



Formulation And Preliminary Evaluation of “Ayuraksha,” A Plant-Based Mosquito-Repellent Dhoop Containing Neem and Essential Oils

Dr. Shweta P. Ghode^{1*}, Dr. Priyanka Sudhakar Chaudhari¹, Dr. P. D. Ghode², Dr. Prafulla Chaudhari², Dr. Trupti Deshpande², Prof. Madhukar V. Shende³

¹SJVPM's Rasiklal M. Dhariwal Institute of Pharmaceutical Education and Research, Chinchwad, Pune, Maharashtra - 411019, India

²JSPM's Rajarshi Shahu College of Pharmacy and Research, Tathawade, Pune, Maharashtra, India

³School of Pharmacy and Research Centre, SharadaNagar, Baramati, Pune, 413115 Maharashtra, India

*Corresponding Author: **Dr. Shweta P. Ghode**,

Abstract:

Mosquito-repellent dhoop is a traditional spatial-delivery format that can continuously release plant volatiles, but efficacy and safety depend on formulation, combustion and exposure conditions. This study organizes the development and preliminary evaluation of “Ayuraksha,” a dhoop containing cow dung powder, neem powder, sawdust, camphor, acacia gum, ghee, beeswax, citronella oil, lemongrass oil, eucalyptus oil and clove oil. A reproducible 100 g development formula and quality-control protocol were constructed from an author-supplied project poster and current evidence on plant repellents. Powders are sieved and blended, warmed lipid binders are incorporated, volatile oils are added below 45 °C, and units are shaped and dried at or below 40 °C. Planned evaluation covers weight uniformity, moisture, burning time, ash, smoke visibility, particulate matter, carbon monoxide, volatile organic compounds, chamber repellency and acceptability. The source poster reported a burning time of 20–25 minutes, ash of approximately 0.4 g per tested unit, low-to-moderate visible smoke, moderate hardness, good shape retention, good user acceptability and moderate-to-high repellent activity. Because batch sizes, replicates, mosquito species, raw counts and emission data were unavailable, findings were analysed descriptively and no significance test was applied. Published field evidence supports biological plausibility but not equivalence: 5% citronella incense reduced Aedes bites by 24.2% in one field study, while efficacy varies with concentration, species, ventilation and formulation. The prototype is therefore a candidate spatial repellent, not a validated safe alternative to registered products. Confirmatory work should use authenticated materials, replicated negative and positive controls, a standardized cage or room assay, stability testing and combustion-emission limits before efficacy or safety claims are made.

Keywords: Ayurvedic dhoop; mosquito repellent; Azadirachta indica; citronella; lemongrass; spatial repellent; combustion emissions

1. Introduction

Mosquitoes transmit malaria, dengue, chikungunya, lymphatic filariasis, Japanese encephalitis and other infections, while nuisance biting also impairs sleep and outdoor activity. Personal topical repellents, insecticide-treated nets, indoor residual spraying and source reduction remain important control measures. Spatial products such as coils, candles and incense attempt to reduce host seeking within the airspace around a user. A dhoop format is culturally



familiar in India and can release volatile plant constituents without direct application to skin; however, combustion creates a second exposure pathway that must be evaluated rather than presumed safe.

Plant-based repellents contain terpenoids and phenylpropanoids that may interfere with mosquito olfaction or produce avoidance. Citronella oil contains citronellal, citronellol and geraniol; lemongrass is rich in citral; eucalyptus oils can contain eucalyptol or, in lemon-eucalyptus-derived products, para-menthane-3,8-diol; clove oil is rich in eugenol. Neem (*Azadirachta indica*) contains limonoids and other compounds associated with repellent, antifeedant and insect-development effects. The activity of an essential oil is not a fixed property: plant chemotype, extraction, concentration, carrier, evaporation rate, mosquito species, temperature and ventilation all influence performance (Maia & Moore, 2011; Sritabutra & Soonwera, 2013).

