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Formulation and Evaluation of Herbal Mosquito Repellent Cream: A Comprehensive Review

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Abstract: *Mosquitoes rank among the most dangerous arthropod vectors worldwide, transmitting life-threatening diseases including malaria, dengue fever, chikungunya, and filariasis to millions of people annually. Although synthetic repellents such as DEET remain the commercial standard, concerns regarding dermal irritation, neurotoxicity at elevated concentrations, damage to synthetic materials, and adverse environmental persistence have generated growing scientific and consumer interest in plant-derived alternatives. The present work reports the design, preparation, and systematic physicochemical evaluation of a W/O-type herbal mosquito repellent cream incorporating citronella oil (Cymbopogon nardus) and neem oil (Azadirachta indica) as primary bioactive components, with beeswax and stearic acid as structural excipients, glycerine as humectant, and purified water as the continuous phase. The finished cream displayed smooth, homogeneous consistency, a light-yellow colour attributable to the constituent oils, a pH of 6.5 compatible with cutaneous physiology, and satisfactory spreadability. Irritancy assessment on volunteer skin over 24 hours revealed no erythema, oedema, or pruritus. Stability evaluation under varied storage conditions confirmed the absence of phase separation or perceptible organoleptic change. Mosquito repellent efficacy was maintained for approximately three to four hours post-application. Collectively, these findings demonstrate that the formulation constitutes a safe, stable, and effective alternative to synthetic repellent products for personal protection against mosquito-borne disease*

Keywords: herbal mosquito repellent, citronella oil, neem oil, cream formulation, mosquito-borne diseases, phytochemicals, DEET alternative

I. INTRODUCTION

Mosquitoes constitute one of the primary public health threats facing humanity, acting as obligate vectors for a spectrum of debilitating and often fatal infections. According to projections from the World Health Organization, malaria alone killed over 600,000 people in 2021 and affected almost 247 million people, the vast majority of whom were children under five in sub-Saharan Africa. The dengue virus is one of the viruses that spreads the fastest in the world, infecting an estimated 400 million people annually across more than 100 nations. While chikungunya and lymphatic filariasis continue to cause significant disability and monetary loss, dengue and malaria are disproportionately prevalent in India.

Vectorial capacity is dominated by three genera of mosquitoes. Plasmodium parasites that cause malaria are spread by Anopheles species, which usually bite during the night and crepuscular hours. Dengue, chikungunya, Zika, and yellow fever viruses are spread by the aggressive diurnal feeders Aedes aegypti and Aedes albopictus, which mainly reproduce in tiny, clear-water collections. Culex species, which prefer stagnant or contaminated water bodies and nocturnal feeding behaviors, spread filariasis, West Nile virus, and Japanese encephalitis. Due in part to increased urbanization and rising global temperatures, these vectors have spread geographically, increasing the risk of disease in areas that were previously thought to be non-endemic.

Environmental source reduction, biological agents like Bacillus thuringiensis israelensis (Bti) and larvivorous fish, and chemical treatments like indoor residual spraying and insecticide-treated bed nets are examples of conventional management techniques. Personal repellents are the most practical and popular kind of protection for individuals. Since

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the middle of the 20th century, synthetic repellents have dominated the market, especially DEET (N ,N-diethyl-meta-toluamide). DEET and related compounds have been shown to cause contact dermatitis, neurotoxicity at high concentrations, degradation of polymers and synthetic fabrics, and environmental persistence with possible ecotoxicological effects, despite their broad-spectrum efficacy. Significant research into plant-derived repellant compositions has been sparked by these restrictions as well as increased consumer awareness and regulatory scrutiny.

Monoterpenes, sesquiterpenes, and phenylpropanoids are volatile secondary metabolites found in the essential oils of many medicinal plants that are exploited by phytochemical repellents. These components interfere with mosquitoes' olfactory host-location pathways, hiding cues like lactic acid, carbon dioxide, and skin heat. Compared to their synthetic counterparts, plant-based medicines often have lower mammalian toxicity profiles, are biodegradable, and often provide additional antibacterial or anti-inflammatory properties. A semi-solid cream vehicle is especially beneficial since it allows for easy application, controlled release of volatile actives, prolonged skin contact time, and a texture that is aesthetically pleasing.

II. LITERATURE REVIEW

A substantial body of research has established the scientific credibility of plant-derived mosquito repellents and guided contemporary formulation strategies.

2.1 Foundational Studies on Botanical Repellents

Sukumar et al. (1991) conducted one of the earliest systematic reviews of botanical derivatives in mosquito control, cataloguing phytochemicals responsible for insecticidal and repellent activity and emphasising their biodegradability as a public health advantage. Dua et al. (1996) subsequently quantified the repellent performance of several essential oils against important mosquito species, identifying citronellal and geraniol in citronella oil as principal bioactive constituents and recommending citronella-based topical formulations.

2.2 Characterisation of Key Herbal Ingredients

Ali et al. (2015) provided a comprehensive systematic review of essential oils used in personal protection, confirming that citronella, eucalyptus, peppermint, and clove oils act by masking human odour and occupying olfactory receptor sites, and concluding that herbal cream vehicles compare favourably with synthetic alternatives on safety grounds.

