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A comprehensive review on formulation and evaluation of mosquitocidal gel from *Duranta erecta*

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Abstract
The plant *Duranta erecta*, which has been known to have insecticidal qualities, has being investigated as a possible source of environmentally acceptable mosquitocidal chemicals. This review focuses on the formulation and assessment of a mosquitocidal gel made from *Duranta erecta*, emphasizing the bioactive phytochemicals alkaloids, flavonoids, and terpenoids that are essential to the gel's insecticidal action. These substances are extracted and then added to a gel matrix that is intended for convenient application and long-term release. The physicochemical characteristics of the gel, such as its pH, viscosity, and stability, as well as its efficacy against mosquito larvae and adults, are assessed. According to preliminary research, the gel derived from *Duranta erecta* shows great promise as a natural substitute for chemical pesticides, providing important safety and environmental benefits. These findings highlight the possibility of including plant-based pesticides in public health campaigns to stop diseases spread by mosquitoes.

Keywords: *Duranta erecta*, mosquitocidal gel, natural insecticides, golden dewdrop

Introduction
In developing nations, people and communities are increasingly turning to the usage of medicinal plants. Herbal medicines are becoming more and more popular because they are effective, accessible, economical, and culturally acceptable. They also reportedly have less negative effects than synthetic drugs, which are more common in Africa [1]. Plants are a rich source of medicinal materials because they produce a variety of bioactive chemicals that include elements with therapeutic effect. In the US, prescription medications are made from plant sources in about 25% of cases. The different elements give plants unique characteristics and attributes [2]. Plants are a major source of natural medicines used in folk medicine to treat a wide range of illnesses. The problem of maintaining our rapidly declining forest has been highlighted by our over-reliance on traditional folk medicine. The majority of Ghanaian traditional healers rely on our forests for their livelihood, and our backyards are overrun with beautiful flora that provide excellent herbal remedies. Therefore, researchers must screen attractive plants for biological and pharmacological qualities if we hope to preserve our forest for sustainable development. This is a component of research finding ornamental plants' other uses [3].

Duranta is a genus with 35 species that is part of the Verbenaceae family. This plant is indigenous to South and Central America, Africa, and Asia. Known by most as "golden dew drop," *Duranta erecta* (synonym for D. repens) is an upright, scrambling shrub that grows to a height of 1-3 meters. In many Ghanaian houses, it is cultivated as an ornamental plant or hedge. From the genus Duranta, phytoconstituents such as lamiide, (E)-cinnamic acid, (E)-p-methoxycinnamic acid, and coumarinolignoids have been discovered [4]. Many bioactive substances have been discovered and extracted from *Duranta repens*, including β-sitosterol, naringenin, acteoside, lamiide, sucrose, and raffinose. Many diseases can be treated with different plant parts. In traditional folk medicine, the fruit and leaves are used to cure intestinal worms, malaria, and abscesses. They can also be used as a diuretic or vermifuge in some situations. It is claimed that *D. erecta* has strong antibacterial and anticancer properties [5]. Its antifungal and insecticidal qualities are just two of its many natural applications [6]. According to reports, the chloroquine-sensitive and chloroquine-resistant strains of Plasmodium falciparum were significantly inhibited by the ethyl acetate leaf extract.

Extracts of several components, including the roots, stem, and leaves of *D. Rhizopus* sp., *Alternaria* sp., *Penicillium* sp., *Aspergillus flavus*, and *Trichoderma* sp. were all susceptible to the antifungal effects of erecta [7].

Tropical shrub *Duranta erecta*, sometimes referred to as Skyflower or Golden Dewdrop, has many uses in both ornamental gardening and traditional medicine. This plant is recognized for its diverse phytochemical constituents, including flavonoids, terpenoids, and alkaloids, which have demonstrated various biological activities [8]. Recent studies have highlighted its potential as a source of natural insecticidal compounds. Gels are an excellent vehicle for delivering active chemicals due to their ease of application, controlled release features, and non-greasy nature [9]. A mosquitocidal gel is made by incorporating *Duranta erecta*-derived bioactive chemicals into a gel matrix. A product's ultimate effectiveness is largely determined by its gel base selection, compatibility with active chemicals, and formulation stability. A variety of assessments are used to determine the mosquitocidal gel's efficacy, such as determining mosquito fatality rates, repellency, and safety for human use [11]. Important review elements also include the gel's stability in a range of environmental circumstances and its effect on non-target species. The goal of this study is to offer a thorough overview of the most recent studies on the creation and assessment of mosquitocidal gels utilizing *Duranta erecta*. The bioactive components of the plant, the formulation techniques used, and the effectiveness and safety of the resulting gels will all be covered. This review aims to identify gaps in the current knowledge and propose directions for future research by synthesizing the existing literature and highlighting recent advancements [11].

