exposed to carbon dioxide.

Upwind flying patterns of mosquitoes closely resemble those of other insects that orient themselves toward a source by following a pulsed chemical gradient. This behavior is known as orientation. It is believed that mosquitoes rely on visual, motion, heat, and scent signals from their prospective host to get attracted to them once they are nearby. Surprisingly little behavioral data are known on patterns that are related to this occurrence and those that directly guide host acceptance by mosquitoes. The underlying behavioral processes that lead to this short-range approach are not well known, even though several host surface volatiles and compounds have been examined and identified as attractants in previous research. The mosquito would encounter the largest variety of host signals during this short-range approach. These cues include a complex volatile mix consisting of semi- and highly volatile chemicals. It is necessary to take into consideration the following to gain an understanding of the myriad of chemicals that are released by the host: (1) primary odors, which do not alter regardless of changes in an individual's diet; (2) secondary odors, which are related to an individual's diet and interaction in the environment; and (3) tertiary odors, which originate from sources that are external to the host. (e.g. lotions, hair products, make-up, etc.). Short-chain (C4–C12) acids, aldehydes, alcohols, esters, and ketones are some of the molecules that have been found by researchers as being present in skin emanations, armpit odor, and even emitted when breathing. It has been pointed out in several different articles that even among members of the same species, there may be a substantial amount of diversity in these aspects of the equation. As soon as the mosquito lands on its host, it immediately begins searching for the most suitable location to begin feeding. A single person can conduct many probes before ultimately committing to a feeding site and recognizing a host as being appropriate for consumption. This is a very critical choice for the mosquito to make since it has to decide where the best place is to draw blood while also avoiding being discovered by its host.

Plants as sources of mosquito control agents

Throughout history, plants have been recognized as significant sources of chemicals that may be used to control insects [21, 22]. They are the sources of the naturally occurring insecticidal and larvicidal substances such as nicotine (*Nicotiana* L. spp.), quassin (*Quassia amara* L.), rotenone and rotenoids (*Derris Lour.* spp. and *Lonchocarpus Kunth* spp. roots), pyrethrins such as chrysanthamic acid and its derivatives present in pyrethrum extract (*Azadirachta indica* A. Juss. seed kernel). The invention of the structurally similar synthetic pyrethroid, nicotinoid, and rotenoid families of insecticides, as well as the piperonyl butoxide synergist, was based on these and other naturally occurring insect repellents. Additionally, pyrethroids and piperonyl butoxide synergism constitute the foundation of a variety of mosquito control treatments that are already on the market [21]. These products are currently in use.

Botanical repellents The majority of citronella essential oils (EOs) come from several cultivars of *Cymbopogon nardus* (L.) Rendle, often known as Ceylon citronella and *C. winterianus Jowitt ex* Bor. (Java citronella). They have been employed in mosquito repellency for more than a century in a significant portion of the globe, and they are the natural repellents that are utilized the most often today [21]. p-menthane-3, 8-diol (PMD), 1,8-cineole, -pinene, p-cymene, and -terpinene are among the insecticidal and repellent components found in the essential oils of Eucalyptus L. Her. spp., which are also frequently employed to repel insects, including mosquitoes [8]. According to a recent review of the scientific literature, the EOs obtained from species belonging to the genera *Cymbopogon Spreng*., Ocimum L., and Eucalyptus L'Her. spp. are the ones that are studied the most frequently as repellents. Additionally, several mosquito-repellent EOs have been identified in recent years having known active repellent chemical components [22]. It is thought that the synergistic interactions between the chemical components of essential oils give them their mosquito-repellent properties. In addition to this, it has been noted that there might be significant synergistic effects between EOs and isolated natural or synthesized compounds [22]. The Citronella Essential Oil, Eucalyptus Essential Oil, and Other Plant Oils Have Been Registered as Safe and Effective Ingredients for Use in Topical Insect Repellents by the United States Environmental Protection Agency [23]. However, because to the many adverse effects that might be caused by the use of EOs in general, extreme care is strongly advised [22].