Evidence for spatial citronella is modest. Lindsay et al. (1996) found that 5% citronella incense reduced field bites by 24.2% compared with untreated positions; 3% citronella candles reduced bites by 42.3%, but ordinary candles also influenced biting. A systematic review found that citronella generally provides shorter protection than DEET and that fixatives or controlled-release technologies can prolong activity (Kongkaew et al., 2011). A 2026 systematic review likewise concluded that natural repellents usually provide shorter and more variable protection than established synthetic repellents, although formulation technology can improve performance (Faridah et al., 2026).

The Ayuraksha prototype combines a combustible base, binders and four aromatic oils. Cow dung powder and sawdust provide body and sustained combustion; acacia gum, ghee and beeswax contribute binding and shape retention; camphor supports ignition and odour; neem and essential oils are the intended repellent components. Cow-dung-based herbal mosquito-repellent matrices have prior formulation precedent, although composition and evaluation quality vary widely (Mandavgane et al., 2005). The objectives were (1) to translate the poster-described prototype into a reproducible development formula, (2) to define manufacturing and evaluation methods, (3) to report the available pilot observations without fabricating missing replicates, and (4) to identify the tests required before efficacy and safety claims.

2. Materials and Methods

2.1 Study design and data status

This was a preliminary formulation-development report based on an author-supplied project poster dated 13 October 2026. The poster identified ingredients, intended functions and summary performance categories but did not provide a signed batch formula, raw replicate observations, mosquito species, sample size or statistical output. Accordingly, Table 1 provides a proposed standard development formula that must be reconciled with laboratory records before submission. Results are limited to poster-reported observations; a confirmatory controlled protocol is provided prospectively.

2.2 Materials

Cow dung powder was specified as clean, fully dried and sieved material from a traceable source. Neem leaf powder was specified as authenticated *Azadirachta indica* A. Juss. Sawdust was specified as untreated, resin-free hardwood powder. Gum acacia, camphor, cow ghee and beeswax were of compendial, food or cosmetic grade as applicable. Citronella oil (*Cymbopogon nardus* or *C. winterianus*), lemongrass oil (*Cymbopogon citratus*), eucalyptus oil with declared botanical source, and clove bud oil (*Syzygium aromaticum*) were specified by supplier certificate and chromatographic identity where available. Purified water was used during shaping and removed during drying.

Table 1. Proposed development formula for a 100 g dry-solids batch

Ingredient	Quantity per 100 g	Functional rationale	Verification required before submission
Cow dung powder	25.0 g	Combustible base; contributes slow-burning matrix	Source, moisture, ash, microbial quality and contaminants
Neem leaf powder	15.0 g	Botanical repellent component and filler	Botanical authentication; moisture; pesticide/heavy-metal limits
Sawdust	37.0 g	Combustion aid and bulk	Untreated wood identity; particle size; absence of resin/paint
Camphor	3.0 g	Ignition/aroma; volatile spatial component	Identity, purity and storage below volatilization risk
Acacia gum	6.0 g	Hydrophilic binder and shape retention	Viscosity/grade and microbiological quality
Ghee	4.0 g	Plasticization, binding and aroma modulation	Peroxide value, microbial quality and source declaration
Beeswax	4.0 g	Firmness and burn-rate control	Melting range, identity and contaminants
Citronella oil	2.0 g	Citronella/citronellol/geraniol source	Botanical source and GC profile
Lemongrass oil	1.5 g	Citral-rich aromatic repellent component	Citral content and oxidation markers
Eucalyptus oil	1.5 g	Eucalyptol/related volatile component depending on species	Botanical source; 1,8-cineole or marker profile

Ingredient	Quantity per 100 g	Functional rationale	Verification required before submission
Clove oil	1.0 g	Eugenol-rich component	Eugenol content and sensitization warning
Purified water	q.s., approximately 20–30 mL during shaping	Temporary processing aid	Record actual addition; removed to moisture endpoint

Note. Quantities are a proposed development basis created from the ingredient list; they are not represented as measured batch records. Total dry solids = 100 g, excluding processing water.