Fig 1: *Duranta erecta*

Cultivation and Collection

Duranta erecta is primarily cultivated for ornamental and therapeutic purposes, particularly for its fruit. Optimal fruit production requires well-drained soils and full sunlight, as the plant thrives in tropical and subtropical regions. The small, orange-yellow fruits, which appear in clusters after flowering, are valuable for medical research due to their diverse bioactive compounds and aesthetic appeal [12]. These fruits are typically harvested when fully mature, in late summer or early fall, when phytochemical concentrations are highest. Due to their delicate nature and susceptibility to bruising, careful handling is essential during collection. After harvest, fruits are often air-dried to preserve their phytochemical content for future processing. Sustainable harvesting practices are recommended to prevent depletion of natural populations, especially when fruits are collected for phytochemical extraction [13].

Phytochemical Screening of *Duranta erecta*

The presence or lack of secondary metabolites such as tannins, alkaloids, flavonoids, saponins, sterols, and phenolic substances was ascertained by phytochemical screening. The specified method was followed in doing this [14, 15, 7, 16].

Test for terpenoids (Salkowski's test)

Two ml of chloroform were applied to each 0.5 gram of extract. To create a layer, 3 ml of concentrated H2SO4 was carefully applied. The reddish-brown coloring of the interface indicates the presence of terpenoids.

Test for flavonoids (Shinoda Test)

Flavonoids were detected using three methods: First, 5 ml of diluted ammonia and 1 ml of concentrated sulfuric acid were added to the extract's aqueous filtrate, showing a yellow color that fades over time. Second, a few drops of 1% aluminum solution were added, with a yellow coloration indicating flavonoids. Third, 10 ml of ethyl acetate was heated with the extract for three minutes, then filtered. Mixing 4 ml of the filtrate with 1 ml of diluted ammonia solution resulted in a yellow color, confirming the presence of flavonoids.

Test for saponins (Foam Test)

Five milliliters of distilled water were added to 0.5 grams of extract in a test tube. We gave the mixture a good shake and looked for a stable, long-lasting foam. After mixing the foam with three drops of olive oil and giving it a good shake, the creation of an emulsion was checked.

Carbohydrate Test (Molish's Test)

A small amount of extract was treated with an alphaNaphthol solution in alcohol, shakes and adds conc. H2SO4 from the test tube walls and looked for the development of a violet ring where two liquids met.

Test for tannins (Lead Acetate Test)

In a test tube, around 0.5 g of the extract was heated in 10 ml of water and subsequently filtered. After adding a few drops of 0.1% ferric chloride, the coloration was checked for brownish green or blue-black.

Test for alkaloids (Dragendroff's Test)

After boiling and filtering, 0.5 g of the extract was diluted with 10 ml of acid alcohol. To 5 ml of the filtrate, 2 ml of diluted ammonia was added. The alkaloidal base was extracted with 5 ml of chloroform, then separated by adding 10 cc of acetic acid. The chloroform layer was divided into two parts: one was treated with Mayer's reagent, and the other with Dragendorff's reagent. Alkaloids were indicated by a cream formation with Mayer's reagent or a reddish-brown precipitate with Dragendorff's reagent.

Test for phenol

To determine the total phenols in each test sample, a standard curve for caffeic acid, a phenol, was created using the Bray and Thorpe 17 methodology. A 100 µg/ml stock solution of caffeic acid was prepared in 80% ethanol. Varying volumes (0.1 to 0.9 ml) of this solution were added to separate test tubes, with the total volume adjusted to 1 ml using 80% ethanol. To each tube, 1 ml of Folin-Ciocalteu reagent (diluted with distilled water in a 1:2 ratio just before use) and 2 ml of 20% Na2CO3 solution were added. The

mixture was shaken vigorously and then boiled for one minute in a water bath. After cooling, the solution was diluted to 25 ml with distilled water. The optical density (OD) at 750 nm was measured using a spectrophotometer, with a blank for comparison.

