

Study on marigold flower based herbal mosquito repellents using natural binders

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(Received 2 May, 2022; Accepted 30 June, 2022)

ABSTRACT

The present study was undertaken to evaluate the mosquito repellent property of marigold flower based cakes using natural binders. Marigold flower cakes were prepared using different natural binders such as neem powder, wood powder, coconut shell powder and cow dung and were impregnated with extracted marigold flower oil of different concentrations i.e. 0%, 5%, 10% and 15% using methanol as a carrier alcohol. The evaluation of mosquito repellent activity was carried out based on 3 parameters – flammability, burning efficiency with respect to burning time and mosquito repellent activity of the cakes. The results showed that marigold flower cakes with neem powder as a binder; impregnated with 15% marigold oil has the most effective repellence activity. From the present study it can be concluded that marigold flower based cakes can be used as potential repellent against mosquitoes.

Key words : Mosquito repellent, Marigold flower cake, Flammability, Natural binders

Introduction

Mosquito control has become crucial in today's environment due to the increased incidence of mosquito-borne diseases such as dengue, malaria, yellow fever, encephalitis and many others (Rani *et al.*, 2013; Ponkiya *et al.*, 2018). Mosquitoes are one of the most vexing bloodsucking insects that humans face (Ranasinghe *et al.*, 2016) which kills millions of people every year (Soonwera, 2015). Mosquitoes are alone responsible for the transmission of diseases to approximately 700 million people worldwide, with more than one million deaths every year (Mohomed *et al.*, 2012; WHO, 2014). Therefore, mosquito control and protection against mosquito bites has become the most significant measures to combat such diseases.

The World Health Organization has advocated different initiatives to control mosquitoes like environmental management of mosquito breeding areas

and use of chemical insecticides (Gou *et al.*, 2020). Other measures include repellents, netting, clothing and other personal protections (Soonwera and Phasomkusolsil, 2014).

Mosquito repellents are efficient in preventing mosquito bites since they may be used in any place and at any time (Gou *et al.*, 2020) and can be applied to the skin or any other surfaces where mosquitoes normally settle (Baruah and Borthakur, 2016). Many chemical repellents are available in the market like mosquito coils, DEET etc. DEET (N-N-diethyl-m-toluamide) is a potent insect repellent available nowadays in variety of forms such as pump sprays, creams, sticks, impregnated towelettes in 5% to 100% concentrations etc (Ponkiya *et al.*, 2018; Soonwera and Phasomkusolsil, 2014). Similarly, mosquito coils consists of synthetic pyrethroids as active components which have significant effect on the mosquitoes but their odour are disliked by many individuals and are thought to cause health compli-

cations (Rani *et al.*, 2013) and also acts as potent mutagen, carcinogen and teratogen (Shasany *et al.*, 2000; Phal *et al.*, 2012; Ponkiya *et al.*, 2018). Therefore, new active, particularly natural compounds have been sought as an alternative for these synthetic chemical repellents.

Plants have been utilised for ages against mosquitoes and other vectors due to its repellent property against mosquitoes and other vectors by hanging bruised plants in houses, as crude fumigants and oil formulations. It is still widely practiced in many developing nations as well as in many traditional communities (Patil and Morbale, 2021). Therefore, plant based mosquito repellent have been identified as an alternative to synthetic repellents as they are effective, easily biodegradable, environment friendly, less costly and have no side-effects (Soonwera, 2015).

The present study was undertaken to evaluate the mosquitocidal property of Marigold (*Tagetes erecta*) flower cakes, formulate herbal mosquito repellent cake using suitable binders and to compare the efficacy of natural repellent with synthetic repellents available in the market. There are various reports of usage of Marigold plants as traditional medicines to cure a variety of human illness and are also reported to have effective insect repellent property (Dixit *et al.*, 2013, Singh *et al.*, 2020 and Ponkiya *et al.*, 2018).

Materials and Methods

Collection of Marigold flowers: Fresh flowers of Marigold were collected from Dibrugarh district during 2018-2019 and identified.

Extraction of essential oil: The flower petals were separated and subjected to steam distillation for extraction of marigold oil. The extracted oil was then stored at a low temperature (4°C) until use. After the distillation process, the flower remains were collected for preparation of flower cakes (Rani *et al.*, 2013; Kumar, 2010; Soonwera, 2015).

Preparation of flower cakes using natural binders: The petals were grounded into a paste using distilled water by a kitchen blender for preparation of cakes. The cakes were prepared using 20% (w/w) of each natural binder and 80% of the marigold flower paste. 50 gm of the paste were placed in different disposal plates and mixed with 4 different natural binders. The natural binders used were neem pow-

der, wood powder, coconut shell powder (purchased from local vendors) and cow dung. Therefore, 4 different combinations of cakes were obtained. The cakes were prepared in duplicates for each combination and marigold flower paste without binder was taken as a control. Wet weights of each cake were taken. The cakes were then dried in the sun. After 4-5 days of drying; the dry weight was taken (Rani *et al.*, 2013). Preparation of different combinations of cakes is shown in Table 1.