Mutagenicity and genotoxicity are two of the most significant harmful effects that may be caused by essential oils. Another potentially harmful impact of essential oils is their allergenic chemical constituents, which are subject to regulation in the European Community and abroad. It is interesting to note that some repellent and insecticidal plant EOs and their chemical components have been investigated using a range of methodologies, and the results suggest that they do not cause mutations [24]. Over the last several decades, a variety of different commercial repellent solutions that employ derivatives of plants such as essential oils (EOs), fractions, and their extracted chemical components as well as synthetic components have been produced. Therefore, having a thorough understanding of the economically relevant applications of EOs in mosquito-repellent technologies is crucial, and to the best of our knowledge, the patent literature on this issue has not been evaluated. This is even though we have done everything in our power to get this information. The purpose of this study is to investigate and evaluate the patent literature about mosquito repellent technologies that make use of or are based solely on plant essential oils (EOs) and/or the chemical components of those EOs. A secondary objective of this study is to investigate the scientific grounds and relevance of the use of plant essential oils (EOs) and the chemical components of these oils in patented insect-repellent compositions.

Table 3: Botanic information, extraction methods, major chemical components, literature sources of plants essential oils

Essential Oils	Family	Species	Method	Part	Major components	Ref.
Ambrette	Malvaceae	*Abelmoschus moschatus* Medik.	steam distilled	whole seed	2E, 6E-farnesyl acetate, Z-7-hexadecen-16-olide, β-farnesene	[25, 26]
Anise	Apiaceae	*Pimpinella anisum* L	steam distilled	fruit, seed	trans-anethole	[29]
Angelica	Apiaceae	*Angelica archangelica* L.	steam distilled	root	ligustilide, α & β-pinene, carvacrol, 3-carene, limonene, β-phellandrene, 15-pentadecanolide	[27, 28]
Basil	Lamiaceae	*Ocimum basilicum* L.	steam distilled	leaf, flower top	estragole, limonene, fenchone, linalool, eugenol E-methyl cinnamate, 1, 8-cineole	[32-34]
Artemisia	Asteraceae	*Artemisia argyi H. Lév.* & Vaniot	steam distilled	leaf	germacrene D, α-phellandrene, α-myrcene, 1, 8-cineole, borneol, terpinol, spathulenol	[30, 31]
Bergamot	Rutaceae	*Citrus* × *bergamia* Risso	pressed	fresh or dried peel	limonene, linalyl acetate, β–pinene, γ-terpinene, linalool	[36]
Bay laurel	Lauraceae	*Laurus nobilis* L.	steam distilled	leaf	1, 8-cineole, sabinene, α-terpinyl acetate, linalool	[35,36]
Cassia	Lauraceae	*Cinnamomum cassia* (L.) C. Presl	steam distilled	leaf, bark, stalk	bark: E-cinnamaldehyde, methyl o-salicylate; leaf: 3-methoxy-1, 2-propanediol, E-cinnamaldehyde, o-methoxycinnamaldehyde	[38, 39]
Camphor	Lauraceae	*Cinnamomum camphora* (L.) J. Pres	steam distilled	wood, bark, leaf	1, 8-cineole, α-terpineol, αpinene, linalool, camphor, sabinene	[37]
Chrysanthemum	Asteraceae	*Chrysanthemum indicum* L.	steam distilled	dry flower	verbenol, 2-(2, 4-hexadiynylidene)-1, 6-dioxaspiro[4.4]non-3-ene, 1, 8-cineole, α-pinene, camphor, borneol, bornyl acetate	[44, 45]
Cinnamon	Lauraceae	*Cinnamomum zeylanicum* Blume	steam distilled	bark, leaf	eugenol, cinnamaldehyde	[46, 47]
Cedar	Pinaceae (Cupressaceae)	Cedrus Trew (*Cupressus L., Juniperus* L.) spp.	steam distilled	wood	thujopsene, eudesmol, E-(+)-α-atlantone; α, β & γ-himachalenes; α- & β-cedrenes; limonene, β-phellandrene, α & β-pinene, 3-carene; p-methyl-Δ-3-tetrahydro & p-methyl acetophenones; hinokitiol, carvacrol	[42]
Citronella	Poaceae	*Cymbopogon nardus* (L.) Rendle, *C. winterianus* Jowitt ex Bor	steam distilled	leaf	citronellal, geraniol, citronellol, geranyl acetate	[48, 49]
Catnip, catmint	Lamiaceae	*Nepeta cataria* L.	steam distilled	dry leaf, stem	nepetalactone, 1, 8-cineole, α-humulene, α-pinene, E-geraniol, β-caryophyllene, citronellol	[40,41]
Chamomile	Asteraceae	*Chamaemelum nobile* (L.) All. *Matricaria recutita* L.	steam distilled	seed, leaf, flower	Roman: isobutyl, isoamyl & 2-methylpentyl angelates, α-pinene German: E-β-farnesene, E, E-α-farnesene, α-bisabolol, α-bisabolol oxides A & B	[41, 43]
Coriander	Apiaceae	*Coriandrum sativum* L.	steam distilled	fruit, seed	linalool, geraniol, geranyl acetate, 2-decenal, 3-dodecena	[51-53]
Dill	Apiaceae	*Anethum graveolens* L	steam distilled	seed, leaf, stem	carvone, limonene, α-phellandrene, α-pinene, cis-dihydrocarvone	[56]
Clove	Myrtaceae	*Syzygium aromaticum* (L.) Merr. & L.M. Perry	steam distilled	flower bud	eugenol, caryophyllene, eugenyl acetate	[50]
Citrus	Rutaceae	*Citrus* × *limon* (L.) Osbeck, C. × sinensis (L.) Osbeck, C. × aurantifolia L	steam distilled	peel	see orange, lemon, lime oil compositions	[49]
Cypress	Cupressaceae	*Cupressus sempervirens* L.	steam distilled	needle, twig	sabinene, α-pinene, terpinen-4-ol, limonene	[54,55]
Eucalyptus	Myrtaceae	*Eucalyptus* L'Hér. spp.	steam distilled	leaf	1,8-cineole, p-menthane-3,8-diol, α-pinene, p-cymene, γ-terpinene, eucamalol, allo-ocimene, citronellol, α-terpineol	[56]
Geranium	Geraniaceae	*Pelargonium graveolens* L' Hér	steam distilled	leaf, stem	2-phenylethanol, geraniol, citronellol, geranyl acetate	[60]
Guaiac wood	Zygophyllaceae	*Bulnesia sarmientoi Lorentz* ex Griseb.	steam distilled	wood	bulnesol, guaiol, α-bulnesene	[64]
Garlic	Amaryllidaceae	*Allium sativum* L.	steam distilled	bulb	diallyl disulfide, diallyl trisulfide, methyl allyl trisulfide	[58, 59]
Fennel	fruit	*Foeniculum vulgare* Mill. Apiaceae	steam distilled	steam distilled	E-anethole, (+)-fenchone, α-phellandrene, (±)-limonene, estragole	[57]
Ginger	Zingiberaceae	*Zingiber officinale* Roscoe	steam distilled	rhizome	geranial, α-zingiberene, E, E-α-farnesene, neral, ar-curcumene, geranio	[61, 62]
Grapefruit	Rutaceae	*Citrus reticulata* Blanco	steam distilled	peel	limonene, geranial, neral	[63]
Hyssop	Lamiaceae	*Hyssopus officinalis* L.	steam distilled	leaf, flower	sabinene, pinocamphene, isopinocamphene, isopinocamphone, pinocarvone, cis & trans-pinocamphones, β-pinene, 1, 8-cineole, camphor, linalool	[70-72]