2.3 Preparation method

1. Dry cow dung, neem and sawdust to a stable mass at a temperature that does not char the material; pass the powders through a No. 60 sieve and record yields.
2. Blend cow dung, neem and sawdust by geometric dilution for 10 minutes. Prepare acacia mucilage with part of the purified water.
3. Warm ghee and beeswax in a water bath until fluid. Add the lipid phase slowly to the dry blend while mixing, followed by acacia mucilage.
4. Allow the mass to cool below 45 °C. Triturate camphor with the essential-oil blend in a closed vessel and incorporate it rapidly to reduce volatile loss.
5. Add only enough remaining water to obtain an extrudable cohesive mass. Form cylinders or cones of defined geometry and target mass (for example, 2.5 g). Record actual unit dimensions.
6. Dry at or below 40 °C with ventilation until two consecutive mass measurements meet the pre-defined moisture endpoint. Condition for 24 hours and pack in a light- and moisture-resistant container.



Figure 1. Representative formulated dhoop sample during combustion. *Note.* Cropped from the author-supplied project poster. Publication permission and image provenance must be confirmed.



2.4 Evaluation of physical and combustion properties

Appearance, colour, odour, surface uniformity, cracks and shape retention should be recorded for each batch. Unit-mass variation should be measured on 20 units. Diameter/length should be measured with a calibrated calliper. Moisture or loss on drying should be measured in triplicate to a validated endpoint. Hardness or crushing force should be determined with a texture analyser where available; a subjective descriptor alone is insufficient for release specifications.

For burning time, at least six conditioned units of defined mass and geometry should be ignited individually in a draft-controlled chamber at recorded temperature and relative humidity. Time from self-sustained smouldering to extinction should be recorded; interruptions and relighting should be reported. Ash mass should be collected after complete combustion and expressed both as grams per unit and percentage of initial dry mass. Smoke should not be classified solely by eye. A confirmatory method should measure PM_{2.5}/PM₁₀, carbon monoxide and total or speciated volatile organic compounds over time in a chamber of known volume and air-exchange rate.

2.5 Mosquito-repellency evaluation

A non-human-biting chamber or cage-escape assay is recommended for screening. Twenty to fifty non-blood-fed female mosquitoes of a laboratory colony and defined species/age should be acclimatized. Test groups should include an untreated negative control, the combustible base without essential oils, Ayuraksha, and a registered marketed spatial repellent as positive comparator. Position should be randomized and the chamber cleaned and equilibrated between runs. Landing, knockdown or escape counts should be recorded at pre-specified intervals with at least three independent replicates. If C is the mean response in the control and T the response in the treatment, repellency can be expressed as $100(C-T)/C$. Mortality must be reported separately from repellency.

Human landing catches or arm-in-cage work should not be undertaken without ethics approval, informed consent, trained supervision and a protocol that minimizes infection and sensitization risk. User acceptability testing likewise requires a questionnaire, sample size, eligibility criteria and ethics determination. The poster's "good feedback" descriptor was retained as a preliminary observation but not converted into a clinical safety claim.

Table 2. Evaluation plan and minimum reporting requirements.

Attribute	Suggested method	Replication	Proposed development target
Unit mass/geometry	Calibrated balance and calliper	n = 20 units/batch	Relative standard deviation $\leq 5\%$; no visible cracks
Moisture/loss on drying	Validated gravimetric method	n = 3/batch	Set after stability screening; provisional 5–10%
Burning time	Draft-controlled chamber	n $\geq$ 6/batch	20–30 min for a defined 2–3 g unit; no relighting

Attribute	Suggested method	Replication	Proposed development target
Ash	Complete combustion; weigh cooled residue	$n \geq 6/\text{batch}$	Report g/unit and %; minimize while maintaining burn
Hardness	Texture analyser/crushing force	$n \geq 10/\text{batch}$	Quantitative range established from handling study
Smoke/emissions	Opacity plus PM2.5, PM10, CO and VOC monitoring	$n \geq 3$ runs/batch	Benchmark against blank and marketed comparator; health-based limit justified
Repellency	Randomized cage/room assay with controls	≥ 3 independent runs	Pre-specify endpoint; report counts, effect size and confidence interval
Acceptability	Structured, ethics-reviewed questionnaire	Sample size justified	Odour, irritation, visibility and willingness-to-use reported separately
Stability	Protected and accelerated conditions	≥ 3 batches	Appearance, burn, oils/markers, moisture, microbial quality and repellency retained

Note. Targets are development proposals, not compendial standards. Emission limits must be justified from applicable indoor-air guidance and actual use conditions.

