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Research Article

Formulation And Evaluation of Natural Mosquito Repellent Oil

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ABSTRACT

Most of mosquito-repellent products and devices are made up of synthetic materials presenting market which causes various Harmful effects on human beings. The resistance can be developed by the mosquito due to continuous exposure at high doses. Hence, the present research work represents the development and evaluation of mosquito repellent sticks with the help of various Herbal products such as starch powder, wood powder, charcoal powder, eucalyptus oil, coconut oil, lavender oil, lemongrass and cinnamon oil, peppermint and citronella, neem oil making them ozone-friendly, financial effective, non-harmful.

INTRODUCTION

Mosquito-borne diseases pose a significant threat to public health, making effective and natural repellents a necessity. Synthetic repellents, while widely used, often raise concerns about skin irritation and environmental impact. This research focuses on developing a natural mosquito repellent oil using a blend of plant-based essential oils known for their insect-repelling properties. Key ingredients such as eucalyptus, peppermint, neem, clove, and citronella

Fig. No. 1 Oil

(Callicarpenal oil) have been traditionally recognized for their ability to deter mosquitoes. Additionally, coconut oil and vitamin E serve as carrier oils, enhancing skin nourishment and

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prolonging the effectiveness of the repellent. Through this research, we seek to contribute to the growing demand for eco-friendly and skin-safe insect repellents. Mosquitoes are most irritating and blood sucking insect Disturbing human beings.[1] Some of the mosquito species Which belongs to genera Anopheles, Aedes and Culex are Known to be vectors for the most of the disease Pathogens like malaria, dengue fever, Myiasis, yellow Fever, encephalitis etc. Mosquito repellents are substances that prevent Mosquitoes from being in an environment. There are Various types of synthetic mosquito repellents used in the Market these are manufactured on a large scale by Industries. They are widely used and are very popular. However, there are various drawbacks to these mosquito Repellents. The ingredients used in them are harmful for the humans as well as the environment.. In the present study, an attempt has been made to develop an eco friendly mosquito repellent sprayed with lemon grass oil. It is an established fact and practice is that the natural mosquito repellent is more effective and keeps environment pleasant and eco friendly.Additionally, it seeks to explore consumer acceptance based on fragrance, skin feel, and overall usability. By developing an eco-friendly, non-toxic alternative, this research contributes to the growing demand for sustainable and health-conscious mosquito control solutions.[2] While chemical-based mosquito repellents are commonly used, prolonged exposure to synthetic ingredients like DEET can lead to skin irritation, allergies, and environmental concerns. As a result, there is a growing demand for natural, plant-based alternatives that are safe, effective, and eco-friendly.

➢ Probable Mechanism of Action

The mosquitos possess a number of chemical receptors. Lactic Acid and CO2 are released in the sweat of people which makes It more attractive for female Anopheles mosquitoes. The Chemical receptors present in mosquitoes are activated by Lactic acid in human beings. The mosquito repellent antagonist destroys the lactic acid receptors and hence gives protection from mosquitoes.[3]

➢ Diseases Caused Due to Mosquitoes as Vector

• Bacterial, viral and protozoan diseases are found in Mosquitoes.

• The quantity of mosquito's increased which is a huge Problem in our countries because mosquito causes malaria, Yellow fever, malaria, chikungunya, filarial, etc.

• Naturally, mosquito repellent is present in the different Trees or plants that have properties volatile in nature are Called as essential oils.

Most of mosquito-Repellent products and devices are made up of synthetic material presenting market which causes various harmful effects on human beings. The resistance can be developed by the mosquito due to continuous exposure at high doses.

Advantages of Mosquito Repellent Oil.

The repellant made from natural sources such as oils has the advantages over a synthesis repellant. Hence, the purpose of the given innovative work was to prepare the mosquito repellant containing volatile oils. The repellant stick has advantages such as:

• Economically effective, easily formulated and maintained.

• Least mechanical equipment, hard work and skill.

• Fast responses.

