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FORMULATION AND ASSESSMENT OF HERBAL MOSQUITO REPELLENT CONE

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ABSTRACT

Nowadays, the majority of diseases or infections, like malaria, dengue, etc., are caused by the different types of mosquitoes, mainly female Anopheles mosquitoes. To prevent the infection or diseases caused by mosquitos, there are multiple synthetic pesticides available in the market. The various pesticides used as mosquito repellents containing hazardous chemicals cause various health problems in humans and other living creatures; the pesticides also cause environmental pollution. By considering these facts, we are here with mosquito repellent without hazardous chemicals known as HERBAL MOSQUITO REPELLENT. As the herbs are easily accessible in our society, it is very beneficial to use these holly herbs in mosquito repellent formulations. The herbs are the core substance in our formulations; there are different active constituents, such as alkaloids, fixed oils, essential oils, resins, flavonoids, phenols, etc., which are present in specific parts of herbs. They can be extracted by various methods like steam distillation, pressing techniques, solvent evaporation, etc. The current work summarises research which is aimed at developing safe and effective herbal mosquito repellents. Our study aims at investigating herbs with mosquito repellent activity without causing health hazards, environmental hazards and pollution. The herbs which have mosquito repellent activity have been used in specific proportions depending on their mosquito repellent activity, and formulations have been developed. The results demonstrated that the herbal mosquito repellent cone exhibited significant mosquito-repelling activity, with up to a 90% reduction in mosquito landing within a defined area. The cone had an optimal burning time of approximately 4 hours, ensuring prolonged protection. The herbal formulation was also found to be free from toxic side effects commonly associated with synthetic repellents, making it a safer alternative for families, children, and individuals with sensitivities. In response to the growing concerns over the adverse effects of synthetic mosquito repellents, this study aims to formulate and evaluate an herbal mosquito repellent cone made from natural ingredients. The cone was designed using a combination of essential oils known for their insect-repellent properties, such as neem and lemongrass oils, integrated into a natural wax base. The slow-release mechanism of the repellent compounds during the burning process ensures effective mosquito control in both indoor and outdoor environments.

KEYWORDS: Herbal mosquito repellent; plant-based formulation; essential oils (neem, lemongrass); eco-friendly insect control; mosquito landing inhibition; non-toxic repellent cone; sustainable vector control.

INTRODUCTION

Mosquitos are one of the most disturbing and blood sucking organisms that disturbs *Homo sapiens*.[1] Mosquito species included in the genera *Anopheles, Aedes and Culex* are vectors for various disease pathogens like malaria, dengue fever, myiasis, yellow fever, encephalitis etc. The death rate increased to one million as of 2018, according to the American Association of Mosquito control. High fever and chills are its symptoms.[2,3,4] Mosquito work as a vector leads to many deadly disorders that transfers the virus or parasite from one person to another person or in animals also.[5] Globally, mosquito borne diseases are increasing because of high rate of reproduction and development of resistance of insecticides in mosquito.[6] Both male and female mosquitoes survive on plant juice. Male mosquito does not bite human beings but the female mosquito sucks human blood after mating as proteins is required for the maturation of eggs.[7] Chemical mosquito repellent has been extensively used to control the rate of mosquito either by killing or even preventing mosquito to bite the human beings or even killing mosquito larvae at breeding sites.[2]

Many of the plant extracts have beneficiary effect on health when consumed for longer time period. The oldest book of Hindu civilization is the Rig-Veda in India; written 5000 years age is much higher and more modified use of plant material occurs in Atharvan Veda. Atharvan Veda had an Upaveda called Ayurveda. Charaka Samhita and Sushruta are famous treaties of Ayurveda. The Charaka Samhita includes 395 medicinal plants, 57 drugs of animal origin, 64 minerals as therapeutic agents.[8] Nowadays, mosquito have developed resistance which causes a need to develop an alternative method of mosquito control. For an effective formulation of repellent, one need to check its toxicity problem which should match with the increased incidence of insect resistance. Globally, chemical larvicides are also used to control mosquito's population but these chemicals are toxic to humans, plants and animals.