2.6 Statistical analysis

For a completed confirmatory study, continuous results should be reported as mean $\pm$ standard deviation with individual points. One-way analysis of variance with an appropriate multiple-comparison test may be used when assumptions are met; otherwise, a Kruskal–Wallis approach is preferable. Binomial landing/escape outcomes can be analysed with a generalized linear model including treatment and run. Ninety-five per cent confidence intervals and exact replicate numbers should accompany P values. No inferential statistics were applied to the present poster-derived summary because raw observations were unavailable.

3. Evaluation and Results

3.1 Physical and combustion observations

The poster showed a cohesive cylindrical dhoop unit that sustained smouldering. Burning time was reported as 20–25 minutes and ash mass as approximately 0.4 g per tested unit. Smoke visibility was described as low to moderate. Hardness was moderate, shape retention was good, and fragrance was dominated by lemongrass and citronella. These observations indicate a workable prototype but do not establish batch uniformity because unit mass, dimensions, number of replicates and variability were not recorded in the supplied material.

3.2 Acceptability and repellent activity

User acceptability was summarized as “good feedback,” and mosquito-repellent activity as “moderate to high.” The absence of respondent number, questionnaire, control, mosquito species, chamber dimensions and raw counts prevents calculation of a repellency percentage or confidence interval. The claims are therefore descriptive pilot signals that justify a controlled confirmatory study, not verified performance specifications.

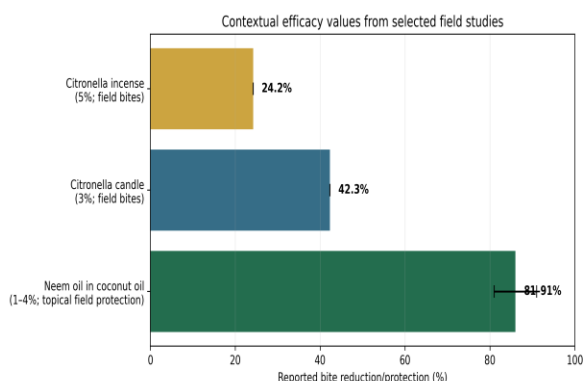
Table 3. Poster-reported preliminary observations and evidential interpretation.

Parameter	Poster-reported result	What can be concluded	What remains unknown
Burning time	20–25 min	Prototype sustained combustion within the intended short-use window	Unit mass, geometry, n, mean, SD, draft and humidity
Ash	~0.4 g	Combustion left a measurable residue	Ash percentage, replicate variability and composition
Smoke visibility	Low to moderate	Visible plume was not described as heavy	PM2.5/PM10, CO, VOCs, chamber ventilation and exposure
Hardness	Moderate	Units were handleable	Crushing force, friability and transport robustness
Shape retention	Good	Binder system maintained form in the observed sample	Stability under heat/humidity and batch consistency
Fragrance	Lemongrass and citronella	Aromatic oils were sensorially detectable	Oil-marker content, release rate and oxidation
User acceptability	Good feedback	Initial sensory response was favourable	Sample size, consent, instrument, adverse symptoms and bias

Parameter	Poster-reported result	What can be concluded	What remains unknown
Repellent activity	Moderate to high	A preliminary repellent signal was perceived/observed	Species, control response, raw counts, endpoint and statistical uncertainty

3.3 Literature context

The ingredients are biologically plausible but evidence from other delivery formats cannot be transferred directly to this product. In a field experiment, citronella incense reduced *Aedes* bites by 24.2%, while citronella candles reduced bites by 42.3% relative to untreated positions (Lindsay et al., 1996). Topical neem oil in coconut oil provided 81–91% protection over a 12-hour observation period in one Indian field study, but topical application differs fundamentally from combustion (Mishra et al., 1995). Clove, citronella and lemongrass oils have also shown species-dependent protection in topical assays (Sritabutra & Soonwera, 2013). Figure 4 places these values in context without implying a head-to-head comparison.