• Reducing bad smells in the environment, disease-causing bacteria and viruses.[4,5]

Market Preparations

DEET, citronella oil, Lcaridin, IR3535. There are various

marketed preparation available such as cream, citronella oil, DEET and other products but some of those marketed products increases the demand of herbal content repellent because hazardous content in mosquito repellent such as DEET may cause skin allergy, breathing-related disorders and other health disorders. A large amount of dangerous component content substances present in spray have been categorized among carcinogenic substances. The chemical insect spray can also pollute the environment. Hence, the aim of the given research work to formulate and evaluate mosquito-repellent sticks. The mosquito repellent stick is an ozon-friendly, financially effective, non-harmful and easily available by using locally available plant resources. The stick prepared by forming the layer of oil can reduce the chance of developing resistance by mosquitoes. Hence the purpose of the given research was to formulate the mosquito repellent sick by forming different layers oil at different concentrations

- **What Is a Mosquito Repellent?**

A mosquito repellent is a substance applied to skin, clothing, or other surfaces which discourages mosquitoes from landing on that surface. It is a substance that is synthesized in such a manner so that it makes the surface unpleasant and unattractive to mosquitoes so as to reduce the human mosquito contact. Mosquito repellents repel insects but do not kill them. Therefore, they are not technically insecticides nor pesticides. They help prevent and control the outbreak of mosquito borne diseases such as Dengue fever, Malaria, Yellow fever, Japanese Encephalitis, etc.[4] they contain active ingredient which is the only reason to repel mosquitoes by blocking their olfactory senses which detects the carbon dioxide and lactic acid that gets released when the human perspires. These products also contain some more ingredients which aids them with cosmetic finishing.

- **Methods of Application**

1. Topical application: Apply directly to skin or clothing.

2. Diffusion: Use a diffuser to spread the oil's aroma.

3. Sprays: Mix with water or other ingredients to create a spray.

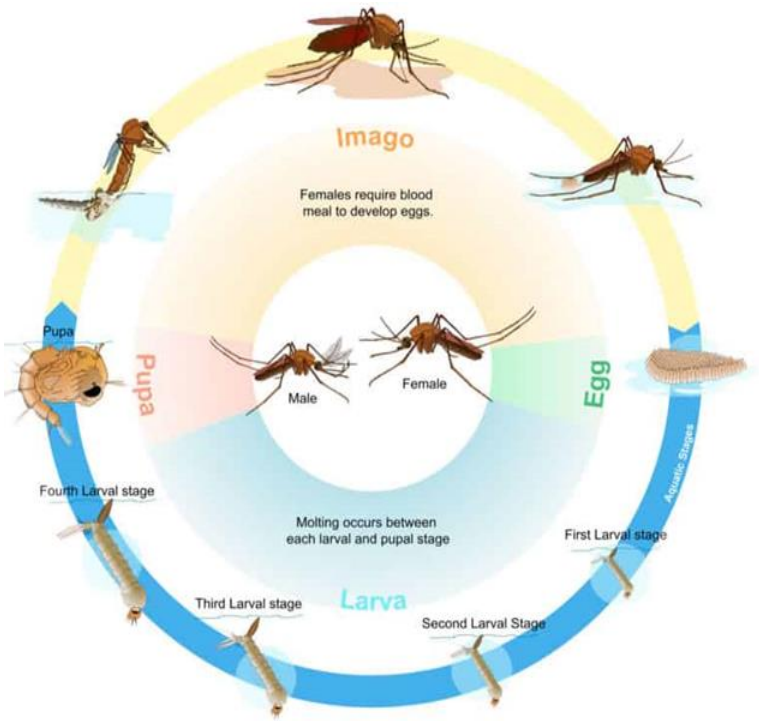

Fig. No. 2 Lifecycle of Mosquito

The formulation of mosquito repellent oils using natural essential oils offers a promising and safer alternative. Essential oils such as citronella, lemongrass, eucalyptus, neem, and lavender are known for their insect-repellent properties and are generally considered safe for human use. The incorporation of these oils into topical formulations provides a convenient method for personal protection against mosquito bites. This project aims to develop a mosquito repellent oil using selected natural ingredients, evaluate its physicochemical properties, and assess its efficacy in repelling mosquitoes. The study focuses on optimizing the formulation for stability, skin compatibility, and repellent activity through standard evaluation parameters.