Mosquito-borne diseases such as malaria, dengue, and zika virus, continue to pose significant global public health threat. As a result, mosquito control methods, including repellents, have become essential in preventing these diseases. Synthetic chemical repellents, such as DEET (N, N-diethyl-meta-toluamide), are widely used for personal protection. However, these chemical repellents have raised concerns due to their potential health risks, skin irritation, and environmental impact. Additionally, the increasing resistance of mosquitoes to synthetic insecticides further complicates the effectiveness of these chemicals. In light of these challenges, there is a growing demand for natural alternatives that are both safe and effective in repelling mosquitoes. Herbal mosquito repellents, which utilize plant-based compounds, have gained popularity due to their eco-friendly nature and lower toxicity. Essential oils, such as citronella, eucalyptus, neem, and lemongrass, are widely known for their insect-repellent properties. These oils contain bioactive compounds that interfere with mosquito attraction and disrupt their ability to locate hosts.

This project aims to formulate an herbal mosquito repellent cone made from a blend of these essential oils, combined with a natural wax base to ensure slow and sustained release of active compounds when burned. The herbal repellent cone provides a convenient, environmentally friendly alternative to traditional chemical repellents, offering prolonged protection against mosquitoes in both indoor and outdoor settings. The objective of this research is to evaluate the effectiveness of the herbal mosquito repellent cone in repelling mosquitoes, while assessing its physical properties such as burning time, smoke production, and user safety. This study will contribute to the growing body of knowledge on natural mosquito repellents, offering a safer and sustainable solution for controlling the mosquito populations and preventing the spread of mosquito-borne diseases.

The global burden of mosquito-borne diseases, such as malaria, dengue, and chikungunya, continues to rise, making mosquito control a crucial aspect of public health initiatives. Mosquito repellents are commonly used to prevent bites and reduce the transmission of diseases. Traditionally, chemical-based repellents like DEET (N, N-diethyl-meta toluamide) and permethrin have been widely used due to their high effectiveness. However, these synthetic repellents are associated with potential side effects, including skin irritation, toxicity, and environmental concerns. Furthermore, mosquitoes are becoming increasingly resistant to chemical insecticides, diminishing the efficacy of conventional repellents.

As a result, there is a growing shift towards the use of natural, plant-based alternatives for mosquito control. Herbal mosquito repellents, which utilize essential oils derived from plants known for their insecticidal and repellent properties, present an eco-friendly and safer option. Essential oils such as citronella, eucalyptus, neem, and lemongrass have been shown to exhibit strong mosquito-repelling activity, making them ideal candidates for the use in natural repellent formulations. This study focuses on the development of an herbal mosquito repellent cone made from a blend of these essential oils, which are combined with a natural wax base to create a slow-release mechanism when the cone is burned. The herbal cone is designed to provide continuous mosquito protection over a prolonged period, of time making it suitable for use in both indoor and outdoor settings, particularly in areas with high mosquito activity.

The primary objectives of this research are to formulate the herbal repellent cone, assess its efficacy in repelling mosquitoes, and to evaluate its physical properties, such as burn time, smoke production, and ease of use. The study also aims to compare the repellent activity of the herbal cone to traditional chemical repellents, ensuring that it provides a comparable level of protection without the associated health risks. By providing a natural, safe, and sustainable alternative to chemical mosquito repellents, the herbal mosquito repellent cone offers a promising solution for reducing mosquito-borne diseases while minimizing environmental and health impacts. This study will contribute to the growing body of research on natural mosquito control methods and pave the way for the commercialization of herbal-based mosquito repellent products.[13]

