

FORMULATION AND EVALUATION OF MOSQUITO REPELLENT SPRAY - AN REVIEW

Magaline breezy. M.K^{1*}, Dr. Shanmugapandian.P^{2*} Gayathri.J¹, Yazhini. K.S¹,
Gnana Bency rani.M¹, Nivedhitha shri. G¹and Nithin Bala. S¹

1* Assistant professor, School of Pharmacy, Sathyabama Institute of Science and Technology, Chennai – 600119, Tamil Nadu

2* Dean school of pharmacy, School of Pharmacy, Sathyabama Institute of Science and Technology, Chennai – 600119, Tamil Nadu

1 B.pharm students, School of Pharmacy, Sathyabama Institute of Science and Technology, Chennai – 600119, Tamil Nadu

1* School of Pharmacy

1* Sathyabama institute of science and technology, Semmancheri, Chennai 600119, India

1* magalinebreezymk@gmail.com 2* dean.pharmacy@sathyabama.ac.in

3 gayujayashankar@gmail.com 4 yazhnikadhiravansumathi@gmail.com 5

Bencyrani08@gmail.com 6 nivedhithashrigk06@gmail.com 7 snithinbeast4@gmail.com

*Corresponding Author

Name: Mrs. Magaline Breezy M.K

Designation: Assistant professor

Phone: +91 80564 41240

Email: magalinebreezymk@gmail.com

ABSTRACT:

Mosquito-borne diseases pose a significant global health challenge, necessitating the development of effective and eco-friendly repellents. This review explores the potential of natural mosquito repellents formulated using orange peel extract and eucalyptus oil. Orange peel (*Citrus sinensis*) is rich in bioactive compounds such as limonene and flavonoids, which exhibit insecticidal and repellent properties. Eucalyptus oil (*Eucalyptus globulus*) contains cineole, a potent bioactive component known for its strong mosquito-repelling effects. The combination of these natural ingredients offers a sustainable alternative to synthetic repellents, reducing health and environmental concerns associated with chemical-based formulations. The findings highlight the promise of orange peel and eucalyptus oil as cost-effective, biodegradable, and non-toxic alternatives for mosquito control. Further research on optimization, longevity, and large-scale production is recommended to enhance their practical applications.

Keywords: Mosquito repellent, Orange peel extract, Eucalyptus oil, Limonene, Natural insecticide.

INTRODUCTION

Mosquitoes are one of the most notorious vectors of various life-threatening diseases, such as malaria, dengue fever, Zika virus, chikungunya, and yellow fever, affecting millions of people worldwide.[2] The increasing incidence of mosquito-borne illnesses has intensified the demand for effective and long-lasting mosquito control measures. Traditionally, chemical-based repellents, particularly those containing **N, N-diethyl-meta-toluamide (DEET)**, have been widely used due to their strong repellent activity.[1] However, prolonged exposure to synthetic repellents has raised significant concerns regarding their potential health risks, including skin irritation, allergic reactions, neurotoxicity, and environmental contamination. Consequently, there is a growing shift toward **eco-friendly, plant-based mosquito repellents** that provide safe and sustainable alternatives.[1]

PLANT BASED COMPOUNDS

Plant-derived compounds have long been recognized for their insect-repelling properties. Various essential oils and plant extracts have shown promising efficacy in repelling mosquitoes due to their high content of bioactive phytochemicals.[4] Among these, **orange peel (Citrus sinensis)** and **eucalyptus oil (Eucalyptus globulus)** have emerged as natural alternatives with significant potential for mosquito repellent formulations.[1]

MOSQUITO REPELLENCY ACTIVITY IN ORANGE PEEL AND EUCALYPTUS:

Orange peel, a commonly discarded byproduct of the citrus industry, is an abundant and cost-effective source of bioactive compounds such as **limonene, linalool, and flavonoids**, which have demonstrated strong insecticidal and repellent properties.[5],1,2,3 Limonene, in particular, has been identified as a potent bioactive compound with proven mosquito-repelling activity.[8] Orange is a rich source of essential oil paintings including limonene, which has been set up to have mosquito repelling rates. factory grounded repellents are fluently biodegradable and present no toxin dangers. When compared to manufactured substance natural substance, natural products are safer for humans.[4] As a result, the time has come to start a thorough study into natural stuff that are environmentally safe and can be used to manage insignificance infestations. Different experimenters have discovered interference parcels of the phytochemicals attained from factory coffers, which can serve as larvicidal, nonentity development controllers, repellents, and ovipositional attractants. In numerous regions of the world natural factory medications have been employed for centuries to shield off or kill mosquitoes. The pressing need to probe phytochemicals as insignificance repellents.[2]



