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Design and Development of Lemongrass Oil Effervescent Tablet to Control the Mosquitoes in Early Stages

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KEYWORDS

Effervescent tablet

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ABSTRACT:

Introduction: Mosquitoes, the buzzing bane of our existence, pose a significant threat to human health, transmitting diseases like dengue, malaria, and chikungunya. So, the effective early-stage mosquito control is crucial for prevention. While existing control methods offer varying degrees of success, they often come with drawbacks like environmental and human toxicity or limited range. But the plant metabolites or secondary metabolites are more effective for killing of mosquito larva and also, they are safer to humans and environment.

Objectives: This study designed and developed to create a lemongrass oil effervescent tablet to control the mosquito in early stages with eco-friendly. Lemongrass oil dispersed effervescent tablet is able to self-disperse and release the lemongrass oil uniformly, which makes it effective in controlling larvae with no toxic to environment and humans.

Methods: In this study, attempts have been made to develop effervescent tablet, containing lemongrass oil as a larvicidal activity. Upon contact with water, these tablets would rapidly dissolve, releasing the encapsulated oil as a fine mist. This targeted release mechanism aims to maximize mosquito exposure while minimizing environmental impact. Factors like tablet composition, and dissolution time will be ensuring the mosquito larvicidal action. In vitro assays (larvicidal assay) will assess the larva killing efficacy of the released oil against mosquito larva and also evaluated for thickness, hardness, diameter, weight variation and friability of tablet.

Results: The formulated lemon grass oil effervescent tablet shows immediate and sustainable larvicidal activity and after 24 hr also tablet maintained larvicidal activity, but mortality time is increased. So, once we are adding tablets to the water, the chance of mosquitoes breeding in this water is very low. Tablet have high strength and resistance to crumbling or breakage under stress but it easily dissolved in water.

Conclusions: This tablet will be very effective for larval control after application. The tablet can be used in stagnant water like water in bottles, used tires etc around the residential areas after rainy season or some drainage problems which will serve as mosquito breeding place. The tablet is safe for humans, animals and the environment. So, effervescent tablet can be used a very good formulation for fast and mosquito control.

1. Introduction

India is a hot spot for many kinds of mosquito-borne illnesses because of its diversified climate and geography. Nearly 40 million people in India get infected with diseases spread by mosquitoes each year. In rainy season rainfall creates stagnant water bodies, such as barrels, and bird baths, as well as discarded or abandoned items like tires, jars, cans, and buckets that serve as ideal breeding sites for mosquitoes. Hence rainy season gives them golden opportunities to breed rapidly. The use of synthetic insecticides have been used to reduce mosquito or mosquito larvae but the continuous application of synthetic insecticides causes the development of resistance in vector species, biological magnification of

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toxic substances through the food chain, and adverse effects on environmental quality and non-target organisms including human health. So, in recent years, the use of many of the former synthetic insecticides in mosquito control programs has been limited. Hence Natural compounds like plant secondary metabolites, plant extracts, and also essential oils are One of the most effective, simple, and suitable alternative approaches to control mosquitos with minimal hazardous effects on human health and the environment. [1,2,3]

Fig No. 1: immature mosquitos discarded water filled jar

Fig No. 2: discarded tires, which are popular habitat for immature container mosquitoes

Many researchers have reported on the effectiveness of plant extracts or essential oils against mosquito larvae. Lemongrass is very popular and used for medicinal, food, and potent insect-repellent properties. Lemongrass essential oil at 10% concentration killed 100% of these three species of mosquitoes within 24 hours of exposure, while citronella oil at 10% also killed 100% of C. *quinquefasciatus* and An. *dirus* and 97.6% of Ae. *aegypti* adults in 24 hours post-exposure. Alkaloids, flavonoids, and carotenoids have been found in lemongrass oil, indicating its potential as a bio-insecticide. In addition, tannin compounds may be used as inhibitors of the enzyme activities in insect digestion. Citral (geranial and neral mixture) is considered for the insecticidal activity of lemongrass oil, resulting from its interaction with oxidative stress and intracellular oxygen radicals. [3,4]

While synthetic larvicides dominate the market, botanical pesticides offer sustainable alternatives for larval control. Among these, lemongrass stands out for its multi-faceted activity. It demonstrates antifeedant, anti-ovipositional, and growth-regulating properties, effectively repelling and killing mosquitoes at various life stages. Its effectiveness against mosquitoes specifically, alongside its lack of harmful residues, makes it an attractive option for both larval and adult control. While numerous formulations exist for adult mosquitoes, such as repellents, coils, and sprays, a gap exists in larval control options[5]. This study aims to bridge this gap by developing effervescent tablets, a rapid and efficient formulation for targeted larval control. These tablets achieve high and uniform dispersion of lemongrass oil through compression with inert binders and rapid release of carbon dioxide upon contact with water.