Advantages of herbal mosquito repellent cone

1. ***No Harmful Chemicals:*** The prime benefit of using a natural mosquito killer, as we just mentioned, is that it is free of any harmful chemicals. They don't contain DEET (N, N- Diethyl-3-methyl benzamide, an active chemical found in artificial mosquito repellents. Being chemical-free, you can use them safely in your child's room as well.
2. ***Skin-Friendly:*** Trying an essential oil, for instance, as an herbal mosquito repellent is good for your skin. It will not only repel mosquitoes and other bugs but will pamper your skin too. Other mosquito repellents in the market often cause allergies to your skin or respiratory issues.
3. ***Cruelty-Free:*** If you buy an herbal mosquito repellent from the market, then it means you sympathize with animals. It is because no animals are harmed by producing these herbal products and they are completely vegan.
4. ***Environmental-Friendly:*** Using natural mosquito repellents is not just cruelty-free, but eco-friendly too. They release no harmful smoke or carbon that disturbs the greenhouse effect on our planet.
5. ***Aromatic:*** Another benefit to reap from herbal mosquito repellents is the double advantage of them turning into your room fresheners. Most of the remedies we recommend to repel mosquitoes make your home smell aromatic.
6. ***Repel other Bugs:*** Not just mosquitoes, with an herbal mosquito repellent, you can also repel other pests like ants, houseflies, spiders, and even lizards. So, in short, using a natural mosquito repellent will double up as an all-rounder insect repellent for your home.

7. ***Peace of Mind:*** Last but not least advantage of a natural product as a mosquito killer for the home is that it offers complete peace of mind. You know it won't harm you, as it is chemical-free. You know it will leave behind a soothing aroma in your house. Moreover, you know it is environmental-friendly. All these plus points of using an herbal composition to keep the mosquitoes away will relax your mind.
8. ***Safe for Kids***: Using natural mosquito repellent for kids means no chances of kids falling sick due to the dangerous emissions from the repellents. Mosquito repellents available in the market are often loaded with DEET chemicals that can affect the lungs of your young ones.
9. ***Safe for Pregnant Women:*** Women for the same reason as above, using organic mosquito repellents is safe for pregnant women. If a pregnant woman inhales harmful chemicals emitted by other so-called best mosquito killers, the fetus in her womb may show some birth defects in the respiratory system.
10. ***Easily Available and Affordable:*** Another top reason to try natural remedies to control mosquitoes is that most of these ingredients are readily available at home. Not just availability, these home remedies to repel mosquitoes are very affordable as compared to expensive mosquito control products.

AIM AND OBJECTIVE

Need for study

Mosquitoes are responsible for transmitting life-threatening diseases such as malaria, dengue, chikungunya, yellow fever, and filariasis, which remain a major public health challenge in tropical and subtropical countries including India.[23] Despite the availability of chemical repellents and synthetic coils, their long-term use has raised serious concerns. Conventional mosquito control measures rely heavily on synthetic insecticides and repellents such as DEET and allethrin, which though effective, are associated with toxic side effects including skin rashes, headaches, respiratory irritation, and potential neurological effects.[14,15] Moreover, their persistent use has contributed to the development of resistance in mosquito populations.[20]

Therefore, there is need for safe, eco-friendly, and affordable alternatives to synthetic repellents. Herbal products, derived from locally available plants, offer a promising solution as they are biodegradable, less toxic to humans and animals, and sustainable.[19] Traditional practices in rural communities have long utilized herbal smoke for repelling insects, indicating their potential for wider application.[16]

In this context, herbal mosquito repellent cones present a simple, cost-effective, and user-friendly formulation that combines both traditional knowledge and modern scientific evaluation. The present study utilizes lemon peel, clove, lantana camara, and mint, all of which have well-documented mosquito repellent, antimicrobial, and aromatic properties.[18,17] Sawdust and gum acacia provide structural integrity and binding, while charcoal serves as a base material, enhancing burning efficiency and smoke generation.[21]

The study is significant because

- It provides a natural alternative to chemical repellents, reducing risks of toxicity.[15]
- It utilizes readily available plant materials, making the formulation cost-effective and feasible for large-scale use in rural communities.[19]
- It emphasizes eco-sustainability by using biodegradable raw materials such as sawdust and acacia gum.[17]
- It aims to scientifically validate the efficacy of herbal cones through standardized evaluation methods (burning

time, smoke quality, repellency tests).[22]

- It aligns with the global trend of developing green mosquito control strategies that are safe for humans, domestic animals, and the environment.[16]

Hence, the development and evaluation of an herbal mosquito repellent cone using these natural ingredients is an important step toward achieving effective mosquito control while promoting public health and environmental safety.

