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RESEARCH ARTICLE

EVALUATION OF MARIGOLD (*TAGETES ERECTA*) LEAVES AS A NATURAL MOSQUITO (DIPTERA: CULICIDAE) REPELLENT

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ABSTRACT

This study was carried out to evaluate marigold (*Tagetes erecta*) leaves as a natural mosquito repellent. This experiment was conducted during March to June 2023 at Entomology Laboratory, EXIM Bank Agricultural University Bangladesh. Marigold leaf extract was tested in three replications at four different concentrations (100ml, 75ml, 50ml and 25ml) to evaluate the efficacy of mosquito larvae. To compare the repellent activity of marigold-based coils with commercial coils on adult mosquitoes, 25 adult mosquitoes were tested with three replications. Data were collected from 25 randomly selected individuals to determine how they responded to marigold-based coils. The highest concentration (100ml) resulted in an impressive mean percentage of 88% mosquito larvae mortality after 24 hours of exposure, highlighting the potent larvicidal potential of marigold leaf extract. The marigold-based coil demonstrated remarkable efficacy in controlling adult mosquitoes. Although it took slightly longer (39.67 minutes) than the commercial coil (16.34 minutes) to kill mosquitoes, it showed sustained and consistent efficiency over time. The evaluation of mosquito repellent activity by respondents indicated a preference for mosquito coils (64%) as the primary method of repelling mosquitoes. Respondents perceived a moderate reduction (52%) in mosquito attacks when using the marigold-based coil and rated its repellent effectiveness as moderate (52%) to high (28%). While some participants reported side effects, including offensive smell (45%), eye burning (20%), breathing problems (15%), and coughing (15%). There was the absence of any adverse impact on non-target organisms. Marigold leaves showcase promising potential as a natural larvicide for mosquito control. The marigold-based coil demonstrates moderate to high repellent effectiveness on adult mosquitoes, with the added advantage of being free from toxic side effects. These findings emphasize the superiority of the marigold-based mosquito coil as a valuable and environmentally friendly mosquito repellent option, offering an effective solution for mosquito control.

KEYWORDS

Bioassay, Coil side effects, Mosquito coil, Mosquito repellent, Smoke toxicity, *Tagetes erecta*

1. INTRODUCTION

Mosquito-borne diseases pose significant health risks worldwide, causing widespread morbidity and mortality. Mosquito-borne diseases, such as Malaria, Dengue, Chikungunya, Japanese encephalitis, Lymphatic filariasis, West Nile fever, Zika and Yellow fever, are a major public health threat worldwide. According to WHO, more than 17% of all infectious diseases are vector-borne, and they account for more than 700,000 annual deaths. They may be brought on by viruses, bacteria, or parasites. A parasitic ailment called malaria is spread by *Anopheles* mosquitoes. Globally, it is thought to be responsible for 219 million diseases and more than 400,000 deaths annually. Children under the age of five account for the majority of deaths. The most frequent viral disease spread by *Aedes* mosquitoes is dengue. Dengue poses a threat to more than 3.9 billion individuals in 129 different countries, with an annual mortality toll of 40,000 and 96 million symptomatic cases. Other viral infections spread by vectors include Japanese encephalitis, West Nile fever, Yellow fever, Chikungunya fever, and Zika virus fever (all transmitted by mosquitoes) (WHO, 2020).

In recent years, the use of synthetic insecticides has become widespread, but these chemicals can have negative impacts on the environment and human health. Around the globe, approximately 2 billion individuals rely on mosquito coils to protect themselves from mosquito bites indoors. Nonetheless, the combustion of the organic materials used as the base components in mosquito coils releases harmful particulate and gaseous substances (Zhang et al., 2010). Therefore, there is a growing interest in natural alternatives, such as plants, to repel mosquitoes. Marigold leaves (*Tagetes erecta*) have been used in traditional medicine as a natural insecticide, and there is some evidence to suggest that they can repel mosquitoes. The traditional usage of *Tagetes erecta* and *Tagetes patula* involves preparing decoctions from their leaves, which are known for their antimalarial properties and febrifuge effects (Rasoanaivo et al., 1992).