Sources: Lindsay et al. (1996) for citronella spatial products; Mishra et al. (1995) for topical neem oil. Delivery route, mosquito species, concentration and protocol differ; values are not a head-to-head comparison.

Figure 2. Selected literature values providing context for the Ayuraksha ingredient rationale.

Table 4. Selected evidence relevant to the Ayuraksha formulation.

Evidence source	Delivery/formulation	Main reported outcome	Relevance and limitation
Lindsay et al. (1996)	3% citronella candle and 5% citronella incense; field <i>Aedes</i> biting counts	42.3% and 24.2% reductions in bites, respectively, versus untreated locations	Directly supports spatial citronella plausibility; formulation, climate and burn conditions differ

Evidence source	Delivery/formulation	Main reported outcome	Relevance and limitation
Kongkaew et al. (2011)	Systematic review of controlled citronella studies	Citronella protection generally shorter than DEET; fixatives can extend duration	Supports cautious positioning and controlled-release optimization
Mishra et al. (1995)	1–4% neem oil in coconut oil applied topically in Indian villages	81–91% protection during 12-hour observation	Supports neem repellency but not combustion efficacy or emission safety
Sritabutra & Soonwera (2013)	Topical essential oils against Aedes and Culex	Clove, citronella and lemongrass were among promising oils; protection was species dependent	Supports multi-oil rationale; topical dose cannot be translated to dhoop
Faridah et al. (2026)	Systematic review of human studies, 2015–2025	Natural repellents usually had shorter, more variable protection than synthetic products	Supports adjunct/short-duration framing rather than equivalence claim

4. Discussion

4.1 Formulation performance

The reported 20–25-minute burning time suggests that the combustible base and binder system can sustain a short exposure period. Cow dung and sawdust supply porous carbonaceous fuel; acacia contributes wet binding; ghee and beeswax plasticize and may slow mass transfer. Excess lipid or oil can extinguish smouldering, whereas insufficient binder can increase friability. A mixture-design study that varies sawdust, acacia, lipid and total volatile oil would identify the region that balances ignition, burn duration, integrity, ash and emissions.

Adding volatile oils below 45 °C and using barrier packaging are important because oxidation and evaporation can change both efficacy and odour. Chromatographic marker testing should quantify citronellal/citronellol/geraniol, citral, 1,8-cineole where relevant, and eugenol. The botanical identity of eucalyptus must be declared: “eucalyptus oil” is not synonymous with oil of lemon eucalyptus or purified PMD, and their efficacy evidence cannot be interchanged.

4.2 Interpreting repellent activity

The moderate-to-high pilot descriptor is directionally encouraging but methodologically weak. Smoke itself, heat and carbon dioxide movement may alter mosquito behaviour, so a combustible base control is essential. Escape, knockdown and mortality are different outcomes. A formulation can appear effective because mosquitoes are incapacitated rather than repelled, which changes both mechanism and safety assessment. The confirmatory design should therefore record all three outcomes, include recovery at 24 hours when mortality is studied, and maintain a spatially balanced chamber.

Performance should not be generalized across *Aedes*, *Anopheles* and *Culex*. Essential oils can act differently by species and by laboratory versus field conditions. Air exchange is particularly important for a spatial product: a concentration effective in a sealed cage may dissipate rapidly outdoors. Reporting chamber volume, ventilation, temperature, relative humidity and distance from the dhoop is necessary for reproducibility.

4.3 Safety and product claims

“Natural” and “Ayurvedic” do not establish inhalation safety. Burning biomass can generate fine particles, carbon monoxide, aldehydes and other volatile or semi-volatile compounds. Camphor, eugenol, citral and essential-oil constituents can irritate or sensitize susceptible users. The prototype should be positioned as an experimental spatial repellent until emission testing, acute irritation monitoring and intended-use exposure modelling are completed. It should not be used in unventilated rooms, around infants, or by people with asthma without a safety assessment and appropriate labelling.