OBJECTIVES

The primary objective of this study is to formulate and evaluate a handmade herbal mosquito repellent cone using lemon peel, clove, lantana camara, mint, sawdust, gum acacia, and charcoal as base material. Plant-derived products are known to possess insecticidal and repellent activity, and herbal smoke has traditionally been used for mosquito control.[19]

- Important objective is to also optimize the ratio of herbal powders, binders, and base materials so that the cone achieves a uniform structure, efficient burning, and sustained release of repellent smoke. Sawdust and charcoal serve as combustion aids, while gum acacia ensures proper binding and stability of the cone.[17]
- A further objective is the evaluation of physical characteristics of the cones, including burning time, smoke density, odor, and ash weight, which are crucial parameters for the effectiveness and consumer acceptability of herbal mosquito repellents.[20]
- The study also aims to assess the mosquito-repellent activity of the formulated cones under controlled laboratory conditions using the mosquito net cage method, as recommended by the World Health Organization for repellent testing.[22]
- In addition, the safety of the formulation is to be tested by observing for any possible irritation effects of the smoke on skin and eyes, ensuring that the cones are safe for domestic use.
- The project also includes a comparative evaluation of different cone formulations, to identify the most effective and user-friendly composition with maximum repellency and minimal side effects.
- Finally, an important objective of this work is to promote eco-sustainability by utilizing natural, biodegradable, and locally available ingredients, thereby providing a low-cost and environmentally safe alternative to chemical repellents.

REVIEW OF LITERATURE

Ghosh et al. (2012) carried out an extensive study to evaluate the mosquito control properties of citrus extracts, particularly Citrus limon (lemon peel). The phytochemical screening confirmed the presence of limonene, citral, and other monoterpenes, which are well- documented for their insecticidal and repellent properties. Laboratory assays revealed that lemon peel extract exhibited significant repellent activity against Aedes aegypti, a primary vector of dengue fever. In addition, larvicidal action was observed, with notable mortality rates at higher concentrations. The study validated the traditional practice of using citrus peels in fumigation and domestic repellents.[27]

Rahuman et al. (2008) investigated the larvicidal activity of several plant essential oils, including lemon peel oil, against Culex quinquefasciatus, Anopheles stephensi, and Aedes aegypti. The results demonstrated concentration-dependent larvicidal effects, with mortality reaching above 90% at higher doses. Lemon oil was particularly effective due to its limonene and citral content, which disrupt mosquito nervous systems. This research suggests the feasibility of integrating lemon peel oil into herbal mosquito repellents as a safer alternative to synthetic larvicides.[28]

Gonzalez Audino et al. (2004) explored the chemical composition and repellent potential of citrus peel essential oils. Their analysis indicated that lemon oil, rich in D-limonene (up to 70%), acted as a powerful mosquito repellent. The study also highlighted its synergistic effect when combined with other plant oils, extending the duration of protection. These findings are highly relevant to polyherbal cone formulations, where lemon peel extract can complement other botanicals for stronger repellent efficacy.[29]

Chaieb et al. (2007) carried out a detailed phytochemical and pharmacological review on clove (Syzygium aromaticum), which is a widely used spice and medicinal plant. The study reported that clove essential oil contains eugenol as the major constituent, along with eugenyl acetate and β-caryophyllene. These compounds are well-known for their broad-spectrum biological activities, including antimicrobial, antioxidant, insecticidal, and repellent properties. In the context of mosquito control, the authors emphasized that eugenol exhibits neurotoxic effects on insects, thereby disrupting their sensory and nervous systems. The review concluded that clove oil is a potent natural insect repellent and suggested its integration into herbal formulations such as coils, sprays, and cones, offering an effective and environmentally safe alternative to synthetic repellents.[30]

Govindarajan et al. (2011) investigated the larvicidal and repellent activities of clove essential oil against common mosquito vectors, namely Aedes aegypti and Culex quinquefasciatus. The larvicidal assays demonstrated concentration-dependent mortality, with LC_{50} and LC_{90} values confirming strong larvicidal potency. In repellency tests, clove oil showed significant protection, with extended complete protection time compared to untreated controls. The study also highlighted the eco-friendly and biodegradable nature of clove oil, making it a suitable candidate for mosquito management programs. The findings validated the traditional use of clove as an insect repellent and supported its potential application in herbal mosquito repellent cones, particularly when blended with other botanicals for synergistic effects.[31]