Fig.1 Orange peel

[15]

Limonene

Limonene is a colourless liquid aliphatic hydrocarbon classified as a cyclic monoterpene, and is the major component in the volatile oil of citrus fruit peels. The (+)- isomer, occurring more commonly in nature as the fragrance of oranges, is a flavoring agent in food manufacturing.[10],5,6,7,8 It is also used in chemical synthesis as a precursor to carvone and as a renewables-based solvent in cleaning products. The less common (-)-isomer has a piny, turpentine-like Odor, and is found in the edible parts of such plants as caraway, dill, and bergamot orange plants. Limonene takes its name from Italian Limone ("lemon").[16],6,8,9 Limonene is a chiral molecule, and biological sources produce one enantiomer: the principal industrial source, citrus fruit, contains (+)-limonene (d-limonene), which is the (R)-enantiomer. (+)-

Limonene is obtained commercially from citrus fruits through two primary methods: centrifugal separation or steam distillation.[1]

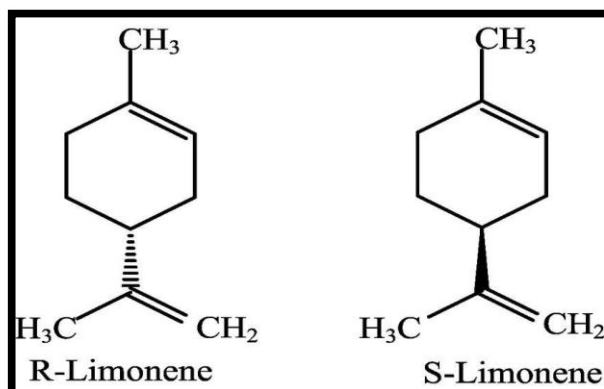


Fig.2 Structure of Limonene

[12]

Phytoconstituents in Orange Peel and Eucalyptus Oil

Plant-derived mosquito repellents are rich in bioactive phytochemicals that contribute to their effectiveness against insects. Orange peel (*Citrus sinensis*) and eucalyptus oil (*Eucalyptus globulus*) contain a variety of phytoconstituents with **insecticidal, repellent, and antimicrobial properties**. Below is a detailed breakdown of the key bioactive compounds present in these natural sources.[5]

1. Phytoconstituents in Orange Peel (*Citrus sinensis*)

Orange peel is a **rich source of essential oils, flavonoids, and terpenoids**, which exhibit strong mosquito-repelling activity.[9],7 Some of the major active compounds include:

a) Monoterpenes (Essential Oil Components)

- **Limonene (up to 90%)** – The dominant compound in orange peel oil, known for its insecticidal and repellent properties. It disrupts mosquito olfactory receptors, making it difficult for them to locate human hosts.[20]
- **Linalool** – Exhibits strong insecticidal activity and acts as a fumigant, making it effective against mosquitoes and other insects.[21]
- **Myrcene** – Has antimicrobial and insect-repelling properties, enhancing the overall efficacy of orange peel oil in repelling mosquitoes.[20]

b) Flavonoids

- **Hesperidin** – A potent antioxidant and antimicrobial agent that contributes to the plant's defense mechanisms.[21]
- **Naringin** – Known for its bioactivity, including insect-repelling and anti-inflammatory properties.[23]

c) Phenolic Compounds

- **Caffeic Acid & Ferulic Acid** – Exhibit antioxidant properties and may contribute to the protective effects against insect bites and oxidative stress.[24]

d) Alkaloids

- **Synephrine** – A natural stimulant that can deter insects and contribute to repellent effects.[6]

These are the other phytoconstituents present in the orange peel other than the limonene also has the mosquito repellence activity.[7]

Eucalyptus Oil

On the other hand, eucalyptus oil is widely recognized for its **high cineole (eucalyptol) content**, which contributes to its strong insect-repelling characteristics. The U.S. Environmental Protection Agency (EPA) has approved **oil of lemon eucalyptus (OLE)** as an effective natural repellent, further supporting the efficacy of eucalyptus-derived compounds in repelling mosquitoes. [8]