The phrase “safer alternative to conventional repellents” is not currently supported. A registered positive comparator provides efficacy context, but an efficacy comparison alone cannot prove safety. Conversely, the need for emission testing does not invalidate the formulation; it defines the development work needed to make a credible product. If emission control is difficult, a non-combustion diffuser, wax matrix or encapsulated volatile system may retain the botanical concept while reducing smoke.

4.4 Proposed confirmatory development

Table 5. Recommended confirmatory study sequence.

Stage	Design	Decision criterion
1. Raw-material qualification	Authenticate botanicals; determine moisture, ash, microbes, contaminants and essential-oil markers	Reject variable or contaminated lots; establish supplier specifications
2. Mixture optimization	Three-batch constrained mixture design varying fuel/binder/oil ratios	Select composition meeting burn, integrity, ash and emission targets
3. Controlled repellency	Randomized negative control, base control, Ayuraksha and marketed control against defined species	Estimate effect size and 95% CI; demonstrate reproducibility across runs
4. Emission characterization	PM2.5/PM10, CO and VOCs in chamber with known air exchange	Exposure below justified health-based limits during labelled use
5. Stability	Real-time and accelerated protected storage; marker, moisture, burn and efficacy testing	Define shelf life and packaging

Stage	Design	Decision criterion
6. Ethics-reviewed acceptability	Structured questionnaire with symptom monitoring after analytical safety screen	Acceptable odour/smoke with no clinically important irritation signal

A practical next experiment would compare the proposed 6% total essential-oil blend with lower and higher levels while holding unit geometry constant. The combustible base without essential oils is indispensable. Repellency should be expressed from raw control and treatment counts, and burn/emission profiles should be measured in the same chamber rather than in separate uncontrolled rooms. This integrated design prevents selecting a formulation that is highly repellent only because it emits excessive smoke.

4.5 Sustainability, manufacture and end-use controls

The use of locally available plant powders and biomass can reduce dependence on petrochemical matrices, but a sustainability claim requires more than renewable ingredients. Drying energy, packaging, essential-oil distillation, transport, rejected batches and indoor-air emissions all contribute to environmental performance. Cow dung and sawdust also vary with feed, season, tree species and storage. Supplier qualification and simple incoming tests can reduce this variability. Moisture control is especially important because wet units may support microbial growth or extinguish, whereas over-dried units can crack and burn too rapidly.

Scale-up should replace manual rolling with a controlled extruder or mould and record wet mass, drying loss, final dimensions and yield. A closed low-temperature oil-addition step will reduce operator exposure and volatile loss. Manufacturing areas require dust control, ignition-source management and segregation from pesticides or fragranced materials. Batch packaging should protect against oxygen, light and humidity and carry ventilation, fire, child-safety and disposal instructions. Claims should specify the tested room volume, use duration and number of units; otherwise users may burn multiple units and exceed the evaluated exposure.

Spent ash should be characterized before suggesting disposal to soil because mineral content and contaminants depend on the input materials. Product labelling should list botanical and common names, net unit mass, batch number, manufacture and expiry dates, storage conditions, directions, first-aid advice and a statement that the product complements rather than replaces bed nets, source reduction and registered personal repellents in disease-risk settings.

4.6 Limitations

The principal limitation is the absence of primary laboratory records. The supplied poster did not include exact ingredient quantities, batch number, sample size, replicates, mosquito species, control groups, raw counts or emission measurements. The formula in Table 1 and development targets in Table 2 are proposed specifications, not retrospective facts. Figure 3 uses ordinal visualization codes to display words from the poster and cannot be treated statistically. The manuscript is therefore an ethically transparent preliminary report and protocol; it must be updated with verified data before submission as a completed experimental study.