2. Materials and methods

Lemongrass oil and Magnesium stearate was obtained from Isochem Laboratories, Kochi, India, Silica powder was purchased from Yarrow Chem Pvt Ltd, Mumbai, Citric acid, Glucose, Sodium lauryl sulphate, Sodium bicarbonate and Tartaric acid was purchased from Nice chemicals, kochi.

2.1 Formulation of effervescent tablet [6,7]

Table No.1 : Formulation Table of Effervescent Tablet

SI.No	Ingredients	Working Formula
1	Lemongrass oil (ml)	0.075
2	Silica (mg)	37.5
3	Sodium lauryl sulphate (mg)	2.5
4	Glucose (mg)	7.5
5	Magnesium stearate (mg)	2.5
6	Citric acid (mg)	20

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7	**Tartaric acid (mg)**	**25**
8	**Sodium bicarbonate (mg)**	**55**

Wet granulation

0.075ml of lemongrass oil, the optimal amount for 37.5mg silica (to avoid aggregation and flowability issues), was transferred to a full cone nozzle sprayer and sprayed onto the weighed silica in a 500ml beaker. The mixture was stirred continuously with a glass rod while spraying.

Once the lemongrass oil was evenly dispersed, inert ingredients were added sequentially; Sodium lauryl sulfate (dispersing agent), Glucose (disintegrating agent), and Silica (filler). All ingredients were homogenized in a kitchen blender at 200 rpm for 10 minutes for uniform mixing. Finally, effervescent agents - citric acid, tartaric acid, and sodium bicarbonate - were incorporated.

Lubrication

Following uniform mixing, magnesium stearate, a crucial lubricant, was added and mix with glass rod for 5 minutes, finalizing the ingredient composition.

Compression

The powders are mixed with glass rod. After granulation then granulated, powdered material was transferred to tablet machine funnel and compressed by tablet punch machine with 250 mg punch set.

2.2 Pre-compression test

Angle of repose [8,9]

To determine the angle of repose, we utilized the fixed funnel method. This technique involves securing a funnel at a set height above horizontally placed graph paper. Granules were gently poured through the funnel, forming a conical pile. When the pile's apex just grazed the funnel tip, the base radius (r) was measured.

$$\tan \theta = h / r$$

h – height , r - radius

Bulk density [8,9]

A precisely weighed sample of the granules was gently funneled into the measuring cylinder. Without disturbing the pile, its level was recorded as the apparent volume.

Bulk density was calculated by the formula given below,

Bulk density = M / VO

Where,

M - Mass of powder taken

Vo - Apparent untapped volume

Tapped density [8,9]

To determine the tapped density, a specific amount of drug-excipient blend was placed in a graduated cylinder. The cylinder was repeatedly dropped from a fixed height (10 cm) onto a hard surface at regular intervals (2 seconds). This tapping continued until the packed volume of the blend stabilized, indicating no further decrease in density.

Tapped density was measured using the following formula,

Tapped density = Weight of the powder / Volume of tapped packaging

Hausner's ratio [8,9]

Building on research by Hausner, who discovered a link between the ratio of tapped and bulk densities and interparticle friction, scientists developed the Hausner ratio as a tool to predict powder flow properties.

Hausner's ratio is calculated using the following formula,

Hausner's ratio = Tapped density / Bulk density

Carr's Index [8,9]

Calculating the difference between a powder's loose and tapped densities, known as percentage compressibility, provides an indirect measurement of its flowability.