Dua et al. (2010) evaluated the efficacy of Lantana camara flowers and leaves in the form of essential oils and extracts for mosquito repellency. The experimental results revealed that the oil provided mean protection times of 1.9 hours against Aedes aegypti under laboratory conditions. Larvicidal activity was also recorded, with notable mortality in third- and fourth- instar larvae. The authors suggested that the incorporation of Lantana extracts into coils or cones could enhance mosquito control measures in domestic settings.[32]

Sathish et al. (2015) investigated the mosquito repellent activity of Lantana camara plant extracts against Culex quinquefasciatus. Their study showed that methanolic leaf extract had the highest repellency rate, achieving up to 90% protection for the first hour post-application. In addition, the extracts were found to be biodegradable and environmentally safe, making them suitable for rural households. The researchers concluded that Lantana camara is a promising plant for use in herbal mosquito repellent formulations, particularly in polyherbal cones where it can complement the action of stronger volatile oils like clove or citrus.[33]

Ansari et al. (2000) investigated the repellent and larvicidal properties of peppermint (Mentha piperita) oil against Anopheles stephensi, Aedes aegypti, and Culex quinquefasciatus. The study demonstrated that topical application of peppermint oil provided significant protection, with mean complete protection times ranging from 45 minutes to 2.5 hours depending on the species. Larvicidal assays also revealed high mortality rates at elevated concentrations. The researchers concluded that peppermint oil, rich in menthol and menthone, could serve as an effective eco-friendly alternative to synthetic repellents.[34]

Chauhan et al. (2014) evaluated the efficacy of Mentha arvensis essential oil against Aedes aegypti under laboratory conditions. The results showed that the oil exhibited strong larvicidal activity, with LC_{50} values recorded at relatively low concentrations, indicating high potency. Repellent tests revealed that Mentha oil provided up to 2 hours of significant protection. The authors highlighted its biodegradability and pleasant aroma as advantages for incorporation into herbal mosquito repellent formulations such as coils and cones.[35]

INGREDIENTS/MATERIALS

1. Lemon peel (Citrus limon)

Figure 1.1: Lemon peel.

Lemon peel contains volatile oils rich in limonene, citral, and other monoterpenes, which are responsible for its strong insect-repellent and larvicidal activities. These compounds interfere with the olfactory receptors of mosquitoes, thereby reducing their host-seeking ability.

A study on the larvicidal activity of citrus peel essential oils demonstrated that lemon oil caused significant mortality in Aedes albopictus larvae, with limonene identified as the major active constituent. The results confirmed that citrus-based oils could serve as eco- friendly larvicides and repellents.

Furthermore, traditional practices in rural communities often use dried citrus peels in fumigation to ward off insects, providing ethnopharmacological evidence for their repellent activity. The incorporation of lemon peel powder in mosquito repellent cones ensures not only effective repellency but also pleasant fragrance and antioxidant stability for the formulation.[9]

2. Clove (*Syzygium aromaticum*)

Figure 1.2: clove buds.

Clove is widely recognized for its insecticidal and antimicrobial properties due to its high concentration of eugenol, along with other compounds such as caryophyllene. Eugenol acts as a neurotoxin against mosquitoes, disturbing their sensory receptors and reducing biting activity.

In a comparative study, clove essential oil and pure eugenol were tested against Anopheles stephensi larvae. The results indicated that whole clove oil exhibited stronger larvicidal activity than eugenol alone, suggesting synergistic effects of other minor constituents.[10]

Clove oil has also been incorporated into coils and fumigant formulations, producing up to 90% repellency against Aedes aegypti. Beyond repellency, clove provides a characteristic aroma and contributes to the antimicrobial stability of herbal cones.

3. Lantana camara

Figure 1.3: lantana camera.