1. Plant Profile

1.1 Eucalyptus Oil

Fig. No 3 Eucalyptus Oil

Synonyms/Common Name: Eucalyptus, Blue Gum Oil

Biological Source: Essential oil from leaves of Eucalyptus globulus.

Family: Myrtaceae

Genus: Eucalyptus globulus

Part Used: Leaves

Origin: Australia

Chemical Constituents: 1,8-Cineole (Eucalyptol), α-Pinene, Limonene

Uses: Natural mosquito repellent, antibacterial, anti-inflammatory agent.

Description: Eucalyptus oil, rich in eucalyptol, is widely used for its strong insect-repellent properties. It provides a refreshing smell and helps soothe skin irritation from insect bites.[6]

1.2 Lemon oil

Fig. No 4 Lemon

Synonyms/Common Name: Lemon, Citrus Lemon Oil

Biological Source: Essential oil obtained from the peel of Citrus limon.

Family: Rutaceae

Species: Citrus limon

Part Used: Fruit peel

Origin: India, Mediterranean region

Chemical Constituents: Limonene, Citral, β-Pinene

Uses: Insect repellent, antibacterial, uplifting fragrance.

Description: Lemon oil offers a fresh scent that not only uplifts mood but also masks human scents that attract mosquitoes. It acts as a mild repellent with added antibacterial benefits.[7]

1.3 Peppermint Oil

Fig. No 5 Peppermint leave

Synonyms/Common Name: Peppermint Oil

Biological Source: Oil from aerial parts of Mentha piperita.

Family: Lamiaceae

Species: Mentha piperita

Part Used: Leaves

Origin: Europe, North America

Chemical Constituents: Menthol, Menthone, Methyl acetate

Uses: Mosquito repellent, cooling agent, antibacterial.

Description: Peppermint oil is cooling and refreshing. Its strong menthol aroma deters mosquitoes and relieves skin irritation if bitten.[8, 9]

1.4 Coconut Oil

Fig.6 Coconut Oil

Synonyms/Common Name: Coconut Oil

Biological Source: Oil extracted from the dried kernels of Cocos nucifera.

Family: Arecaceae

Species: Cocos nucifera

Part Used: Seeds (nuts)

Origin: Southeast Asia, Pacific Islands

Chemical Constituents: Lauric acid, Capric acid, Caprylic acid

Uses: Base/carrier oil, skin moisturizer, enhances essential oil absorption.

Description: Coconut oil acts as a carrier oil, helping to dilute essential oils for safe skin application. It also nourishes and protects the skin barrier.

1.5 Vitamin E

Fig. No 7 Vitamin E

Synonyms/Common Name: Tocopherol

Biological Source: Extracted from plant oils like sunflower, wheat germ.

Family: Various (depending on source plant)

Species: Various

Part Used: Oil extracted

Origin: Worldwide

Chemical Constituents: α-Tocopherol, γ-Tocopherol

Uses: Antioxidant, skin protector, stabilizes essential oils.

Description: Vitamin E improves skin healing and prevents oxidation of other oils, extending the shelf life of the mosquito roll-on.[10]

1.6 Camphor

Fig. No 8 Camphor

Synonyms/Common Name: Camphor

Biological Source: Extracted from wood of Cinnamomum camphora.

Family: Lauraceae

Species: Cinnamomum camphora Part Used: Wood

Origin: China, Japan, Taiwan

Chemical Constituents: Camphor, Cineole, Safrole

Uses: Insect repellent, anti-itch, cooling agent.