The marigold plant (*Tagetes erecta*), belonging to the family Asteraceae has been reported to have mosquito repelling properties (Gupta and Vasudeva, 2012). This is because the presence of various compounds, including d-limonene, α-pinene, β-pinene, dipentene, ocimene, β-phellandrene, linalool, gereniol, menthol, tagetone, nonanal, and linalyl acetate, was detected in the essential oil derived from the leaves of *Tagetes erecta* (Baslas and Singh, 1981). Subsequently, a total of forty-four components, which make up 94.1% of the leaf oil, and forty-five components, accounting for 94.0% of the flower oil, were successfully identified. The predominant constituents found in the leaf oil were limonene (7.6%), terpinolene (11.2%), (Z)-myroxide (4.2%), piperitone

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(52.4%), and piperitenone (5.0%) (Krishna et al., 2004). The water-based extract from the leaves of *Tagetes erecta* demonstrated notable effectiveness in controlling *Meloidogyne incognita* and *Rotylenchulus reniformis* (Mahmood et al., 1979). A study examined the mosquitocidal properties of the ethanolic extract from *Tagetes erecta* flowers, along with its chloroform and petroleum ether-soluble fractions, against *Culex quinquefasciatus* larvae (Nikkon et al., 2011). The use of marigold as a natural plant product showed promise as an effective and non-toxic mosquito repellent (Rana et al., 2017).

A study reported that the essential oils extracted from both fresh and dried plants of *Tagetes minuta* demonstrated high efficacy against *Anopheles stephensi* larvae, with LC50 values of 1.0532 and 1.0315 mg/L, respectively (Hadjiakhoondi et al., 2008). Conventional chemical-based mosquito repellents often raise concerns regarding their potential adverse effects on human health and the environment. Therefore, exploring natural alternatives with proven efficacy and safety is of paramount importance. The primary objective of this study is to find out the effectiveness of marigold leaves as natural mosquito repellent. Specifically, the following research objectives will be addressed to find out the efficacy of marigold leaf extract on larvae of mosquito, to observe repellent activity of marigold-based coil on adult mosquito comparing to commercial coils and to know the perception of marigold-based coil users.

2. METHODS

2.1 Collection of Marigold Plants

Disease-free, healthy with more branches American marigold (*Tagetes erecta*) plants were procured from the local nursery in the Chapainawabganj Sadar upazilla of the Chapainawabganj district. The average plant height was 24.5 cm, and the average leaf length was 18 cm.

2.2 Collection of Mosquito Larvae

Mosquito larvae were collected near the Chapainawabganj Sadar Hospital, Chapainawabganj.

2.3 Collection of Materials and Equipments

Charcoal, starch, mosquito net, cork sheet, plastic pot, sucrose, fish feed and commercial coil were collected from the local market of Chapainawabganj Sadar upazilla, Chapainawabganj. Mechanical grinder, digital scale, pipette, petridish, test-tube, test-tube rake, beaker, electric heater, mortar and pestle, spatula, dropper, pot, stainless tray, 5ml glass bottle, micro-oven, strainer, compound microscope, slides, cover slip, glycerin, plastic bowl, wash bottle, distill water, knife, scissors and lighter were collected from Entomology laboratory, EXIM Bank Agricultural University Bangladesh, Chapainawabganj-6300.

A rectangular-shaped glass box with a measurement of 60 cm length, 35.7 cm width, and 38 cm height was prepared (Figure 1).

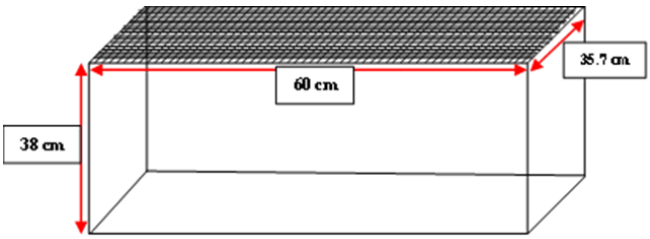


Figure 1: A rectangular-shaped glass box

2.4 Study Area

Entomology laboratory, EXIM Bank Agricultural University Bangladesh, Chapainawabganj-6300.