Govindarajan (2013) evaluated plant extracts against dengue vectors, reporting that neem and citronella oils delivered appreciable protection with negligible dermal toxicity, and advocating their incorporation into prophylactic cream formulations. Isman (2006) reviewed the regulatory and ecotoxicological landscape for botanical insecticides, noting their lower mammalian hazard profiles and natural environmental degradation relative to synthetic compounds.

Essential oils from eucalyptus (Eucalyptus globulus), lemongrass (Cymbopogon citratus), and tulsi (Ocimum tenuiflorum) were examined by Das et al. (2003), who confirmed the technical viability of using these oils in cream formulations and demonstrated multi-hour repellant effectiveness. According to Kokate et al. (2009), the main bioactive compounds that contribute to the repellent effectiveness of herbal remedies are azadirachtin in neem, citronellal in citronella, eugenol in tulsi, and menthol in peppermint.

2.3 Formulation and Evaluation Studies

Patel et al. (2012) prepared and characterised a herbal mosquito repellent cream based on neem and citronella oils, evaluating appearance, pH, spreadability, viscosity, washability, and repellency. The cream demonstrated acceptable homogeneity, a pH within the dermatologically appropriate range, and protection against mosquito bites for three to four hours, with no skin irritation recorded. Rani et al. (2014) extended this approach by formulating a polyherbal cream combining neem, citronella, and tulsi extracts; the synergistic combination prolonged protection duration compared with single-oil formulations and retained satisfactory physicochemical stability. Singh et al. (2016) incorporated aloe vera gel alongside citronella oil to counteract the desiccating tendency of essential oils, achieving

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improved spreadability and user cosmetic acceptability. Verma et al. (2017) reported strong repellency and pleasant fragrance from a cream combining eucalyptus and clove oils, with good consumer acceptability.

2.4 Stability and Safety Assessments

Sharma et al. (2010) emphasised the diagnostic value of pH, viscosity, spreadability, stability, and irritancy parameters in determining the pharmaceutical quality of topical herbal preparations, highlighting that stable emulsions improve both patient compliance and therapeutic outcome. Joshi et al. (2018) subjected herbal repellent creams to accelerated and long-term stability protocols, reporting the absence of phase separation, microbial growth, and significant organoleptic change when appropriate emulsifying agents and preservatives were selected. Kumar et al. (2020) validated repellent efficacy through cage bioassays and human volunteer studies, confirming several hours of sustained protection and endorsing herbal creams for regular personal use.

III. AIM AND OBJECTIVES

The primary aim of the study was to design and evaluate a herbal mosquito repellent cream using natural ingredients as a safe and eco-friendly alternative to synthetic repellents.

Specific objectives were:

• To prepare a herbal cream formulation incorporating citronella oil and neem oil as the primary repellent actives.
• To characterise the cream for physical appearance, pH, homogeneity, spreadability, washability, and irritancy.
• To investigate the physicochemical stability of the formulation under different storage conditions.
• To assess mosquito repellent efficacy of the prepared cream.
• To develop a safe, effective, and environmentally sustainable alternative to commercial synthetic repellents.

IV. PLANT PROFILES OF ACTIVE INGREDIENTS

4.1 Citronella (Cymbopogon nardus)

Parameter	Details
Biological Name	Cymbopogon nardus
Family	Poaceae
Part Used	Leaves (steam-distilled to obtain essential oil)
Active Constituents	Citronellal (25–45%), Geraniol (15–30%), Citronellol (10–20%)
Primary Use	Mosquito repellent; EPA-registered biopesticide

The aerial parts of Cymbopogon nardus are steam-distilled to produce citronella oil. Its volatile terpenoid components, namely geraniol and citronellal, interfere with mosquitoes' olfactory host-detection system, decreasing host-seeking behavior. The oil has been shown to offer protection against Aedes and Culex species for one to three hours, depending on formulation concentration and ambient conditions, and the US ambient Protection Agency has approved it as a biopesticide.

4.2 Neem (Azadirachta indica)

Parameter	Details
Biological Name	Azadirachta indica
Family	Meliaceae
Part Used	Seeds (cold-pressed to yield fixed oil)
Active Constituents	Azadirachtin, Nimbin, Nimbidin, Salannin
Primary Use	Insect growth regulator, repellent, antimicrobial, anti-inflammatory

Azadirachtin is the main bioinsecticidal component of neem oil that is derived from Azadirachta indica seeds. In addition to having direct repellant and feeding-deterrent effects, azadirachtin interferes with insect moulting and metamorphosis. Nimbin, nimbidin, and salannin are further limonoids that add to the oil's insecticidal properties.

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Additionally, neem oil has strong antibacterial, wound-healing, and anti-inflammatory qualities, making it a versatile component ideal for topical medication formulation.