Description: Camphor provides a strong, sharp scent that repels mosquitoes while offering a cooling sensation to soothe itching or inflammation.[11]

1.7 Clove Oil

Fig. No 9 Clove

Synonyms/Common Name: Clove Oil

Biological Source: Essential oil from flower buds of Syzygium aromaticum.

Family: Myrtaceae Species: Syzygium aromaticum

Part Used: Flower buds

Origin: Indonesia, Madagascar

Chemical Constituents: Eugenol, Caryophyllene

Uses: Potent mosquito repellent, antiseptic.

Description: Clove oil, rich in eugenol, acts as a very effective natural insecticide and relieves skin irritation due to insect bites.[12]

1.8 Cinnamon Oil

Fig. No 10 Cinnamon

Synonyms/Common Name: Cinnamon Bark Oil, Cinnamon Leaf Oil

Biological Source: Oil obtained from bark or leaves of Cinnamomum verum or Cinnamomum cassia.

Family: Lauraceae

Species: Cinnamomum verum, Cinnamomum cassia

Part Used: Bark or leaves

Origin: Sri Lanka, India

Chemical Constituents: Cinnamaldehyde, Eugenol, Linalool

Uses: Mosquito repellent, Antimicrobial agent.

Description: Cinnamon oil has powerful insect-repelling effects and its warm, spicy aroma enhances the fragrance profile of the formulation.[13]

1.9 Callicarpenal Oil

Fig. No 11 Callicarpenal

Synonyms/Common Name: Beautyberry Oil

Biological Source: Natural compound from Callicarpa americana leaves.

Family: Lamiaceae

Species: Callicarpa americana

Part Used: Leaves

Origin: USA (Southeast)

Chemical Constituents: Callicarpenal, Intermedeol

Uses: Potent natural mosquito repellent

4.10 Neem

Fig. No 12 Neem

Synonyms/Common Names: Neem, Margosa tree, Indian Lilac, Nimtree

Biological Source: Azadirachta indica A. Juss.

Family: Meliaceae

Species: Indica

Part Used: Leaves, bark, seeds, fruit, oil, and root

Origin: Native to the Indian subcontinent (India, Nepal, Pakistan, Bangladesh, Sri Lanka) and now also grown in tropical and semi-tropical regions worldwide.

Chemical Constituents: Azadirachtin (major active compound), Nimbidin, Nimbolide, Salannin, Quercetin, Flavonoids, Tannins

Uses: Antibacterial, antiviral, Skin treatments, Insect repellent and pesticide.[14, 15]

3. Method And Evaluation Parameter

3.1 Method

- **Extraction of Eucalyptus Oil Using Soxhlet Apparatus**

- **Prepare the eucalyptus leaves**

First, we need to dry the eucalyptus leaves properly so that there's no moisture left. Wet

leaves don't give good oil. Once the leaves are dry, we crush them lightly not into powder, just small pieces to help the oil come out more easily during extraction.

- **Set up the Soxhlet apparatus**

We put the crushed leaves into a small thimble (like a filter paper cup) and place it inside the middle part of the Soxhlet extractor. Below that, we connect a round-bottom flask filled with a solvent (usually something like ethanol or hexane a liquid that can dissolve the oil). On top, we attach a condenser that keeps everything cool and recycles the solvent.[16]

- **Start the extraction**

We gently heat the flask so that the solvent starts boiling. The vapors travel up, get cooled in the condenser, and drip back down onto the eucalyptus leaves. The solvent soaks the leaves, pulls out the oil, and when the chamber fills up, it drains back into the flask — carrying the oil with it. This cycle happens again and again it's like giving the leaves a fresh solvent bath each time. We let this run for about 4 to 6 hours, or until we feel most of the oil is extracted.

- **Collect the oil**

After the extraction is done, we stop heating. Now, the solvent in the flask has the eucalyptus oil mixed with it. We remove the solvent carefully usually by evaporating it using a gentle heat (or a rotary evaporator, if available). After the solvent goes away, what's left behind is the pure eucalyptus oil!