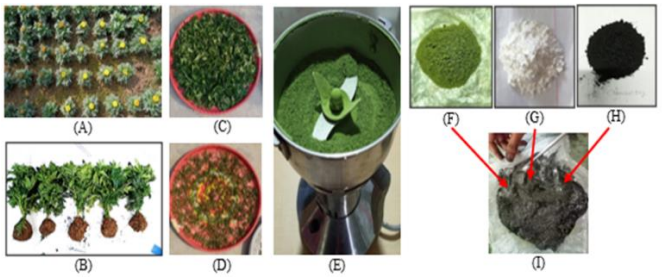
2.5 Time Duration

During the period from March 2023 to June 2023, we gathered all the necessary data for the evaluation of marigold (*Tagetes erecta*) leaves as a natural mosquito repellent.

2.6 Formation of Coil

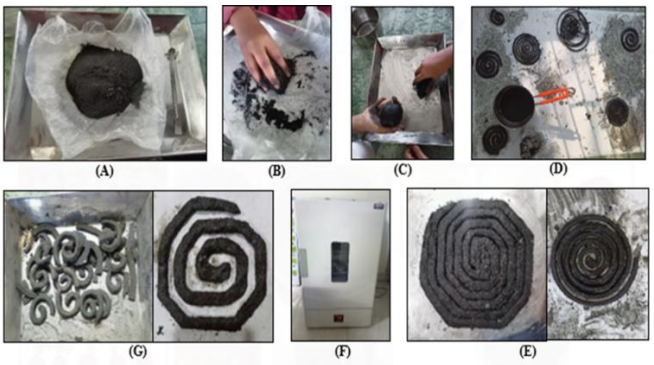
The process of forming marigold leaf powder begins with carefully cutting down leaves from each plant. These freshly harvested leaves are then left to dry naturally under the sun for approximately two days. The duration of sun-drying allows the leaves to reach an optimal level of dryness, ensuring they are ready for the next step. Once the leaves have been thoroughly dried, they are prepared for the powder-making process. A mechanical grinder is employed to grind the well-dried leaves into a fine powder. This grinder utilizes mechanical force to break down the leaves into smaller particles, resulting in a consistent and uniform texture. The use of a mechanical grinder is crucial in achieving the desired fineness of the marigold leaf powder. This grinding process ensures that the powder retains its potency and characteristic properties, allowing for easy incorporation into the coil-making process. Researchers state that the ingredients of an incense stick include a stick prepared from leaves as the base, with marigold plant material comprising 25% of the mixture (Ponkiya et al., 2018). The remaining 75% consists of a combination of charcoal and a binding agent. In this experiment, a coil was formed using a mixture of different materials. The composition of the mixture consisted of 25% leaf powder, 37.5% charcoal, and 37.5% starch as a binding agent (Figure 2).

To begin, the materials were carefully measured and combined. Gradually, boiled water was added to the mixture, allowing a thick and consistent paste to be formed. Next, the paste was rolled into a thin ribbon-like structure by hand, with precision employed to ensure uniformity and durability of the coil. Once the desired ribbon shape was achieved, the coil was left to dry (Figure 3). An oven drying method was chosen to accelerate the process and maintain control over the temperature. The coil was carefully placed in an oven set at a temperature of 67°C. The coil was left inside the oven for a period of two days, allowing ample time for the moisture to evaporate and the coil to solidify. Throughout the drying period, the oven temperature was closely monitored to ensure consistency. This temperature control was essential to prevent potential damage to the coil or alteration of its properties. After the two-day drying period, the coil was removed from the oven. It had been transformed into a hardened structure, exhibiting the characteristics of the materials used.