V. MATERIALS AND METHODS

5.1 Formulation Composition

S.No.	Ingredient	Quantity (per 30 g batch)	Functional Role
1	Citronella Oil	1.5 g	Mosquito repellent (primary active)
2	Neem Oil	1.9 g	Repellent & antimicrobial (secondary active)
3	Stearic Acid	8.0 g	Emulsifying and thickening agent
4	Beeswax	17.0 g	Structural thickener; improves consistency
5	Glycerine	1.5 g	Humectant; skin softening
6	Purified Water	q.s.	Aqueous vehicle; continuous phase

5.2 Preparation Procedure

The oil phase was assembled by heating beeswax and stearic acid together in a glass beaker on a thermostatically controlled water bath until complete liquefaction was achieved. Citronella oil and neem oil were incorporated into this molten mixture with continuous mechanical stirring to yield a homogeneous lipid phase. The aqueous phase was prepared separately by heating purified water to approximately the same temperature and dissolving glycerine under constant agitation. The aqueous phase was then added dropwise to the oil phase with uninterrupted stirring. Stirring was maintained throughout the cooling phase until a smooth, semisolid cream of uniform consistency was obtained. The finished cream was transferred to clean, airtight amber-coloured containers and stored at room temperature pending evaluation.

5.3 Evaluation Parameters

The prepared formulation was assessed across the following parameters:

Physical Appearance: The cream was visually inspected under ambient lighting for colour uniformity, odour character, texture, and freedom from phase separation or particulate contamination.

pH Determination: One gram of cream was dispersed in 10 mL of purified water. pH was measured using a calibrated digital pH meter and recorded after thermal equilibration.

Homogeneity: The cream was examined by spreading a thin film between two glass plates to detect the presence of lumps, coarse particles, or discontinuities in the emulsion structure.

Spreadability: A known quantity of cream was placed between two horizontal glass slides and subject to a defined gravitational load for a specified interval. The diameter of the resulting cream film served as the metric for spreadability.

Washability: The formulation was applied to a skin area and removed with running tap water; the ease of removal and absence of excessive oily residue were documented.

Irritancy: A small quantity of cream was applied to a marked area of forearm skin on healthy adult volunteers and observed over a 24-hour period for erythema, oedema, pruritus, or other cutaneous reactions.

5.4 Discussion

The cream's light yellow color is not a sign of formulation instability; rather, it is a predictable result of the chromophores found naturally in neem and citronella oils. The smooth, uniform texture and lack of noticeable phase separation attest to the stearic acid–beeswax system's sufficient emulsification. The measured pH of 6.5 is within the range of 5.5 to 7.0 that is advised for topical medicines in order to guarantee compatibility with the slightly acidic surface mantle of healthy skin; deviations from this range increase the risk of inflammatory reactions and compromised barrier function.

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For repellent lotions, appropriate spreadability is essential since insufficient spreading prevents even coverage of exposed skin, leaving gaps in personal protection. The spreadability parameters of the formulation indicate that the ratio of beeswax to stearic acid produced a viscosity suitable for easy application without undue thinning or drag. From the standpoint of the user, easy washability is a practical benefit that improves compliance and stops residue accumulation.

The formulation's dermal safety is supported by the lack of unfavorable cutaneous reactions throughout the 24-hour irritancy assessment. The low amounts of essential oils used—sufficient for repellent efficacy but below the reported irritation limits for citronella and neem oils—may have contributed to this positive result. The glycerine component probably lessens the desiccant effects that essential oil-based topical treatments occasionally have.

The emulsion's physical integrity under various storage settings was verified by stability testing, which showed no phase separation, color change, or loss of odor. This result illustrates how stearic acid contributes to interfacial film strength and beeswax has a structural role in stabilizing the oil phase against coalescence. The dual volatile-release profile of neem and citronella oils is mechanistically responsible for the mosquito repellent effect that lasts for three to four hours. The carbon dioxide, lactic acid, and heat cues that direct mosquitoes to human hosts are concealed by citronellal and geraniol from citronella oil. Neem oil's azadirachtin enhances this action by directly interfering with smell receptors and discouraging feeding. The complementary mechanisms of these two oils suggest a degree of synergism that may account for the duration of protection exceeding that typically reported for single-oil citronella formulations.

VI. SUMMARY AND CONCLUSION

A Citronella oil, neem oil, beeswax, stearic acid, glycerine, and filtered water were used to successfully create a herbal insect repellent lotion. A thorough assessment revealed an acceptable physical appearance, a pH of 6.5 that is suitable for dermatology, uniform consistency, adequate spreadability and washability, no skin irritation, and physicochemical stability under various storage circumstances. Due to the synergistic activity of azadirachtin from neem oil and citronellal and geraniol from citronella oil, the mixture effectively repelled mosquitoes for around three to four hours.

The study demonstrates that it is theoretically possible to make a plant-based repellent cream that meets pharmaceutical quality standards and has significant protective efficacy without the drawbacks of synthetic chemicals like DEET. For personal protection against mosquito bites and the diseases they spread, the formulation offers a stable, safe, affordable, and environmentally friendly solution. Long-term clinical irritancy and sensitization tests in various population subgroups, quantitative structure–activity connections for the volatile actives, and comparative field experiments against commercial repellent benchmarks should all be part of future research.

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