Lantana camara is a medicinal plant known for its insecticidal, antimicrobial, and larvicidal properties. The leaves contain compounds such as lantadene A, lantadene B, and sesquiterpenes that are toxic to mosquitoes and other pests.

An experimental study tested the ethanol extract of lantana leaves as a repellent against Aedes aegypti. The results demonstrated dose-dependent protection, with higher concentrations providing up to 90% repellency [11]. This validates the traditional practice of burning lantana leaves to deter mosquitoes in rural communities.

Thus, the incorporation of lantana in herbal cones not only enhances repellent efficacy but also contributes to larvicidal action, making it a versatile component in eco-friendly mosquito control strategies.

4. Mint (Mentha piperita / Mentha arvensis)

Figure 1.4: Mint leaves.

Mint is rich in menthol, menthone, carvone, and limonene, which are volatile compounds with insecticidal, antimicrobial, and aromatic properties. Menthol has been reported to act as a mosquito repellent by interfering with the insect's nervous system and sensory perception.

A phytochemical study of nine Mentha species identified menthol and related compounds as major constituents, many of which possess strong bioactivity. While the study primarily focused on antimicrobial effects, menthol's known insect-repellent action makes mint extracts suitable for mosquito control.

Fumigation with mint leaves or cones containing mint powder has been reported to reduce mosquito landings significantly. The cooling fragrance of menthol also increases consumer acceptability, making mint a valuable addition to herbal repellent formulations.[12]

Sawdust as a Base Material

Figure 1.5: Saw dust powder.

Sawdust, a by-product of the wood industry, is composed mainly of cellulose, hemicellulose, and lignin. It is widely used in mosquito coils and incense formulations because it ensures steady burning and acts as a filler material for shaping the product. Sawdust does not have direct repellent activity, but it plays a vital role in combustion and smoke release, which are necessary for dispersing herbal actives.

A study on eco-friendly mosquito coils demonstrated that formulations using sawdust produced less harmful smoke and exhibited steady burning properties, compared to conventional synthetic fillers. The researchers concluded that sawdust is a sustainable and inexpensive material suitable for herbal repellent formulations.

Gum Acacia (*Acacia senegal*) as a Binder

Figure 1.6: Acacia powder.

Gum acacia, also known as gum arabic, is a natural exudate obtained from *Acacia senegal* trees. It consists of polysaccharides and glycoproteins that make it an excellent binder, stabilizer, and emulsifier in pharmaceutical and food products. In mosquito repellent cones, gum acacia ensures cohesion of powdered ingredients, prevents cracking during drying, and supports uniform combustion.

Charcoal as a Combustion Enhancer

Figure 1.7: Charcoal powder.

Charcoal is a carbon-rich material obtained from the partial combustion of organic matter. It is frequently used in incense sticks and mosquito coils because it provides ignition support, consistent heat, and efficient burning. In herbal mosquito repellent cones, charcoal improves smoke output and helps maintain a slow, steady release of repellent compounds.

METHODOLOGY

Collection of materials

For this formulation, all the required raw materials were collected from simple and easily available sources, keeping in mind their authenticity, affordability, and local availability.

- Lemon peel (*Citrus limon*) – Fresh lemons were purchased from the local fruit market. The peels were separated, carefully washed to remove dust and chemicals, and left to dry in the shade for about a week. Once they were crisp, they were ground into fine powder to preserve their natural fragrance and active components.
- Clove (*Syzygium aromaticum*) – Dried clove buds were bought from a local spice shop. They were clean, aromatic, and of good quality, and were stored in airtight containers to retain their characteristic smell until used.
- Lantana camara leaves – Fresh green leaves were handpicked from plants growing near garden areas and roadside shrubs. The collected leaves were gently washed, shade-dried for several days, and powdered for use in the cone formulation.
- Mint (*Mentha piperita / Mentha arvensis*) – Fresh mint leaves were obtained from a vegetable market. Their strong menthol aroma made them easy to identify. After cleaning and shade drying, the leaves were ground into fine powder to capture their cooling fragrance.
- Sawdust – Clean sawdust was collected from a local carpentry shop, where it is normally discarded as waste. It was sieved to remove larger particles, giving a smooth, fine powder suitable for cone-making.
- Gum acacia (*Acacia senegal*) – Gum acacia powder was purchased from a local Ayurvedic raw drug supplier. Its natural binding property made it an ideal choice to hold the powdered ingredients together while shaping the cones.
- Charcoal powder – Charcoal was obtained from a local vendor. The larger chunks were crushed and sieved to produce a fine black powder, which helps in steady burning and smoke production during the cone's use.