Impregnation of the flower cakes with oil. The cakes were sprayed with the extracted essential oil of the marigold flower of different concentrations, i.e. 0%, 5%, 10% and 15% using methanol as a carrier alcohol.

Collection of mosquitoes. The mosquitoes were collected using a net between 7 P.M. to 10 P.M. The mosquitoes were then caged and provided with a 5% sugar solution until processing (Ranasinghe *et al.*, 2016; Costantini *et al.*, 2004).

Evaluation of mosquito repellent activity

The evaluation of mosquito repellent activity of marigold cakes were carried out based on its flammability, burning efficiency with respect to burning time and mosquito repellent activity as described by Rani *et al.*, 2013; Krober *et al.* and 2010; Sogan *et al.*, 2021.

Results and Discussion

The flammability, combustion time and effectiveness of the herbal repellent made up of different formulation of binders with marigold flower remains were checked by burning the cakes. The results of the present study showed a variable difference of the cakes in their effectiveness towards mosquito.

The amount of water loss was calculated by using the wet and dry weights of the cakes. The average water loss was found to be 39.4 g (Table 2).

Flammability and burning time test

15 g of cake from each type of dried cakes were burnt to maintain the uniformity to check the parameters. The residual percentage of the cakes was calculated based on ash weight and dry weight of the cakes (Table 3).

The lowest residual percentage was found to be of preparation-III impregnated with 15% marigold oil and the highest was found to be in preparation-

Table 1. Table showing different sets of cakes with their subsets.

Composition of cake	Nomenclature	Subsets
Marigold flower paste	Control	Control + 0% marigold oil Control + 5% marigold oil Control + 10% marigold oil Control +15% marigold oil
Marigold flower paste + 20% wood powder	Preparation-I	Preparation-I + 0% marigold oil Preparation-I + 5% marigold oil Preparation-I + 10% marigold oil Preparation-I + 15% marigold oil
Marigold flower paste +20% coconut shell powder	Preparation-II	Preparation-II + 0% marigold oil Preparation-II + 5% marigold oil Preparation-II + 10% marigold oil Preparation-II + 15% marigold oil
Marigold flower paste+ 20% neem powder	Preparation-III	Preparation-III + 0% marigold oil Preparation-III + 5% marigold oil Preparation-III + 10% marigold oil Preparation-III + 15% marigold oil
Marigold flower paste + 20% cow dung	Preparation-IV	Preparation-IV + 0% marigold oil Preparation-IV + 5% marigold oil Preparation-IV + 10% marigold oil Preparation-IV + 15% marigold oil

Table 2. Average wet and dry weights of marigold flower cakes.

Samples	Average wet weight (g)	Average dry weight (g)	Water loss(g)
Control	50±0	8.2±1.2	42.8
Preparation-I	50±0	13.8±1.4	36.2
Preparation-II	50±0	11.2±1.3	38.8
Preparation-III	50±0	10.6±1.2	39.4
Preparation-IV	50±0	10.1±1.5	39.9

Average water loss=39.4 g

IV impregnated with 0% marigold oil. The maximum time for combustion was found to be of the control cakes whereas; the minimum time was taken by the cakes under preparation-III.

The cakes were also checked for their irritability factor. The control, preparation-I and preparation-III showed no irritability whereas; preparation-II showed little irritability and had a burning effect on eyes. Preparation-IV showed high irritability and also had a burning effect on eyes with a pungent smell. It was also observed that the cakes of preparation-I, preparation-II and preparation-III were fully flammable but the cakes under control and preparation-IV were partially flammable (Table 3).

Test for effectiveness

(a) In- field test: The cakes were burnt in mosquito

prone areas of DHSK College, Dibrugarh and the reviews of people were noted down. The reports were positive i.e. the mosquitoes escaped from the area of burning (Table 4).

The total combustion time and the time of repellence showed by each cake are shown in Table 5. Preparation-III showed the maximum repellence for at least 180 minutes, followed by Preparation-II. Control and Preparation-IV showed repellence for a total of 90 minutes approximately, while, the least repellence was seen in Preparation-I.

(b) In-vitro test: The total number of mosquitoes killed with respect to total combustion period of the cakes and specific time period of 15 minutes were evaluated by the smoke-toxicity test shown in Table 6.

The results showed that, during a specific time period of 15 minutes, the highest number of mosquitoes killed was 13 in Preparation-III, while, the least number of mosquitoes killed was 5 in Preparation-I. On the basis of total combustion time of the cakes, the highest number of deaths recorded was 24, in Preparation-III, while, the least number of death was 11, in Preparation-I. It can also be inferred from the given data that the effectiveness of the cakes increases with the increase in the concentration of marigold oil impregnation.