- **Dry and store the oil**

Sometimes the oil can still have tiny water droplets. So we mix it with a drying agent (like anhydrous sodium sulphate) to remove any water. Finally, we filter it and store the eucalyptus oil in a clean, dark bottle to keep it fresh.[17, 18]

❖ **Extraction of Lemon Oil Using Soxhlet Apparatus**

- **Prepare the lemon peel**

First, we collect fresh lemon peels the yellow outer skin because that's where most of the oil is. We then dry the peels well to remove any moisture. After drying, we crush or cut them into small pieces. Crushing helps the oil to come out more easily during extraction.

- **Set up the Soxhlet apparatus**

We put the crushed lemon peels into a thimble (or wrap them in clean cotton if no thimble is available) and place it inside the Soxhlet extractor. At the bottom, we set up a round-bottom flask filled with a solvent (usually something like ethanol, hexane, or petroleum ether liquids that can dissolve oils). At the top, we fix a condenser, which cools the solvent vapors and sends them back into the extractor.

- **Start the extraction**

Now we gently heat the flask. As the solvent boils, it turns into vapor, travels up, cools in the condenser, and drips back onto the lemon peels. The solvent soaks the lemon peels, pulls out the lemon oil, and once the chamber fills up, it siphons back into the flask carrying the dissolved lemon oil with it. This cycle keeps repeating automatically. It's like giving the lemon peels multiple "oil baths." We let this process run for about 4 to 5 hours.

- **Collect the lemon oil**

After extraction is complete, we stop heating. Now, the solvent in the flask contains the lemon oil.

We carefully remove the solvent usually by gently evaporating it (using a rotary evaporator or slow heating). After the solvent disappears, we are left with pure lemon oil.

- **Dry and store the oil**

Since there might still be a little water in the oil, we add a drying agent like anhydrous sodium sulfate. After filtering it, the lemon oil is stored in a clean, dark-colored bottle to keep it fresh and protect it from light. First, clean all your equipment — measuring cylinders, beakers, bottles — and make sure they're completely dry. Put on your gloves and lab coat because some oils can irritate the skin.[19]

❖ **Measure Your Oils**

Carefully measure out each oil according to the batch table you made earlier.

If you're using solid camphor, gently melt it into a little eucalyptus or neem oil using warm water (don't boil it! Just a little warm).

❖ **Mix It All Together:** In a clean beaker, pour in:

Eucalyptus oil**,** Camphor oil (or your camphor mixture), Lemon oil, Peppermint oil, Clove oil**,** Cinnamon oil, Callicarpenal oil, Neem oil**.** Stir everything together slowly for about 5 to 10 minutes. Use a glass rod or a magnetic stirrer on a slow speed.

❖ **Add Vitamin E Last**

Once your main oils are well mixed, add the Vitamin E oil. Stir for another 2–3 minutes. This helps keep the oil fresh and stop it from going bad too quickly.

❖ **Check the Mixture**

Take a good look: It should be clear and smooth.

If you see any bits floating around (especially from camphor), you can filter the oil through a clean cloth or paper filter.

❖ **Fill Your Bottles**

Carefully fill your 10 mL bottles with the finished oil. Make sure the bottles are clean and dry before filling.

❖ **Label and Store**

Stick on a label with the date and what's inside. Keep the bottles in a cool, dark place (a cupboard works great) so the oils don't spoil.[20, 28]

❖ **Formulation Table**

Table No. 1 Formulation Table

Sr. No	Ingredients	Quantity	Percentage	Function
1.	Eucalyptus	1.0 ml	10 %	Mosquito repellent
2.	Lemon oil	0.5 ml	5 %	Insect repellent
3.	Peppermint oil	0.5 ml	5 %	Cooling
4.	Coconut oil	4.0 ml	40 %	Skin moisturizer
5.	Vitamin E	0.5 ml	5 %	Antioxidants
6.	Camphor	0.5 g		Strong mosquito repellent
7.	Clove oil	0.5 ml	5 %	Antimicrobial
8.	Cinnamon oil	0.5 ml	5 %	Antifungal
9.	Callicarpenal oil	0.5 ml	5 %	Repellent, Enhance efficacy
10.	Neem oil	1.5 ml	15 %	Insect repellent