Procedure

1. All the collected ingredients are sieved (it helps to remove impurities, ensures uniform particle size and enhances burning quality).

Figure 1.8: Ingriedients.

Figure 1.9: Apparatusl.

2. Weighing & Mixing: Weigh each powdered ingredient in the desired ratio (as per formulation table), mix thoroughly to get a uniform blend.
3. Binding: Dissolve gum acacia in warm water to make a sticky binder solution. Add this solution into herbal powder mixture, mix until a dough-like consistency is achieved.
4. Shaping: The paste is shaped into small cones by hand rolling method.
5. Drying: Cones are dried at room temperature or in a drying chamber (under 50–60°C) for several days to remove moisture.

Figure 2.0: Drying.

6. Packaging: Once completely dry, cones are packed in airtight containers to preserve aroma and efficacy.

Table 1: Formula for preparing herbal mosquito cone with respective formulations (F_1 to F_7).

Ingredients	F_1	F_2	F_3	F_4	F_5	F_6	F_7
Lantana camera	12g	-	-	-	6g	4g	3g
mint	-	12g	-	-	6g	-	3g
Lemon peel	-	-	12g	6g	-	4g	3g
clove	-	-	-	6g	-	4g	3g
Acacia	5g	5g	5g	5g	5g	5g	5g
Saw dust	20g	20g	20g	20g	20g	20g	20g
Charcoal powder	8g	8g	8g	8g	8g	8g	8g
Water	q.s	q.s	q.s	q.s	q.s	q.s	q.s

F_1- Contains Lantana camera + Base materials.

F_2- Contains Mint + Base materials.

F_3- Contains lemon peel + Base materials.

F_4- Contains lemon peel + clove + Base materials.

F_5- Contains Lantana camera + Mint + Base materials.

F_6- Contains Lantana camera + Contains lemon peel + clove + Base materials.

F_7- Contains Lantana camera + Mint + lemon peel + clove + Base materials.

Base materials- Acacia, Saw dust, Charcoal powder, Water.

EVALUATION

1. **Burning time(minutes):** Measured from the ignition to extinguishing of cone.[25]

Figure 2.1: Burning time evaluation.

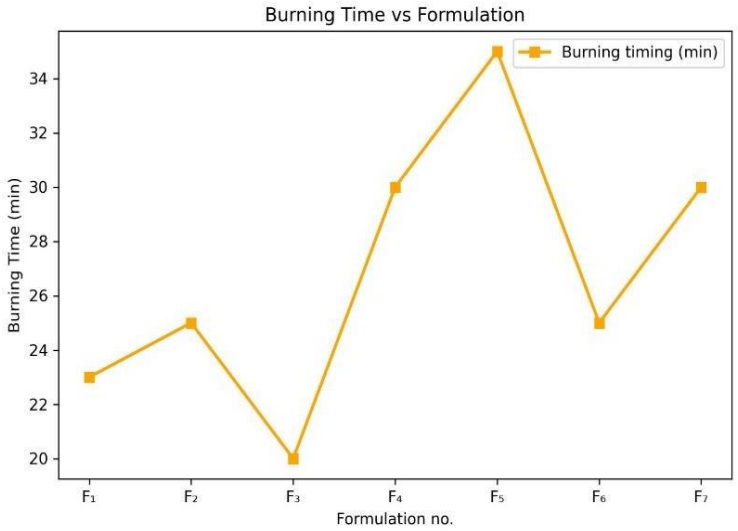

Figure 2.2: Burning time graph.