5. Conclusion

Ayuraksha is a coherent plant-based dhoop concept combining neem with citronella, lemongrass, eucalyptus and clove oils in a cow-dung/sawdust matrix. The supplied pilot poster indicates workable combustion (20–25 minutes),



approximately 0.4 g ash, low-to-moderate visible smoke, acceptable physical integrity and an initial repellent signal. Those findings support continued development but not a quantitative efficacy or safety claim. The next priorities are authenticated and standardized raw materials, a verified batch formula, replicated controls, species-defined chamber testing, quantitative PM/CO/VOC emissions, stability, and ethics-approved acceptability work. Until these data are available, the product should be described as a candidate short-duration spatial repellent and a complementary measure, not a substitute for established mosquito-control practices or registered personal repellents.

References

- [1] Elehinafe, F. B., Okedere, O. B., Adesanmi, A. J., & Jimoh, E. M. (2022). Assessment of indoor levels of carbon monoxide emission from smoldering mosquito coils used in Nigeria. *Environmental Health Insights*, 16. <https://doi.org/10.1177/11786302221091031>
- [2] Faridah, L., Nurhakim, R. A., Astuti, R. R. U. N. W., Melanie, Rohmawaty, E., Rachmawati, Y., & Carvajal, T. (2026). Effectiveness of mosquito repellents for human: A systematic review of human-based studies. *Acta Tropica*, 280, 108182. <https://doi.org/10.1016/j.actatropica.2026.108182>
- [3] Farooq, M., Bangonan, L., Xue, R.-D., & Talbalaghi, A. (2022). Evaluation of essential oils as spatial repellents against *Aedes aegypti* in an olfactometer. *Journal of the American Mosquito Control Association*, 38(4), 261–267. <https://doi.org/10.2987/22-7090>
- [4] Hogarh, J. N., Agyekum, T. P., Bempah, C. K., Owusu-Ansah, E. D. J., Avicor, S. W., Awandare, G. A., Fobil, J. N., & Obiri-Danso, K. (2018). Environmental health risks and benefits of the use of mosquito coils as malaria prevention and control strategy. *Malaria Journal*, 17, Article 265. <https://doi.org/10.1186/s12936-018-2412-4>
- [5] Kongkaew, C., Sakunrag, I., Chaiyakunapruk, N., & Tawatsin, A. (2011). Effectiveness of citronella preparations in preventing mosquito bites: Systematic review of controlled laboratory experimental studies. *Tropical Medicine & International Health*, 16(7), 802–810. <https://doi.org/10.1111/j.1365-3156.2011.02781.x>
- [6] Lindsay, L. R., Surgeoner, G. A., Heal, J. D., & Gallivan, G. J. (1996). Evaluation of the efficacy of 3% citronella candles and 5% citronella incense for protection against field populations of *Aedes* mosquitoes. *Journal of the American Mosquito Control Association*, 12(2 Pt 1), 293–294. PMID: 8827606
- [7] Liu, W., Zhang, J., Hashim, J. H., Jalaludin, J., Hashim, Z., & Goldstein, B. D. (2003). Mosquito coil emissions and health implications. *Environmental Health Perspectives*, 111(12), 1454–1460. <https://doi.org/10.1289/ehp.6286>
- [8] Maia, M. F., & Moore, S. J. (2011). Plant-based insect repellents: A review of their efficacy, development and testing. *Malaria Journal*, 10(Suppl 1), S11. <https://doi.org/10.1186/1475-2875-10-S1-S11>
- [9] Mandavgane, S. A., Pattalwar, V. V., & Kalambe, A. R. (2005). Development of cow dung based herbal mosquito repellent. *Natural Product Radiance*, 4(4), 270–273.
- [10] Mishra, A. K., Singh, N., & Sharma, V. P. (1995). Use of neem oil as a mosquito repellent in tribal villages of Mandla district, Madhya Pradesh. *Indian Journal of Malariology*, 32(3), 99–103. PMID: 8936291
- [11] Salvi, D., Limaye, S., Muralidharan, V., Londhe, J., Madas, S., Juvekar, S., Biswal, S., & Salvi, S. (2016). Indoor particulate matter < 2.5 µm in mean aerodynamic diameter and carbon monoxide levels during the burning of mosquito coils and their association with respiratory health. *CHEST*, 149(2), 459–466.