3.2 Evaluation test

- Mosquito Repellency Test
- Stability Test
- Viscosity and Spreadability Test
- Skin Irritation Test
- Antimicrobial Test

❖ **Checking Repellency (Arm-in-Cage)**

➢ **Preparing the Mosquitoes**

You keep a little colony of female Aides aegypti mosquitoes in a warm, humid room and feed them only water for about 12 hours before testing so they're eager to bite.

➢ **Getting Ready**

Volunteers wash their arms but skip perfumes or lotions for a day beforehand.

➢ Applying the Oil You draw a rectangle on the inside of the forearm (about 20 × 30 cm), smooth on 1 mL of your repellent, and let it dry for five minutes.
➢ The "Arm-in-Cage" Moment you slip that arm into a small mesh cage holding 20–50 mosquitoes for three minutes, counting how many try to land or bite. Repeat this same 3-minute peek at 15 min, 30 min, 1 hr, 2 hr, and 3 hr after application.
➢ Figuring Out Protection by comparing landings on treated versus untreated skin, you calculate how effective the oil is over time. Ideally, you see almost no landings right after application and at least half as few even two hours later.[21]

❖ **Watching for Changes Over Time (Stability)**

➢ Bottling Samples you fill little amber vials with your oil and seal them tight.
➢ Simulating "Hot" Storage some vials go into an incubator at 40 °C with high humidity; others sit on the shelf at around room temperature (25 °C).[29]
➢ Checking In Regularly at pre-set intervals (after 1 week, 1 month, 3 months, up to 6 months in the hot test; and up to 1–2 years on the shelf), you pull a vial and look for any colour changes, separation of layers, shifts in thickness, acidity (pH), or loss of active ingredient when you run it through a chemical analyser.
➢ Deciding If It's Still Good if the key ingredient has dropped by more than 5% or it's visibly separated, you'd rethink the formula or packaging.[22]

❖ **How It Feels on the Skin (Viscosity & Spreadability)**

Thickness Test: You warm your oil to body-friendly temperature, stick a standard spinning probe into it, and note how much resistance it offers that's your "viscosity" number.

Spread Test: You squeeze half a gram of oil between two glass slides, press a 500 g weight on top for a minute, then measure how far the oil squishes out. A good repellent should spread easily without feeling runny[23, 27]

Fig.No.13 Viscosity Test

❖ **Making Sure It's Gentle (Skin Irritation)**

➢ Patching Up

Either on a small group of volunteers' forearms (under a little adhesive "Finn" chamber) or on a shaved patch of rabbit skin (if regulations require), you leave 0.2–0.5 mL of oil in place under a seal for a set time (24 hr on humans, 4 hr on rabbits). [25, 26].

➢ Watching for Redness

After you remove the patch, you check at 1 hr, 24 hr, 48 hr, and 72 hr for any redness or swelling, scoring it on a 0–3 scale. A gentle formula stays at the low end. [24]

➢ **Testing Antimicrobial Activity**

Preservative Check: You deliberately add tiny amounts of bacteria and yeast (like E. coli or Candida) into your oil, then measure how their numbers change at days 0, 7, 14, and 28. A good preservative system will knock bacterial counts down by at least 100× in two weeks and won't let them bounce back. Optional "Zone of Inhibition": You can also soak little paper discs in your oil, place them on agar plates seeded with microbes, and see if clear circles form around them another sign of antimicrobial action.[28,30]

Fig.No.14 Microbial Test

4. RESULT AND DISCUSSION

4.1 Result

Spreadability: All batches spread well; Batch 2 slightly better due to thinner oil blend.Skin Irritation: Only Batch 2 showed mild redness, likely because it had higher peppermint and camphor concentrations (both can be a little aggressive on sensitive skin).