(A) American Marigold, (B) Preparation of Plants, (C) Leaves, (D) Dried Leaves, (E) Grinding leaves, (F) Leaf powder, (G) Starch, (H) Charcoal and (I) Mixture of ingredients

Figure 2: Formation of leaf powder and mixture of ingredients

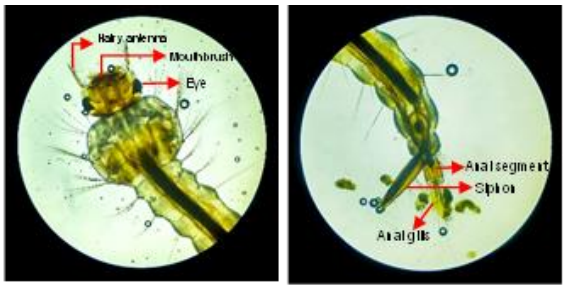


(A) Composition of Mixture, (B) Added boiled water, (C) Thick and consistent paste formed, (D) Paste was rolled into a thin ribbon, (E) Moist coil shape was formed, (F) Coil was left inside the oven, (G) Dried marigold based coil

Figure 3: Formation of Marigold based mosquito coil

2.7 Larval Rearing

Initially, the collected larvae were meticulously examined under a compound microscope at a magnification of 40x to confirm their classification as mosquito larvae at the species level. The observed larvae were successfully identified as belonging to the genus *Culex*, signifying an important discovery in our study (Figure 4). To ensure the larvae's nutritional needs were met, a nourishing diet of fish feed was thoughtfully provided.



Microscopic view of *Culex spp.* larvae

Figure 4: Identification of mosquito larvae

2.8 Adults' Development

2.8.1 The emergence of adult insects from the pupal stage

Upon reaching the appropriate developmental stage, approximately two days after pupation, the adult insects underwent a graceful emergence, marking the initiation of a new phase in their life cycle. During this process, the mature individuals delicately settled on the surface, patiently awaiting the drying and hardening of their bodies. This crucial period allowed them to acquire the necessary strength and resilience for survival and navigation within their environment.

2.8.2 Transfer of adult insects to a designated glass enclosure

In preparation for the subsequent smoke toxicity tests, it was deemed essential to carefully transfer the freshly emerged adult insects from their hatching containers into a specifically designated glass enclosure. This controlled environment was selected as the optimal setting for evaluating the effects of smoke generated by two distinct types of coils: the marigold-based coil and the commercially available coil.

2.9 Larvicidal activity test

2.9.1 Preparation of plant extract

The preparation of the plant extract involved several steps. First, fresh marigold leaves were carefully washed using fresh tap water to remove any impurities. Once cleaned, the leaves were placed in a mortar and pestle. Using the mortar and pestle, the leaves were crushed and ground to create a leaf extract. This process allowed the active compounds present in the marigold leaves to be released and extracted into a liquid form. The utmost care was taken to ensure the cleanliness and integrity of the marigold leaves throughout the extraction process to maintain the quality and potency of the plant extract.

2.9.2 Biological Assay

In order to determine the efficacy of marigold leaves, various concentrations of leaf extract were prepared and tested over a period of 24 hours. The concentrations tested included 25%, 50%, 75%, and 100% of the extract. To ensure consistency and accuracy, each concentration was placed in a separate 5ml test tube. Marigold leaves extract on larvae were tested with three replications, and the results showed significant effects on their growth and development. The number of tested larvae, the number of dead larvae, the mean number of dead larvae, mean percentage, and the duration of exposure were recorded and analyzed.

The next step of the experiment involved placing 25 larvae inside each Petri dish. The Petri dishes were then treated with the different concentrations of the marigold leaf extract. During the testing period, precise measurements and observations were taken to assess the impact of the different concentrations on the larvae. The following formula is used to determine the mortality percentage-

$$\text{Percentage of mortality \%} = \frac{\text{Mean number of dead larvae}}{\text{Number of tested larvae}} \times 100$$

By testing different concentrations of the extract on the larvae, the experiment was able to determine the most effective concentration for controlling the larvae population.