Carr's index of each formulation was calculated according to the equation given below,

$$\text{Carr's Index} = [(Df - DO) / Df] \times 100$$

DO - Bulk density

Df - Tapped density

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2.3 Evaluation of effervescent tablet (Post-compression Parameters)

Tablet dimensions [9]

Consistent tablet size, reflected in the minimal thickness variation within each formulation, indicated uniform powder blends and stable compressive behaviour. Both thickness and diameter were measured with a vernier calliper.

Hardness of tablet [10]

To assess tablet hardness, a Monsanto hardness tester, a device employing a compression spring, was utilized. The tester's lower plunger was positioned on the tablet, establishing a baseline reading. The upper plunger was then incrementally driven downward via a threaded bolt, compressing the spring until tablet fracture occurred. A pointer, tracking spring compression along a gauge, visually indicated the applied force. The fracture force was noted, with the initial zero-force reading subtracted to determine net force. This procedure was performed on ten tablets representing each formulation.

Weight variation [11]

Weight variation was determined to know whether different batches of tablets have uniformity. Weighed 20 tablets individually, calculated the average weight and compared the individual tablet weights to the average. The tablets meet the test if not more than two tablets are outside the % limit and none of the tablet differ by more than two times the % limit. Weight variation specification as per I.P. is shown in table.

Percentage Deviation = (Individual weight - Average weight) / (Average weight) × 100

Friability [12]

Ten tablets were subjected to a friability test. The instrument rotated at 25 revolutions per minute for 4 minutes. The tablets were then reweighed, and the weight difference was used to determine the friability.

Friability Percent = (Initial weight - Final weight)/ (Final weight) × 100

Measurement of effervescent time [13,14]

The effervescent time is measured *in vitro* by placing a defined amount of the formulation in 150 ml of water and recording the time it takes for the bubbling to cease. This test is repeated to ensure accurate results.

Larvicidal assay [15,16]

In 200 millilitre beakers holding 100 larvae, four effervescent tablets infused with lemongrass oil were introduced. Upon tablet dispersion, the time it took for the first larva to dead was recorded. Subsequently, the duration for all 100 larvae to mortality was monitored, along with retesting the mortality rate after 3,6,9,12 and 24 hours, each time introducing a new batch of 100 larvae into the same solution. This entire study was conducted three times, and the average results were considered. The larvae were considered dead if they were immobile and unable to reach the water surface. The experiments were carried out under stable conditions at 25±2 °C.

3. Results And Discussion

3.1 Pre-com pression test

The powder flow is critical during tableting as it must flow easily and uniformly into the tablet dies to ensure tablet weight uniformity and production of tablet with consistent and reproducible properties. The pre-compression study confirmed that the powder is good flow property. So, it's very effective for tablet preparation.

Table No.2: Average value of Pre-compression Parameters of the powder

formulation	Angle of repose	Bulk density	Tapped density	Hausners ratio	Carr's index
F1	25.68°	0.416 g/ml	0.487 g/ml	1.17	14.5

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3.2 Formulation of effervescent Tablets encapsulated with lemongrass oil

Lemongrass oil encapsulated effervescent tablets was prepared using silica powder. Silica has good oil absorption power. Disintegrating agent, lubricating agent and effervescent agent is added. The powders are mixed with glass rod. After granulation then granulated, powdered material was transferred to tablet machine funnel and compressed by tablet punch machine with 250 mg punch set. the photograph of formulated tablets is given below.

Fig No.3: Lemongrass oil effervescent tablet

indicates that, all formulated tablets have good strength characteristics.

Weight variation and Friability

Weight variation was found to be 0.38 % and friability was found to be 0.959 % indicates a high resistance of the tablet to crumbling or breakage under stress.

Measurement of effervescent time

The effervescent time of tablets is determined by its dissolution rate when placed in water, usually ranges as 2.50, 3.0, 2.58 minutes and having a resultant average time of 3.09 minutes for complete dissolving.

Larvicidal Assay

The larvicidal assay of the effervescent tablet was conducted through a series tests aimed at evaluating its efficacy in eliminating larvae. After the complete dissolution of the tablet within less than 1 minute, the first larva died. After 74.33 min, 100% mortality takes place. Then, after 3, 6,9, 12, and 24 hours, mortality was checked. As a result, the tablet should be showing a 100% mortality rate, but the killing time is varying. These results collectively highlight the tablet's consistent and robust larvicidal properties across multiple tests, emphasizing its potential effectiveness in controlling Larva populations. After 24 hr the tablet is also maintained its activity, but mortality time is increased. So, once we are adding tablets to the water, the chance of mosquitoes breeding in this water is very low.