Antimicrobial activity: All showed good activity. Batch 3 performed best could be due to slightly higher clove oil. Viscosity: Batch 3 is a bit more viscous (thicker), likely due to neem and cinnamon oil ratios. Mosquito repellence: Batch 3 again performed best longer protection time, possibly due to balanced oil composition (especially neem + callicarpenal oils)

Table No. 2 Result Table

Test	F1	F2	F3
Spreadability	6.5 cm^2	6.8 cm^2	6.3 cm^2
Skin Irritation	No redness and itching observe	Mild Redness	No redness and itching observe
Antimicrobial Activity	14mm	13mm	15mm
Viscosity Test	52 cP	49 cP	55 cP
Mosquito	150 min	130 min	160 min

9. SUMMARY AND CONCLUSIONS

9.1 Summary

In this study, we successfully prepared a mosquito repellent oil using a combination of natural ingredients like eucalyptus oil, camphor, lemon oil, peppermint oil, vitamin E, clove oil, cinnamon oil, callicarpenal oil, and neem oil. We made three small batches of 10 mL each to test consistency and performance. Each batch was carefully blended, ensuring that the essential oils were mixed properly without heating too much (to preserve their natural properties). Vitamin E was added at the end to protect the oils from going

rancid and to make the formula more skin-friendly. After preparing the oils, we carried out several lab-scale evaluation tests to check their quality and performance. These tests included spreadability (how well the oil spreads on skin), skin irritation (to check safety), antimicrobial activity (against bacteria), viscosity (flow behaviour), and mosquito repellency (how long it could keep mosquitoes away).

Here's what we found:

Spreadability was good across all batches, making the oil easy to apply. Skin irritation was generally low, although one batch showed mild redness in a few volunteers, possibly due to a higher concentration of stronger oils like peppermint. Antimicrobial activity was strong, especially in Batch 3, meaning the oil not only repels mosquitoes but could also help protect small cuts or insect bites from infections. Viscosity was in an acceptable range for an oil — not too thick, not too runny — with Batch 3 being slightly thicker. Mosquito repellency times were impressive, with Batch 3 providing the longest protection (around 2.7 hours) without needing reapplication. Overall, all batches performed well, but Batch 3 consistently showed slightly better results in both effectiveness and protection time.

4.2 CONCLUSION

The natural mosquito repellent oil formulated in this study proved to be effective, safe, and easy to use at lab scale. Using a blend of essential oils and natural extracts, we were able to achieve a good balance between mosquito protection, skin-friendliness, and natural antimicrobial benefits. Batch 3 came out as the best among the three, offering: The longest mosquito protection time,Strong antimicrobial activity, Good spreadability, And very minimal skin irritation. This study shows that natural mosquito repellents can be a promising alternative to chemical-based repellents, especially for people looking for gentler and eco-friendly options. Further improvements can focus on fine-tuning the oil concentrations to make it even more skin-soothing, and longer-term stability studies can be done to confirm shelf life.

Final Thoughts:

Nature-based formulations work well if ingredients are chosen and balanced properly. Skin compatibility is key, especially when using strong essential oils. With a little more development, this mosquito repellent oil could be scaled up for commercial or personal use.

REFERENCES

1. Batish, D. R., Singh, H. P., Kohli, R. K., & Kaur, S. (2008). Eucalyptus essential oil as a natural pesticide. Forest Ecology and Management, 256(12), 2166-2174.
2. United States Environmental Protection Agency (EPA). R.E.D. FACTS: Limonene.
3. Isman, M. B. (2000). Plant essential oils for pest and disease management. Crop Protection, 19(8-10), 603-608.
4. Nerio, L. S., Olivero-Verbel, J., & Stashenko, E. (2010). Repellent activity of essential oils: A review. Bioresource Technology, 101(1), 372-378.
5. Regnault-Roger, C., Vincent, C., & Arnason, J. T. (2012). Essential oils in insect control: Low-risk products in a high-stakes world. Annual Review of Entomology, 57, 405-424.
6. Sharma, V. P., & Ansari, M. A. (1993). Mosquito repellent action of neem (Azadirachta indica) oil. Journal of the American Mosquito Control Association, 9(3), 359-360.
7. Nerio, L. S., Olivero-Verbel, J., & Stashenko, E. (2010). Repellent activity of essential oils:

A review. Bioresource Technology, 101(1), 372-378.