Ho leaf	Lauraceae	*Cinnamomum camphora* (L.) J. Presl	steam distilled	leaf	1, 8-cineole, α-terpineol, linalool, camphor, safrole, sabinene, nerolidol	[68, 69]
Hiba	Cupressaceae	*Thujopsis dolabrata* (Thunb. ex L. f.) Siebold & Zucc.	steam distilled	wood	sabinene, 4-terpineol, thujopsene, hinokitiol, α-thujaplicine, carvacrol	[65-67]
Jasmine	Oleaceae	*Jasminum officinale* L.	steam distilled	flower	linalool, benzyl acetate, methyl & benzyl benzoates, methyl anthranilate, Z-jasmone, eugenol	[73, 74]

Conclusion

Several ethnobotanical studies cite the use of plants as an alternate source of the repellant ingredient. They have a long history of usage in a lot of different places across the globe. Before the development of synthetic chemicals, it was common knowledge that some essential oils extracted from plants had insect and mosquito-deterring characteristics. Repellents generated from plants often do not provide any toxicity risks to people or domestic animals and are simple to break down in the environment. Natural goods are generally considered to be safer for human consumption when compared to manufactured chemicals. Natural Polymers are the new area of intrest for the designing of new mosquito repellant formulations, they are obtained from natural sources. [75].

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