2.10 Smoke Toxicity Test

The smoke toxicity test was conducted using a controlled environment within a glass box. To begin the experiment, 25 adult mosquitoes were carefully released into the glass box, ensuring a representative sample of the mosquito population. The upper portion of the box was covered by a mosquito net and a thermocol sheet to prevent the mosquitoes from escaping and to confine the smoke within the box (Fig. 1). The effectiveness of the herbal mosquito coil "Morizena" against *Aedes aegypti* was investigated and compared with the synthetic chemical mosquito coil "Transfluthrin" in terms of killing *Aedes aegypti* (Susilowati et al., 2018).

The first stage of the experiment involved burning a marigold-based mosquito coil inside the glass box. As the coil burned, the resulting smoke permeated the enclosed space. Throughout this stage, precise measurements were taken to record the concentration of smoke and the duration of exposure.

After collecting data from the marigold-based coil, the glass box was thoroughly cleaned and prepared for the subsequent phase of the experiment. Once again, 25 adult mosquitoes were introduced into the box, maintaining consistency with the previous stage. This time, a commercially available mosquito coil was burned. This commercial coil was selected to examine the potential differences in smoke toxicity compared to the natural alternative. The upper portion of the box, covered by a mosquito net and a thermocol sheet, ensured the confinement of smoke produced by the commercial coil.

Similar to the previous stage, meticulous measurements were taken to monitor the concentration of smoke and the duration of exposure during the burning of the commercial coil. Both the marigold-based mosquito coil and the commercial mosquito coil were tested with three replications, where we observed the mean number of tested mosquitoes, the mean number of dead mosquitoes, the mean time (in minutes), and the mean number of dead mosquitoes based on time ranges, including 0-10 minutes, 11-20 minutes, 21-30 minutes, and 31-40 minutes. This data, combined with the previous data collected from the marigold-based coil, allowed for a comprehensive analysis of the smoke toxicity levels associated with both types of mosquito coils.

2.11 Evaluation of Mosquito Repellent Activity

To evaluate the effectiveness of the marigold-based coil as a mosquito repellent, a sample group of 25 participants was selected. Each participant was provided with a marigold coil and asked to provide feedback on its performance in repelling mosquitoes. A semi-structured questionnaire was used to collect the participants' responses. The questionnaire included questions about their experiences with the marigold coil, side effects including skin irritation, eye burning, coughing, breathing problem, offensive smell, tears and its effectiveness in repelling mosquitoes. The feedback obtained from the participants through the questionnaire was analyzed to gain insights into the performance of the marigold coil as a mosquito repellent. The results of the evaluation were then summarized and reported, providing an overall assessment of the marigold-based coil's effectiveness in repelling mosquitoes.

2.12 Analytical Tools

The collected data were properly edited and coded before final analysis. All inconsistent data were avoided to eliminate the errors and faults. The Statistical Package for Social Sciences (SPSS) and MS Excel was used for data management. Many statistical properties like average, percentage, frequency, mean etc. were used for analysis.

3. Results

3.1 Results of Larvicidal Activity Using Marigold Leaf Extract

Table 1: The outcome of different concentration of Marigold leaf extract on mosquito larvae

Extract	Concentration	No. of tested larvae	Mean no. of dead larvae	Cumulative mean percentage of mortality	Duration
Marigold leaves extract	100ml	25	22	88%	24h
Marigold leaves extract + Distil water	75ml + 25ml	25	19	76%	24h
Marigold leaves extract + Distil water	50ml + 50ml	25	17	68%	24h
Marigold leaves extract + Distil water	25ml + 75ml	25	11	44%	24h

3.2 Smoke Toxicity Test on Adult Mosquitoes

Table 2: Outcomes of the combustion of a marigold-based mosquito coil				
No. of tested mosquitoes	**Mean no. of dead mosquitoes**	**Mean time (min.)**	**Mean no. of dead mosquitoes based on time range**	
			Time range (min.)	**Mean no. of dead mosquitoes**
25	25	39.67	0-10	5
			11-20	8
			21-30	8
			31-40	4