Table No.3: Larvicidal Assay of the effervescent tablet

Experient time	TEST I	TEST II	TSET III	Average time (min)
First larva dead time (min)	3.23 min	4.20 min	3.50 min	3.64 min
100 larva dead time (min)	70 min	78 min	75 min	74.33 min
After 3 hr, 100 larva killing time (min)	150 min	147 min	152 min	149.67 min
After 6 hr, 100 larva killing time (min)	210 min	220 min	217 min	215.67 min
After 9 hr, 100 larva killing time (min)	275 min	279 min	274 min	276 min
After 12 hr, 100 larva killing time (min)	338 min	330 min	340 min	336 min
After 24 hr, 100 larva killing time (min)	550 min	520 min	530 min	533.33 min

3.3 Evaluation of Effervescent Tablets

Thickness, Diameter and hardness

Thickness and hardness of effervescent tablets average range was 4.04 mm and hardness were 6.26 kg/cm2.It

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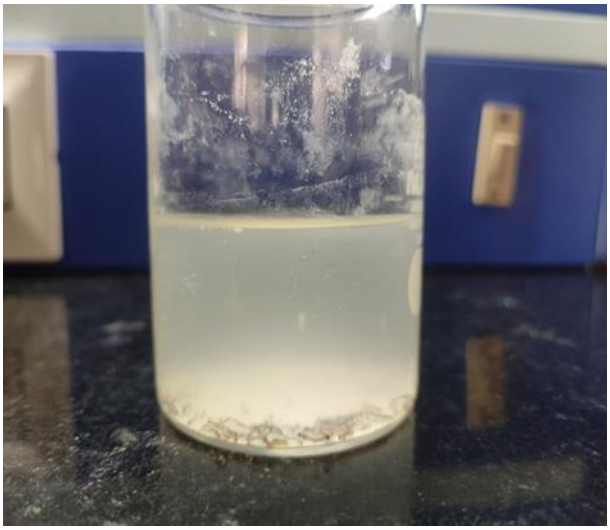

Fig No.4: larvicidal assay

4. Summary

The research aimed at designing and developing lemongrass oil effervescent tablets with the objective of controlling mosquitoes during their early stages. The pre-compression parameters revealed favourable characteristics, with an angle of repose at 25.68°, bulk density of 0.416g/ml, tapped density of 0.487 g/ml, Hausner ratio at 1.17, and a Carr index of 14.5. During the evaluation of these effervescent tablets, dimensions were recorded at a diameter of 7.6 mm and a thickness of 4.04 mm, with hardness measuring at 6.26 kg/cm2. The tablets showed a weight variation of 0.38 % and exhibited a high resistance to breakage with a friability index of 0.959 %. The effervescent reaction time was measured at 3.09 seconds, highlighting the efficient release of the active ingredient. Moreover, the larvicidal activity displayed promising results in three separate tests. All the test after the dissolution within less than 1 minutes the first larva is died. Similarly, all the larva was dead in average 74 minutes is take it. As a result of all the study tablet have 100% mortality rate but the time is varying. These results demonstrate that it has strong larvicidal action, which it sustained they are action, and it inhibit mosquito reproduction in the same water.

5. Conclusions

The formulated Lemongrass Oil Effervescent Tablets effective to control the mosquito larva from the early stages. The tablet exhibited promising pre-compression parameters and tablet characteristics, demonstrating stability and robustness. Despite slight variations in weight and consistent effervescent behaviour, the tablets-maintained integrity with high friability resistance and appropriate dimensions. The significant highlight emerged from the larvicidal activity tests, showcasing effectiveness against mosquito larvae across multiple trials and mortality immediately after the using of tablet. The varying death times and killing rates signify potential for mosquito control in their early stages, indicating the tablets viability as potential solution in mosquito management and preventing further chance for mosquito breeding in same as. So, this effervescent tablet can be used as a very good formulation for immediate and sustained action for mosquito larva control, it is safe for humans, animals and the environment. Hence, it is a more important and useful formulation for our society.

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