Eucalyptus oil is extracted from the leaves of the eucalyptus plant through steam distillation. Eucalyptus oil is composed of various compounds in which these has mosquito repellent activity [3]

1. Eucalyptol (1,8-Cineole): A major component of eucalyptus oil, eucalyptol has insect repelling properties.[3],4,5
2. Camphor: A minor component of eucalyptus oil, camphor has insecticidal properties.
3. Limonene: A minor component of eucalyptus oil, limonene has insect-repelling properties.[4]



Fig 3. Eucalyptus leaves and oil [16]

2. Phytoconstituents in Eucalyptus Oil (*Eucalyptus globulus*)

Eucalyptus oil is widely used as a natural mosquito repellent due to its high content of volatile compounds, particularly **cineole-rich monoterpenes**. [28],22,25 The major active constituents include:

a) Monoterpenes (Primary Essential Oil Components)

- **1,8-Cineole (Eucalyptol) (70-85%)** – The most abundant compound in eucalyptus oil, responsible for its strong mosquito-repelling activity. It interferes with mosquito olfactory receptors and has insecticidal properties.[30]
- **α -Pinene & β -Pinene** – Monoterpenes with strong repellent activity against insects.[31]
- **Limonene** – Also found in orange peel, it enhances the overall repellent efficacy.[31]

b) Other Bioactive Compounds

- **Piperitone** – A naturally occurring monoterpenoid with insecticidal properties.
- **Geraniol** – Known for its strong insect-repelling and antimicrobial effects.[35]

Piperitone and geraniol are the other constituents present in the eucalyptus oil also has the mosquito repellence activity.

Synergistic Effect of Orange Peel and Eucalyptus Oil

When combined, the phytochemicals in orange peel and eucalyptus oil work **synergistically** to enhance their overall mosquito-repellent efficacy. The **high limonene content in orange peel** complements the **cineole-rich eucalyptus oil**, providing a dual mechanism of action:[8]

1. **Olfactory Disruption** – The strong volatile aroma of these compounds confuses mosquitoes, making it difficult for them to detect human hosts.[48]
2. **Toxic Effects on Mosquitoes** – Some of these compounds, such as limonene and cineole, have direct insecticidal effects, reducing mosquito populations over time.[38]

Advancements in Formulation

New technologies like **microencapsulation and nanoencapsulation** can enhance the **stability, controlled release, and longevity** of essential oils, making natural repellents more effective.[37]

Expanding Applications

These repellents can be used in **personal care, outdoor protection, agriculture, and veterinary applications**, increasing their market potential.[26]

Sustainability and Waste Reduction

Using **orange peel, a citrus industry byproduct**, supports waste reduction and promotes **biodegradable, plant-based solutions**, aligning with **green consumer preferences**.[25]

Research and Innovation

Future research will focus on **synergistic plant formulations, clinical efficacy studies, and regulatory approvals** to enhance product performance and market adoption.[12]

With advances in **technology, sustainability, and consumer demand**, mosquito repellent sprays containing **orange peel extract and eucalyptus oil** have **immense future potential** in creating safer, eco-friendly insect control solutions.[11]

Conclusion

Both orange peel and eucalyptus oil are rich in potent phytoconstituents that contribute to their efficacy as natural mosquito repellents. The combination of **limonene, cineole, and other terpenoids** offers an eco-friendly, biodegradable, and non-toxic alternative to synthetic repellents like DEET. Further research on optimized formulations and delivery methods can enhance their effectiveness, making them a promising solution for mosquito control in public health and environmental sustainability. The future of mosquito repellent sprays is shifting towards **natural, eco-friendly alternatives** to replace synthetic chemicals. **Orange peel extract and eucalyptus oil** offer proven insect-repelling properties, making them sustainable options.

ACKNOWLEDGEMENT:

I would like to thank to the Dean and management of the Sathyabama Institute of Science and Technology, School of Pharmacy, Semmancheri for their constant support and guidance for completing this review.

