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A Review On API As A Lemon Eucalyptus Herbal Mosquito Repellent

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Abstract: *Oil of lemon eucalyptus (OLE) and its principal active derivative, p-menthane-3,8-diol (PMD), are widely used plant-derived mosquito repellents marketed as natural alternatives to synthetic repellents such as DEET and picaridin. This review synthesizes current knowledge on the botany and chemistry of lemon eucalyptus, mechanisms of action, laboratory and field efficacy data, formulation approaches, safety and regulatory considerations, and gaps for future research. Overall, PMD-containing products offer protection comparable to low-to-moderate concentrations of DEET in many studies and are an evidence-backed option for adult use; however, limitations include shorter duration in some settings, potential for skin sensitization, and restricted recommendations for young children. The review highlights areas where standardized clinical and field studies are still needed to support wider use and optimized formulations.*

Keywords*:* oil of lemon eucalyptus, OLE, p-menthane-3,8-diol (PMD), mosquito repellent, efficacy, safety, formulation, CDC, botanical insect repellents

I. INTRODUCTION

Interest in plant-derived repellents has grown due to demand for "natural" alternatives to synthetic active ingredients. Oil of lemon eucalyptus (OLE), derived from the leaves of Corymbia citriodora (formerly Eucalyptus citriodora), and its bioactive transformation product PMD have emerged as one of the better-studied botanical repellents. Agencies including the U.S. Centers for Disease Control and Prevention (CDC) list OLE/PMD among acceptable repellents, while cautioning about unformulated essential oil use and recommending age limits for children.

2. Botany, extraction, and chemistry

Corymbia citriodora (lemon eucalyptus) is native to Australia and cultivated worldwide. The leaves contain volatile essential oils rich in citronellal and related monoterpenoids; commercial "oil of lemon eucalyptus" may be either the essential oil itself or a processed product high in PMD produced by converting citronellal to PMD. PMD (para-menthane-3,8-diol) is the component most strongly associated with repellency and is the active ingredient in many registered products.

3. Mechanism of action

PMD and related essential oil constituents act primarily by interfering with mosquito olfactory cues — masking or disrupting the host-seeking response mediated by carbon dioxide, lactic acid and skin volatiles. The exact molecular receptor targets in insects are an area of ongoing research, but behavioral assays consistently demonstrate reduced landings and bites in the presence of PMD/OLE formulations.

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4. Efficacy — laboratory and field evidence

4.1 Laboratory assays

Multiple laboratory bioassays (arm-in-cage, olfactometer, Y-tube) show that PMD and OLE formulations significantly reduce attraction and landing rates of Aedes, Anopheles, and other genera. Reported protection times in controlled tests vary with concentration and formulation: typical commercial PMD formulations (≈20–30% PMD) often provide several hours of protection in lab settings.

4.2 Field studies and comparative performance

Comparative studies suggest that PMD-based repellents can provide protection comparable to low-to-moderate concentrations of DEET in many field settings, though DEET and picaridin tend to retain efficacy longer in some tropical, high-challenge environments. Consumer testing and product evaluations (including independent testing groups) have reported protection durations from ~3–6 hours for PMD products depending on concentration and test conditions.

4.3 Limitations of efficacy data

Heterogeneity in study design (different mosquito species, challenge intensity, climatic conditions, and formulations) makes direct comparison across studies difficult. Some essential-oil studies show rapid loss of efficacy due to volatility unless formulation strategies (e.g., microencapsulation, fixatives) are used.

5. Formulation science and product types

OLE/PMD is available in sprays, lotions, creams, and some consumer products (candles, diffusers). Formulation goals are to (1) deliver effective active concentration to skin, (2) control volatility to extend protection time, and (3) minimize skin irritation. Common formulation approaches include solvent systems (ethanol, isopropanol), emollients (glycerin, esters), and thickening agents for creams. Advanced techniques such as microencapsulation and polymer carriers have been investigated to slow release and improve longevity. Example simple spray composition reported in literature and product manuals: PMD 5–30% (depending on claim), ethanol 30–50%, humectant (glycerin) 3–5%, water q.s.

6. Safety, tolerability, and regulatory status

6.1 Safety profile

PMD and formulated OLE are generally considered safe for adult use when used as directed, but cases of skin sensitization and allergic dermatitis have been reported, and essential oil-grade OLE (unformulated) is not recommended because safety and efficacy data are lacking for pure oils. Several public health bodies advise against applying OLE/PMD products to children under 3 years due to limited pediatric safety data. Pregnant and breastfeeding individuals are generally considered able to use DEET, picaridin, IR3535 or PMD products with typical precautions, but product labels and local guidance should be followed.

6.2 Regulatory considerations

In the United States, PMD is an EPA-registered active ingredient when formulated and labeled appropriately; manufacturers must provide efficacy and safety data for registration. Public health agencies (CDC) explicitly distinguish between registered PMD/OLE formulations and unregistered pure essential oils and recommend using registered products.

7. Advantages and disadvantages.

Advantages

Plant-derived, perceived as natural by consumers.

Pleasant lemon scent vs chemical odors of some synthetics.

Effective in many settings; some formulations show 3–6 h protection for adults.

Disadvantages

Potential for allergic skin reactions in susceptible individuals.

Not recommended for children under 3 years.

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Efficacy and duration can be shorter than high-concentration DEET in some high-challenge environments; formulation matters.

8. Research gaps and future directions

1. Standardized comparative field trials: head-to-head trials of well-characterized PMD formulations against DEET, picaridin and IR3535 across multiple mosquito species and ecological settings are limited.
2. Pediatric safety data: rigorous toxicology and tolerability studies for infants and toddlers are lacking; currently authorities caution use in <3-year-olds.
3. Mechanistic studies: molecular targets and receptor interactions in mosquitoes for PMD need more detailed investigation to understand potential for resistance and to design synergistic blends.
4. Improved formulations: development of controlled-release and skin-friendly carriers (microencapsulation, polymers) to extend duration without increasing irritation.

9. Practical recommendations

Use EPA-registered PMD/OLE products and follow label instructions; do not apply unformulated essential oil to skin as a repellent.

For high-risk travel or prolonged outdoor exposures in tropical regions, consider longer-lasting synthetic repellents (DEET or picaridin) or reapply PMD formulations per label to maintain protection.

Test on a small skin area prior to widespread use, particularly if there is a history of sensitive skin or plant allergies (EWG and clinical sources note skin sensitization risk).

II. CONCLUSION

Oil of lemon eucalyptus and its active derivative PMD represent one of the most effective plant-based mosquito repellents available and can be an appropriate alternative to synthetics for many adult users. The body of evidence supports efficacy against common vector genera in laboratory and many field settings, but variability in protection time and pediatric safety limitations warrant cautious, label-guided use. Future standardized field trials, pediatric safety studies, and formulation innovations will strengthen the evidence base and broaden safe, effective applications.

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