Table 3: Outcomes of the combustion of a commercial mosquito coil				
No. of tested mosquitoes	**Mean no. of dead mosquitoes**	**Mean time (min.)**	**Mean no. of dead mosquitoes based on time range**	
			Time range (min.)	**Mean no. of dead mosquitoes**
25	25	16.34	0-10	16
			11-20	9

3.3 Evaluation of Mosquito Repellent Activity by the Respondents

The evaluation of the mosquito repellent activity focused on several aspects, including the respondents' response towards side effects after burning a marigold-based mosquito coil, the side effects experienced, the repel methods used by respondents, their perception of reducing mosquito attacks, the effectiveness of repelling mosquitoes, their opinions about the product, whether they would encourage someone to use it, and any observed organism deaths.

3.3.1 Mosquito Repelling Methods

Table 4: The Repelling methods used by respondents		
Methods	**Frequency**	**Percent (%)**
Mosquito coil	16	64
Aerosols	2	8
Liquid Vaporizer refill	3	12
Electric bat	4	16
Total	25	100

3.3.2 Response Towards Reducing Mosquito Attacks by Using Marigold-Based Coil

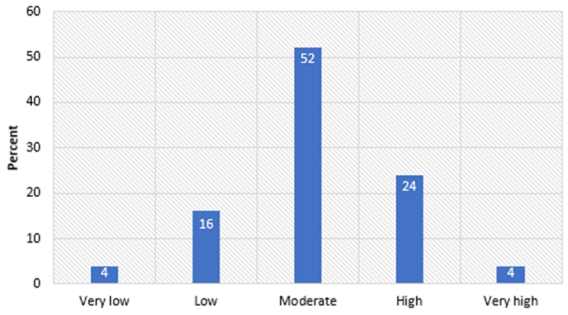


Figure 5: Response of respondents towards reducing mosquito attacks

3.3.3 Side effect after burning marigold-based coil

Figure 6: Respondent response towards side effect

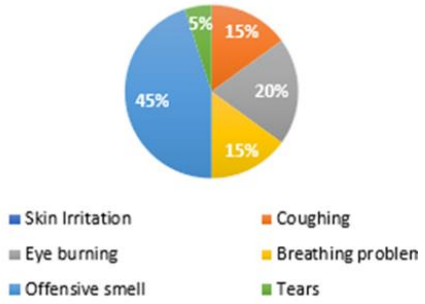


Figure 7: Side Effect after burning coil

3.3.4 Marigold-Based Coil as a Mosquito Repellent

Table 5: Responses for repelling mosquitoes		
Response	**Frequency**	**Percent**
Low	5	20
Moderate	13	52
High	7	28
Total	25	100

3.3.5 Effect on Non-Target Organisms

None of the respondents reported observing any organism deaths associated with the use of the marigold-based mosquito coil. This indicates that the product did not appear to have any adverse impact on non-target organisms in the vicinity.

3.3.6 Opinions of The Respondents on Using Marigold-Based Mosquito Coil

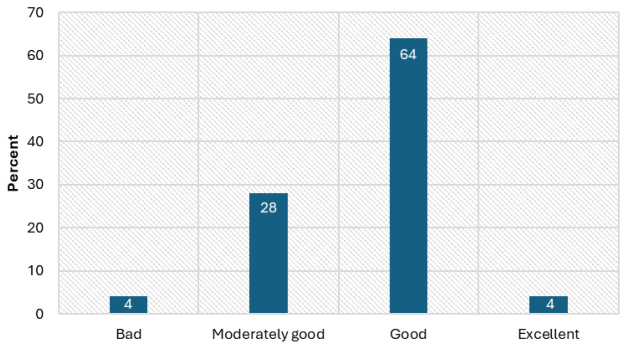


Figure 8: Opinions of the respondents

3.3.7 Supportive Encouragement: Respondents' Perspectives

An overwhelming majority of the respondents (96%) indicated that they would recommend the marigold-based mosquito coil to someone else, while only 4% reported that they would not. This finding demonstrates a high level of satisfaction and confidence in the product's effectiveness among the respondents.