The results of the comparison between the marigold cakes formulated with different herbal binders

Table 3. Parameters for checking the burning time and flammability

Samples	% of marigold oil	Dry weight (g)	Ash weight (g)	Burning time (min)	Residual %	Irritation	Flammability (PF – Partially flammable FF – Fully flammable)
Control	0	15	5.2	41	34.7	No	PF
	5	15	4.2	43	28	No	PF
	10	15	4.02	39	26.8	No	PF
	15	15	4.5	41	30	No	PF
Preparation- I	0	15	2.79	35	18.6	No	FF
	5	15	2.6	27	17.3	No	FF
	10	15	2.7	25	18	No	FF
	15	15	2.28	28	15.2	No	FF
Preparation-II	0	15	2.22	25	14.8	Less	FF
	5	15	2.28	22	15.2	Less	FF
	10	15	2.11	28	14.06	Less	FF
	15	15	2.37	32	15.8	Less	FF
Preparation-III	0	15	1.36	24	9.06	No	FF
	5	15	1.07	22	7.13	No	FF
	10	15	1.05	21	7	No	FF
	15	15	1.02	19	6.8	No	FF
Preparation-IV	0	15	5.80	32	38.6	High	PF
	5	15	5.68	31	37.8	High	PF
	10	15	5.26	28	35	High	PF
	15	15	5.22	33	34.8	High	PF

Table 4. Mosquito repellency test in different areas of College campus.

Areas	Observation	Remarks
College premises	Mosquitoes escaped	Repels mosquitoes
Laboratory	No mosquitoes were observed	Repels mosquitoes
Cafeteria	Mosquitoes escaped	Repels mosquitoes

Table 5. Comparison of time for effectiveness of the cakes after burning of full cake.

Marigold cake samples	Total combustion time (min)	Effectiveness				
		30 min	60 min	90 min	120 min	180 min
Control	65.75	+	+	+	-	-
Preparation-I	37	+	+	-	-	-
Preparation-II	28.25	+	+	+	+	-
Preparation-III	22	+	+	+	+	+
Preparation-IV	49	+	+	+	-	-

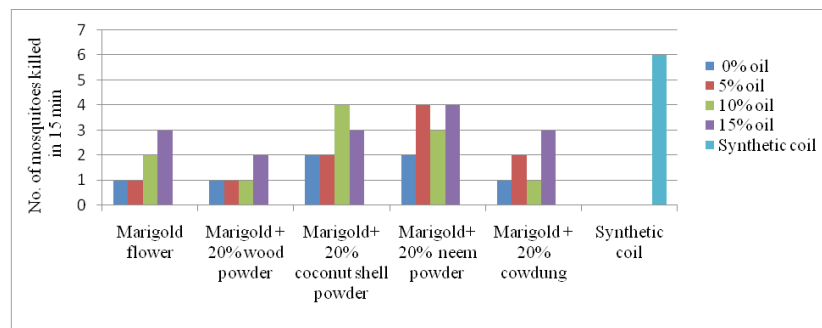
and a synthetic repellent showed that the synthetic repellents was more efficient than the marigold cakes with different herbal binders (Figure 1).

A number of synthetic pesticides or repellents used to control insects pose various environmental and human health risks (Baruah and Borthakur, 2016) and are mostly expensive (Karunamoorthi *et al.*, 2008). Therefore, natural products with high ef-

ficacy and low environmental impact are searched as an alternate approach and plants are considered as an effective alternative. Plants-based products are used since ancient times in controlling mosquitoes and other vectors and are known to be effective as they are environment friendly, less costly, easily biodegradable, has less side-effects and are easily available (Soonwera, 2015; Karunamoorthi *et al.*, 2008).

Table 6. Showing smoke toxicity of the formulated repellent with respect to the knock down rate of mosquitoes.

Samples	Concentration of marigold oil (%)	Burning time (min)	No. of mosquitoes killed in 15 minutes	Total mosquitoes killed in 15 minutes	No. of mosquitoes killed (out of 10)	Total mosquitoes killed
Control	0	69	1	7	3	15
	5	65	1			
	10	62	2			
	15	67	3			
Preparation-I	0	39	1	5	2	11
	5	36	1			
	10	38	1			
	15	35	2			
Preparation-II	0	27	2	11	4	18
	5	29	2			
	10	25	4			
	15	32	3			
Preparation-III	0	25	2	13	5	24
	5	21	4			
	10	22	3			
	15	20	4			
Preparation-IV	0	52	1	7	3	16
	5	49	2			
	10	50	1			
	15	45	3			

**Fig. 1.** Graphical comparison of repellence property between marigold cakes formulated with different binders and also with synthetic coil.

The results indicated that the marigold flower cakes with different binders have variable effects against mosquitoes and the marigold flower cake with neem powder impregnated with 15% marigold oil proved to be the best combination and showed the greatest repellence property among all the combinations formulated and hence, can be used as a suitable natural mosquito repellent. The comparison between synthetic repellents and marigold flower cakes indicated that the synthetic repellents were more effective than the natural repellents. However, the cakes showed the nearest knockdown rate to the synthetic one.

Conclusion

From the present study it can be concluded that Marigold plant can be used an efficient alternative against synthetic mosquito repellent. The marigold flower cakes with neem powder as a binder, impregnated with 15% marigold oil have less residual percentage, shows efficient flammability, does not show irritability and is able to repel mosquitoes effectively and thus is considered as an efficient herbal repellent against mosquitoes.

Interest conflict

There is no interest conflict.

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