REFERENCES:

1. Agrawal S, Haldankar N, Jadhav A. Formulation of natural mosquito repellent. *Int J Adv Res Ideas Innov Technol*. 2018;4(1):11-7.
2. Abolade YA, Adegoke A, Noi SM, Nwoye CM, Ajayi O, Kyrian O, et al. Promoting health: Introducing an eco-friendly herbal mosquito repellent extracted from local sweet orange peels. *GSC Biol Pharm Sci*. 2024;26(1):315-27.
3. Keshwar A, Keshwar U, Deogirkar A, Dhurde SS, Deo V, Shrikhande Keshwar BK, et al. Formulation development and evaluation of cream containing natural essential oils having mosquito repellent property. *World J Pharm Pharm Sci*. 2016;5(8):1-14.
4. Anaso HU, Ilouno LE, Onuorah D, Umerie SC. Potency of orange peel as a mosquito fumigant. *Biol Wastes*. 2019;34(1):83-8.
5. Adeogun A.O., Adewuyi G.O., Etaturvie S... O., Fawehinmi AB., Lawal HO: Bioassay of Herbal Mosquito Repellent Formulated from the Essential Oil of Plants. *J Nat prod* 2012; 5: 109-115.
6. Barreca D, Bellocco E, Leuzzi U, Gattuso G. First evidence of C- and O-glycosyl flavone in blood orange (*Citrus sinensis* (L.) Osbeck) juice and their influence on antioxidant properties. *Food Chem*. 2014; 149:244-52.
7. Batish, DR.; l'al, 11., Kumar, R., Kaur, S. Forest Ecology and Management Eucalyptus Essential Oil as a Natural Pesticide. *For El May*, 2008, 256, 2166-2174,
8. Saraballo AJ. Mosquito repellent action of Nemo's. *J Am Mosq Control Assoc*. 2000; 16:45-6.
9. Carey AF, Wang G, Su CY, Zwiebel LJ, Carlson JR. Odorant reception in the malaria mosquito *Anopheles gambiae*. *Nature*. 2010; 464:66-71.

10. Chaiyakunapruk N, Kong Kaew C, Sakunrag I, Tawatsin A. Effectiveness of citronella preparations in preventing mosquito bites: systematic review of controlled laboratory experimental studies. *Trop Med Int Health*. 2011; 16:802-10.
11. Dari AW, Narsa AC, Zamruddin NM. Literature review: Orange peel activities in the pharmaceutical field. In: *Proceedings of Mulawarman Pharmaceuticals Conferences; 2020 Dec*. Vol. 12, p. 125-51.
12. Effiom OE, Avoaja DA, Ohaeri CC. Mosquito repellent activity of phytochemical extracts from peels of citrus fruit species. *Glob J Sci Frontier Res*. 2012;12(1):1-4.
13. Formulation of Novel Herbal Mosquito Repellent: A New Approach in Antimalarial Management. *Int J Medi Pharm Res*. 2015;1(2):78-85.
14. Green N, Beroza M, Hall SA. Recent developments in chemical attractants for insects. *Adv Pest Control Res*. 1960; 3:129-79.
15. Hegazy AE, Ibrahim MI. Antioxidant activities of orange peel extracts. *World Appl Sci J*. 2012;18(5):684-8.
16. Jaenson TG, Garboui S, Pålsson K. Repellence of oils of lemon eucalyptus, geranium, and lavender and the mosquito repellent Mega natural to *Ixodes ricinus* (Acari: Ixodidae) in the laboratory and field. *J Med Entomol*. 2006; 43:731-6.
17. Liu XC, Li YP, Li HQ, Deng ZW, Zhou L, Liu ZL, et al. Identification of repellent and insecticidal constituents of the essential oil of *Artemisia rupestris* L. aerial parts against *Liposcelis bostrychophila* Badonnel. *Molecules*. 2013; 18:10733-46.
18. Maia MF, Moore SJ. Plant-based insect repellents: a review of their efficacy, development and testing. *Malar J*. 2011;10
19. Murugan K, Mahesh Kumar P, Kovendan K, Amerasan D, Subramaniam J, Hwang JS. Larvicidal, pupicidal, repellent and adulticidal activity of *Citrus sinensis* orange peel extract against *Anopheles stephensi*, *Aedes aegypti* and *Culex quinquefasciatus* (Diptera: Culicidae). *Parasitol Res*. 2012; 111:1757-69.
20. Moore SJ, Debboun M. *Insect repellents: principles, methods, and uses*. Boca Raton: CRC Press; 2007. p. 3-29.
21. Prakash C, Kumaran SKS, Sree PS. Effect of repellence on mosquito nets using citrus peel extract. *Int J Innov Technol Explor Eng*. 2015;8(11):1531-5.
22. Patel, A. Gupta, and R. oswal, "A Review on: mosquito repellent methods. *Int J Pharm Chem Biol Sci*, 2012, 2(3), pp. 310-317.
23. Yates, R. N' Guessan, H. Kaur, M. Akogbéto, and M. Rowland, "Evaluation of KO-Tab 2-3: a wash-resistant 'dip-it-yourself' insecticide formulation for long-lasting treatment of mosquito nets", *Malaria Journal*, 2005, 4(1), p.52.
24. Hangargekar PB, Birajdar AS, Joshi AA, Hangargekar CB, Kulkarni DR. Formulation and evaluation of safe herbal mosquito repellent dhoop sticks. *Int J Biol Pharm Allied Sci*. 2023 Nov;12(11):5017-5024. doi: 10.31032/IJBPAS /2023/ 12.11.7540.
25. Hlongwana KW, Tsoka-Gwegweni J, Sartorius B, Mwambi H, Balfour C, Kunene S. Community knowledge, attitudes and practices (KAP) on malaria in Swaziland: A country earmarked for malaria elimination. *Malar J*. 2021;20(1):1–11.
26. Jatkar P, Vrunal M, Maniyar MG, Waghmare V. Formulation and evaluation of herbal mosquito repellent cream. *Eur Chem Bull*. 2023;12(Special Issue 10):21052112. doi:10.48047/ecb/2023.12.si10.00252.