4. Discussion

At a concentration of 100ml of marigold leaf extract, a total of 25 larvae were exposed, resulting in 22 dead larvae after 24 hours of exposure. The mean number of dead larvae was calculated to be 22, with a mean percentage of 88%. This indicates a high larvicidal activity of the marigold leaf extract at this concentration. When a combination of 75ml marigold leaf extract and 25ml distilled water was used, a total of 25 larvae were exposed, and 19 larvae were found dead after 24 hours. The mean number of dead larvae was 19, corresponding to a mean percentage of 76%. Although slightly lower than the previous concentration, this result still demonstrates a significant larvicidal effect (Table 1). Further diluting the marigold leaf extract to a ratio of 50ml marigold leaf extract and 50ml distilled water resulted in 17 dead larvae out of the 25 exposed larvae. The mean number of dead larvae was 17, corresponding to a mean percentage of 68%. Despite the decrease in larvicidal activity compared to higher concentrations, the effectiveness of the marigold leaf extract in reducing larvae populations is still apparent. At the lowest concentration tested, with 25ml marigold leaf extract and 75ml distilled water, only 11 out of

the 25 exposed larvae were found dead. This translates to a mean number of dead larvae of 11 and a mean percentage of 44%. While the larvicidal activity is reduced at this concentration, it still exhibits some efficacy in decreasing larval populations. Overall, these results demonstrate the larvicidal potential of marigold leaf extract against mosquito larvae. The efficacy of the extract is concentration-dependent, with higher concentrations exhibiting greater larvicidal activity. However, even at lower concentrations, the marigold leaf extract shows some effectiveness in reducing larval populations. The duration of exposure for all concentrations was set at 24 hours. It is important to note that the observed larvicidal activity occurred within this timeframe, indicating a relatively fast-acting effect of the marigold leaf extract on mosquito larvae. According to Hutagalung et al., in 2013, Six different concentrations (ranging from 0% to 5%) of the extract were tested, with three replications. The results demonstrated that marigold leaf extract had a significant repellent effect on *Aedes spp.* mosquitoes. The average protection power increased with higher concentrations, reaching 100% at a concentration of 5%. These findings suggest that marigold leaf extract has the potential to be utilized as a natural larvicide for mosquito control.

The results obtained from the combustion of a marigold-based mosquito coil (Table 2) were compared with the outcomes of burning a commercial mosquito coil (Table 3). In both experiments, 25 mosquitoes were tested. Surprisingly, in both cases, all of the tested mosquitoes were found dead at the end of the experiment. This suggests that both the marigold-based and commercial mosquito coils have a high efficacy in killing mosquitoes. However, a notable difference was observed in the mean time required to achieve mosquito mortality. For the marigold-based mosquito coil, the mean time was found to be 39.67 minutes (Table 2), while for the commercial mosquito coil, it was significantly shorter at 16.34 minutes (Table 3). This indicates that the commercial mosquito coil acted faster in eliminating mosquitoes compared to the marigold-based coil. When examining the mosquito mortality based on time ranges, it was observed that the marigold-based coil showed a consistent trend of mosquito death across different time intervals. The mean number of dead mosquitoes for each time range remained relatively steady: 5 mosquitoes in the 0-10 minutes range, 8 mosquitoes in both the 11-20 minute and 21-30 minutes ranges, and 4 mosquitoes in the 31-40 minutes range. These results suggest that the marigold-based mosquito coil had a consistent efficacy over time. On the other hand, the commercial mosquito coil exhibited a slightly different pattern. In the 0–10 minutes range, the mean number of dead mosquitoes was significantly higher at 16, indicating a rapid initial effect. However, in the 11-20 minutes range, the mean number decreased to 9 mosquitoes. This suggests a potential decrease in effectiveness over time for the commercial mosquito coil. The marigold-based mosquito coil demonstrated remarkable effectiveness in killing mosquitoes, resulting in 25 dead mosquitoes within a mean time of 39.67 minutes for mosquito mortality. Although the commercial coil acted faster, requiring only 16.34 minutes to achieve the same number of dead mosquitoes, the marigold-based coil's consistent efficacy over time makes it a highly promising and eco-friendly mosquito control method. These findings provide strong support for the use of marigold-based coils as an effective and sustainable choice for mosquito management strategies.