2. **Smoke visibility:** Smoke is observed and rated as light, moderate or dense.[24]

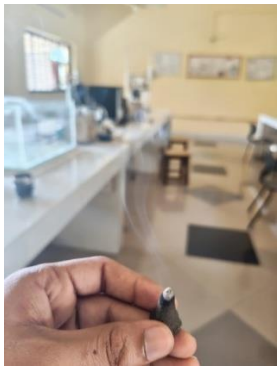

Figure 2.3: Smoke visibility.

3. **Irritation test:** Tested by exposing individual smoke for sign of eye or skin irritation.[26]
4. **Odor:** Evaluated its pleasant.[24]
5. **Ash weight(g):** Final ash weight after complete burning of cone was measured.[25]

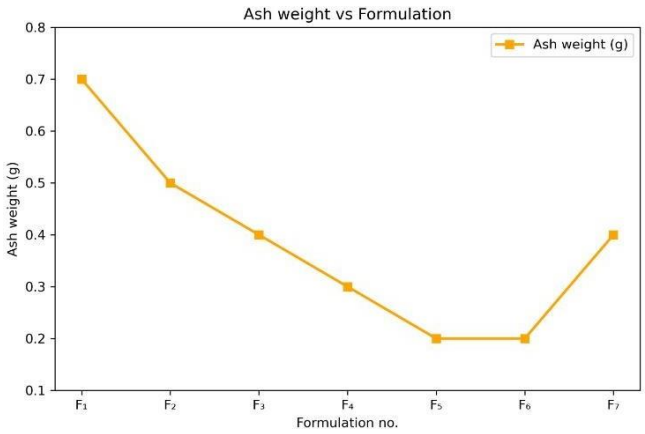

Figure 2.4: Ash weight graph.

6. Evaluation of mosquito repellent activity in cage: The cone was burnt in the Cage and check the repellent activity of the mosquitoes.

Figure 2.5: Cage for testing repellent activity.

RESULTS AND DISCUSSION

The herbal mosquito repellent cone was successfully formulated using powdered forms of lemon peel, clove, lantana camara, and mint, with sawdust, gum acacia, and charcoal serving as base materials. The prepared cones were evaluated for their physical characteristics such as appearance, odor, burning time, stability, and ease of handling. The cones exhibited uniform shape, firm texture, and a characteristic herbal aroma, indicating proper binding and formulation.

The burning time of the cones was observed to be adequate, providing sustained release of repellent vapors for a considerable period. The evaluation of repellency activity was carried out against Aedes aegypti mosquitoes. Results showed that the herbal cones produced significant repellency, with maximum effectiveness observed in cones containing higher proportions of clove and lemon peel. The repellent effect was sustained for several hours, comparable to synthetic repellents, but without any signs of irritation or adverse effects.

The overall findings indicated that the combination of selected herbal powders with natural base materials resulted in a safe, eco-friendly, and effective mosquito repellent cone.

Table 2: evaluation parameters of herbal mosquito repellent cone.

Formulation	Burning time (minutes)	Smoke visibility (observation)	Odor	Irritation test	Ash weight (g m)	Mosquito repellent activity(number)
F_1	23	light	Satisfactory	No	0.7	2
F_2	25	light	Good	No	0.5	3
F_3	20	light	Good	No	0.4	4
F_4	30	moderate	Satisfactory	No	0.3	3
F_5	35	moderate	Good	No	0.2	4
F_6	25	dense	Satisfactory	No	0.2	5
F_7	30	dense	Good	No	0.4	6

CONCLUSION

The present study demonstrated that herbal mosquito repellent cones prepared from lemon peel, clove, lantana camara, and mint, using sawdust, gum acacia, and charcoal as base materials, possess significant mosquito repellent activity. The cones were found to be stable, non-irritant, and effective in repelling Aedes aegypti mosquitoes for prolonged durations.

This research supports the use of herbal alternatives as eco-friendly substitutes for synthetic repellents, which are often associated with side effects and environmental hazards. The synergistic effect of lemon peel and lantana camera provided enhanced repellent action, while clove and mint contributed to the aromatic and functional qualities of the cones.

Hence, the formulated herbal mosquito repellent cone can be considered a promising natural product for household use, providing a safer and more sustainable method of mosquito control.

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