27. Jeevan AR, Sreeramulu K. Repellent activity of citrus oils against the cockroaches *Blattella germanica*, *Periplaneta americana*, and *P. fuliginosa*.
28. Kakde S, et al. Preparation of a mosquito repellent coil using orange peels as a rich source of essential oils. 2024;
29. Kompa, P.M., et al. (2023). Development and assessment of a dhoop that kills and repels mosquitoes utilizing herbal elements including Neem leaves powder, orange peel powder, Camphor, Eucalyptus oil, pharmaceutical perfume, Cow dung powder, Coconut shell powder, and Rose water
30. Kakde S, Ayaz MA, Khade A, Kalapad V, Kulkarni N, Kakde R, et al. Production of mosquito repellent insecticide coil using orange peel. *Eur J Pharm Med Res*. 2025 Jan;12(1)
31. Keshwar A, Keshwar U, Deogirkar A, Dhurde SS, Deo V, Shrikhande BK. Formulation Development and Evaluation of Cream Containing Natural Essential Oils Having Mosquito Repellent Property. *World J Pharm Pharm Sci*.
32. Kaura T, Mewara A, Zaman K, Sharma A, Agrawal SK, Thakur V, Garg A, Sehgal R. Utilizing larvicidal and pupicidal efficacy of Eucalyptus and neem oil against *Aedes* mosquito: An approach for mosquito control. *Trop Parasitol*. 2019 May 22;9(1):12–17. doi: 10.4103/tp.TP_35_18.
33. Klein G, Pack A, Bonaparte C, Reuter G. Taxonomy and physiology of probiotic lactic acid bacteria. *Int J Food Microbiol*. 2014 Jan 2;190:1-17. doi: 10.1016/j.ijfoodmicro.2014.03.029.
34. Kongkaew C, Sakunrag I, Chaiyakunapruk N, Tawatsin A. Effectiveness of citronella preparations in preventing mosquito bites: systematic review of controlled laboratory experimental studies. *Trop Med Int Health*. 2011;16(7):802-810. doi:10.1111/j.1365-3156.2011.02781.x.
35. Kompa PM, Suryawanshi SS, Patil SV, Kharmate PB, Kolekar AS, Mane SB, et al. Formulation and evaluation of mosquito killing and repellent dhoop from herbal ingredients. *Int J Innov Res Technol*. 2023 Aug;10(3):393-7.
36. Lokhande GGL, et al. Preparation of mosquito repellent insecticide coil using orange peel. [Journal Name]. 2022.
37. Lucía A, Guzmán E, Juárez P, Pedrini N, Bailez O, Zapata P, et al. Toxicity of citrus essential oils against *Ceratitis capitata* (Diptera: Tephritidae) larvae [Internet]. ResearchGate; 2010 [cited 2025 Feb 27].
38. Mandal S. Repellent activity of Eucalyptus and *Azadirachta indica* seed oil against the filarial mosquito *Culex quinquefasciatus* Say (Diptera: Culicidae) in India. *Asian Pacific Journal of Tropical Biomedicine*. 2011 Sep 1;1(1):S109-12
39. Mohd Shoeb Abdul Mukhtar, Shaikh S, Khan A, Ansari MA. Preparation of mosquito repellent insecticide coil using orange peel. [Journal Name]. 2023
41. Mangalarapu N, Kusam AR, Ganasala HP, Begum S, Dhammai AR, Prasuna Sundari PJ. Formulation and evaluation of plant-based mosquito repellent candles. *J Emerg Technol Innov Res*. 2024 Aug;11(8):398-403.
42. Mukhtar MSA, Chafekar A, Khan S, Sufi B. Production of mosquitoes repellents insecticides (mosquitoes coil) using orange peels. *Int J Adv Res Sci Commun Technol*. 2023 Jun;3(5):179-184