The majority of respondents (64%) used mosquito coils as their preferred method of repelling mosquitoes, followed by electric bats (16%), liquid vaporizer refills (12%), and aerosols (8%) (Table 4). These results indicate a strong preference for traditional methods such as mosquito coils. When asked about their perception of reducing mosquito attacks, the highest proportion of respondents (52%) reported a moderate reduction, followed by low reduction (16%), high reduction (24%), very low reduction (4%), and very high reduction (4%). This suggests that the marigold-based mosquito coil had a varying degree of effectiveness in reducing mosquito attacks, with most respondents perceiving a moderate reduction (Table 5). The majority of respondents (52%) reported a moderate level of effectiveness in repelling mosquitoes, followed by high effectiveness (28%) and low effectiveness (20%). These findings indicate that the marigold-based mosquito coil demonstrated a moderate to high efficacy in repelling mosquitoes, as reported by the participants (Fig. 5). Out of the total respondents, 60% reported experiencing some form of side effect after burning the marigold-based mosquito coil, while the remaining 40% reported no side effects (Fig. 6). These findings indicate that a considerable proportion of the participants experienced some adverse reactions. Among the 60% of the respondents, the most commonly reported side effects were offensive smell 45%, eye burning 20%, breathing problems 15%, coughing 15% and tears 5%. However, no instances of skin irritation were reported, suggesting that the product did not cause any significant skin-related issues (Fig. 7). No respondents noted any instances of organism deaths linked to the application of the marigold-based mosquito coil. This suggests that the product did not seem to cause any harmful effects on non-target organisms nearby. Regarding the overall opinion of the product, a significant majority (64%) of the respondents rated it as good, followed by moderately good (28%), excellent (4%), and only one respondent considering it bad (4%) (Fig. 8). These results suggest a generally positive perception of the marigold-based mosquito coil among the participants.

Overall, the results of the evaluation suggest that the marigold-based mosquito coil has demonstrated positive effects in repelling mosquitoes and reducing mosquito attacks according to the perceptions of the respondents. However, a notable proportion of participants reported experiencing side effects, primarily in the form of offensive smell, eye burning, breathing problems, coughing and tears. These findings highlight the importance of considering the potential side effects associated with the use of mosquito repellents.

5. Conclusion

In summary, this study aimed to evaluate marigold *(Tagetes erecta)* leaves as a natural mosquito repellent. The findings from study demonstrated the larvicidal activity of marigold leaf extract, with higher concentrations showing greater efficacy in reducing mosquito larvae populations. The extract exhibited a relatively fast-acting effect on larvae, highlighting its potential as a natural larvicide for mosquito control. Additionally, the smoke toxicity test showed that the marigold-based coil performs efficiently at eliminating adult mosquitoes, resulting in a very effective and eco-friendly mosquito control method. However, the commercial coil demonstrated a quicker action, while the marigold-based coil consistently maintained its efficacy over time. These outcomes contribute to our understanding of diverse mosquito control methods and can inform decision-making regarding mosquito management strategies. The evaluation of the mosquito repellent activity indicated that the marigold-based coil exhibited moderate to high effectiveness in repelling mosquitoes, as reported by the respondents. However, a significant proportion of respondents experienced side effects such as offensive smell, eye irritation, breathing problems, coughing, and tearing. It is crucial to consider and address these potential side effects when utilizing mosquito repellents.

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