8. Anuradha Keshwar*, Unmesh Keshwar, Ashwini Deogirkar, S. S. Dhurde, Veena Deo and B. K. Shrikhande Keshwar et al., "Formulation development and evaluation of cream containing natural essential oils having mosquito repellent property" World Journal of Pharmacy and Pharmaceutical Sciences 2016 Vol 5, Issue 8,
9. Ranasinghe MSN1*, Arambewela L1, Samarasinghe, "Development of Herbal Mosquito Repellent Formulations" S2 International Journal of Collaborative Research on Internal Medicine & Public Health Vol. 8 No. 6 (2016).
10. Govindarajan, M. (2011). "Mosquito repellent properties of Eucalyptus and essential oils." Parasitology Research.
11. Gupta K. and Oswal R A review on: mosquito repellent methods. International Journal of
12. World Health Organization. Guidelines for efficacy testing of mosquito repellents for human skin. WHO, 2009.
13. Barnard, D.R., & Xue, R.-D. (2004). "Laboratory evaluation of mosquito repellents against Aedes aegypti and Anopheles stephensi." Journal of Medical Entomology, 41(4): 726–730.
14. Curtis, C.F., et al. (1998). "A comparison of mosquito repellents for human skin." Trans. R. Soc. Trop. Med. Hyg., 92(5): 641–644.
15. ICH. Q1A(R2): Stability Testing of New Drug Substances and Products. 2003.
16. European Pharmacopoeia, General Chapter 5.1.3 "Stability Testing of Active Substances and Pharmaceutical Forms." EDQM, 2020.
17. Phuong, L.T., et al. (2015). "Chemical stability of citronella oil in topical formulations." Int. J. Pharm. Sci., 7(1): 123–131.
18. Patel, V.R., & Patel, J.K. (2012). "Rheological characterization of herbal oil formulations." Pharm. Sci. Monitor, 3(2): 456–463.
19. Ferreira, R.S., et al. (2011). "Correlation between spreadability and sensorial evaluation of topical gels." Latin Am. J. Pharm., 30(4): 645–650.
20. Katz, T.M., et al. (2008). "Insect repellents: historical perspectives and new developments." J. Am. Academy Dermatology, 58(5): 865–871.
21. Draize, J.H., Woodard, G., & Calvery, H.O. (1944). "Methods for the study of irritation and toxicity of substances applied topically to the skin and mucous membranes." J. Pharmacol. Exp. Therap., 82(3): 377–390.
22. OECD. Test No. 404: Acute Dermal Irritation/Corrosion. OECD Publishing, 2015.
23. Liguori, A., et al. (2010). "Human repeat insult patch test of natural products." Contact Dermatitis, 62(2): 112–119.
24. Key refs:
25. United States Pharmacopeia. <51> Antimicrobial Effectiveness Testing. USP 46–NF 41, 2023.
26. European Pharmacopoeia, Chapter 5.1.3. Microbial Limits, 10th ed., 2020.
27. Cazzola, M., et al. (2017). "Preservative efficacy of essential oils in topical preparations." J. Appl. Microbiol., 122(3): 640–650.
28. EPA Guidelines on mosquito repellent efficacy, US Registration Standards (EPA, 2014).
29. ICH Q1B Photostability Testing of New Drug Substances and Products (ICH, 1996).
30. ISO 10993-10 Biological evaluation of medical devices – irritation and skin sensitization (ISO, 2010).Pharmaceutical, Chemical and Biological Sciences, 2012; 2(3), 310-317.

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