43. Massebo F, Tadesse M, Balkew M, Gebre-Michael T. Bioactivity of essential oils of local plants against adult *Anopheles arabiensis* (Diptera: Culicidae) in Ethiopia. *Adv Biosci Biotechnol.* 2013;4(8):805-809. doi:10.4236/abb.2013.48105.
44. Navayan A, Moghimipour E, Khodayar MJ, Vazirianzadeh B, Siahpoosh A, Valizadeh M, Mansourzadeh Z. Evaluation of the mosquito repellent activity of nanosized microemulsion of *Eucalyptus globulus* essential oil against Culicinae. *Jundishapur J Nat Pharm Prod.* 2017;12(4):e55626. doi:10.5812/jjnpp.55626.
45. Nutt DJ, Spriggs MJ, Erritzoe D, et al. Measuring the mind: biomarkers of cognitive and affective processes. *Front Psychiatry.* 2017;8:63. doi:10.3389/fpsy.2017.00063.
46. Nerio LS, Olivero-Verbel J, Stashenko E. Repellent activity of essential oils: A review. *Bioresour Technol.* 2010;101(1):372-378.
47. Onyia C, Okorie C. Bio-insecticides/repellent from citrus peels extract and its efficacy on mosquitoes. *International Research Journal of Applied Sciences, Engineering and Technology.* 2019;5(11):11-20
48. Oshaghi MA, Ghalandari R, Vatandoost H, Shayeghi M, Kamali-nejad M, TourabiKhaledi H, et al. Repellent effect of extracts and essential oils of *Citrus limon* (Rutaceae) and *Melissa officinalis* (Labiatae) against main malaria vector, *Anopheles stephensi* (Diptera: Culicidae). *Iran J Public Health.* 2003;32(4):47-52.
49. Okoro CA, Zhao G, Li C, Balluz LS. Has the prevalence of chronic obstructive pulmonary disease among adults increased in the United States? [Internet]. *Chest.* 2017 Dec;152(6):1318-26.
50. Oboh G, Ademosun AO, Olumuyiwa TA, Olasehinde TA, Ademiluyi AO, Adeyemo AC. Insecticidal activity of essential oil from orange peels (*Citrus sinensis*) against *Tribolium confusum*, *Callosobruchus maculatus* and *Sitophilus oryzae* and its inhibitory effects on acetylcholinesterase and Na⁺/K⁺-ATPase activities. *Phytoparasitica.* 2017;45(4):501-508. doi:10.1007/s12600-017-0620-z.
51. Osanloo M, Sedaghat MM, Sanei-Dehkordi A, Amani A. Plant-derived essential oils; their larvicidal properties and potential application for control of mosquito-borne diseases. *Galen Med J.* 2019 Aug 16;8:e1532. doi: 10.31661/gmj.v8i0.1532.
52. Okuyama J, Funakoshi S, Tomita H, et al. A real-world usability study of a mobile health application in the management of patients with chronic kidney disease. *JMIR Mhealth Uhealth.* 2019;7(2):e12675. doi:10.2196/12675.
53. Pangga FA, [co-authors' names]. Formulation of Mosquito Repellent Spray Using Citrus Peel Waste as an Alternative to Malaria Prevention. [Journal Name]. 2024; Issue: [Pages]. doi: [DOI number, if available]
54. Qiao Y, Xie BJ, Zhang Y, Zhang Y, Fan G, Yao XL, Pan SY. Characterization of aroma active compounds in fruit juice and peel oil of Jincheng sweet orange fruit (*Citrus sinensis* (L.) Osbeck) by GC-MS and GC-O. *Molecules.* 2008 Jun 12;13(6):1333-44. doi: 10.3390/molecules13061333.
55. Ranasinghe MSN, Perera PK, Abeywickrama KR, et al. Formulation of an efficient herbal mosquito repellent using combinations of selected plant materials. *J Nat Prod Res.* 2016;30(15):1780-1785.
56. Ridjal JA. Analisis faktor determinan keikutsertaan petani berkelompok, pendapatan dan pemasaran jeruk siam di Kabupaten Jember. *JSEP.* 2008 Mar;2(1):1-2.

57. Ranasinghe MSN, Arambewela L, Samarasinghe S. Development of herbal mosquito repellent formulations. *Int J Pharm Sci Res.* 2016 Sep 1;7(9):3643-8. doi: a. 10.13040/IJPSR.0975-8232.7(9).3643-48.
58. Rahuman AA, Gopalakrishnan G, Venkatesan P, Geetha K. Mosquito repellent activity of phytochemical extracts. *Glob J Sci Front Res.* 2012;12(1):16-25.
59. Shelake ST, et al. Development of herbal mosquito repellent candle using lavender oil and rose water. [Journal Name]. 2023.
60. Shriram BKS, et al. Evaluation of mosquito repellent sticks using herbal products. [Journal Name]. 2023.
61. Singh VK, Singh RK, Mishra B, Singh D. Formulation and Evaluation of Eco-friendly Handmade Herbal Mosquito Repellent Cone. *International Journal of Pharmaceutics and Drug Analysis.* 2021;9(4):230-5.
62. Singh K, Abdulhammed NA, Singh J, Norouzi R, Khoshkhoo A. Insecticidal efficacy of lemon grass (*Cymbopogon citratus*) and orange peel (*Citrus sinensis*) on mosquitoes. *J Vet Res Adv.* 2024;6(1):36-40.
63. Sheikh Z, Amani A, Basseri HR, Moosa Kazemi SH, Sedaghat MM, Azam K, Azizi M, Amirmohammadi F. Repellent efficacy of *Eucalyptus globulus* and *Syzygium aromaticum* essential oils against malaria vector, *Anopheles stephensi* (Diptera: Culicidae). *Iran J Public Health.* 2021 Aug;50(8):1668–1677. doi: 10.18502/ijph. v50i8.6813.
64. Schreck CE, Leonhardt BA. Efficacy assessment of Quwenling, a mosquito repellent from China. *J Am Mosq Control Assoc.* 1991;7(3):433-6.
65. Trigg JK. Evaluation of a eucalyptus-based repellent against *Anopheles* spp. in Tanzania. *J Am Mosq Control Assoc.* 1996;12(2):243-6.
66. Trigg JK. Evaluation of a eucalyptus-based repellent against *Culicoides impunctatus* (Diptera: Ceratopogonidae) in Scotland. *J Am Mosq Control Assoc.* 1996;12(2):329-330
67. Tavakol M, Ajami S, Saeidi R. New Approach to Evaluate the Performance of Medical Information Systems Using Fuzzy AHP and Z-Numbers. *Acta Inform Med.* 2017 Sep;25(3):162-166. doi:10.5455/aim.2017.25.162-166.
68. Trongtokit Y, Rongsriyam Y, Komalamisra N, Apiwathnasorn C. Comparative repellency of 38 essential oils against mosquito bites. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives.* 2005 Apr;19(4):303-9.
69. Tawatsin A, Wratten SD, Scott RR, Thavara U, Techadamrongsin Y. Repellency of volatile oils from plants against three mosquito vectors. *J Vector Ecol.* 2001 Jun;26(1):76-82.
70. Visakh NU, Pathrose B, Narayanankutty A, Alfarhan A, Ramesh V. Utilization of Pomelo (*Citrus maxima*) Peel Waste into Bioactive Essential Oils: Chemical Composition and Insecticidal Properties. *Insects.* 2022;13(5):480. doi:10.3390/insects13050480.