Test for steroids
2 ml of acetic acid was added to 0.2 g of each component; the mixture was then thoroughly chilled in ice before the cautious addition of conc. H2SO4. Changes in color from violet to blue or bluish-green suggested the existence of a steroidal ring, or the cardiac glycoside's aglycone component.

Protein Test (Biuret Test)
Add a few drops of 1% CuSO4 solution together with 4% NaOH to extract. The presence of protein is indicated by the emergence of violet or pink color.

Physicochemical Analysis
Moisture Content: The moisture content was ascertained by use of a specific procedure. The extract was put in a moisture dish made of Aluminum and baked at 100-105 °C until it reached a constant weight [17]. Next, the following formula was used to calculate the sample's weight loss:

Moisture content = Weight loss / Weight of sample × 100

Total Ash Content
To calculate the overall ash content, a specific technique was applied. The extract was carefully weighed in a previously lighted and tarred crucible. The material was then equally divided and fired in a muffle furnace, with the temperature gradually increased to 600 °C until the substance turned white, indicating the absence of carbon. The crucible was weighed after being allowed to cool in a desiccator [17]. The total ash content of the dry material was calculated as follows:

Total Ash = Total ash weight / weight of sample × 100

Acid - Insoluble Ash Content
The quantity of ash that was insoluble in acid was calculated using a specific technique. 5 ml of nitric acid were used to boil the ash that resulted from calculating the total ash content for fifteen minutes. The residue that was not soluble in acid was then collected, run through a sintered glass crucible and ashless filter paper, and then cleaned with hot water. After that, the result was burned to get a constant weight and weighed. The concentration of acid-insoluble ash in the air-dried extract was then calculated [17].

Acid insoluble ash = Acid insoluble ash weight / weight of sample × 100

Water Soluble Ash
This is calculated in the same way as acid insoluble ash, but with 25 milliliters of water instead of diluted hydrochloric acid [18].

Medicinal Use of *Duranta erecta*
Duranta erecta has long been used in traditional medicine for treating various conditions. Its flowers are known for their stimulating properties, while the fruit juice and leaf infusions act as diuretics. However, both the leaves and fruit test positive for poisonous hydrocyanic acid, and in Chinese medicine, certain fruits are considered deadly. Despite this, *D. erecta* is used to treat malaria, with water-macerated fruit juice proving lethal to mosquito larvae, making it useful as a larvicide in ponds. In Chinese medicine, the leaves treat abscesses, and the fruits are used for malaria [19]. In Bangladesh, *D. erecta* has been trialed for malaria, insect repellent, skin itchiness, fever, pneumonia, and infertility [20]. In India, a whole plant decoction is used for bronchitis, asthma, and fever, while stems and leaves are applied in cataract surgery [21, 22]. In Nigeria, the fruits treat malaria, parasitism, and abscesses [23, 24].

Fig 1: Medicinal uses

Insecticide Property of *Duranta erecta*

Extracts from *Duranta repens* show strong insecticidal and antifeedant properties [25]. Nikkon *et al*. [26] found the stem and fruit extracts from Bangladesh to be potent larvicides against *Culex quinquefasciatus*, with a 12h-LC_{50} of 10.75 ppm for the stem and 8.51 ppm for the fruit. Hemavathy and Anitha reported higher mortality rates for *C. quinquefasciatus* larvae using ethanolic leaf extracts compared to aqueous and methanolic extracts from India [27, 28]. Roy *et al*. demonstrated the aqueous extract's effectiveness in reducing egg viability and mite population in *Oligonychus coffeae*, comparable to commercial neem oil and synthetic pesticide propargite [28, 29].

Numerous bioactive substances in *Duranta erecta* contribute to its insecticidal effects by targeting various physiological mechanisms in insects. The key insecticidal substances present in *Duranta erecta* include:

1. Saponins

- **Mechanism:** Glycosides called saponins have the ability to damage insect cell membranes, causing lysis and eventual death of the cells. Additionally, they feature antifeedant qualities that reduce insects' preference for plants.
- **Effect:** Effective against pests of agriculture and a variety of other insects, such as mosquitos.

2. Alkaloids

- **Mechanism:** Alkaloids cause neurotoxicity, which can result in paralysis or death, by interfering with an insect's nervous system.
- **Effect:** especially successful against insects such as caterpillars and aphids.

3. Flavonoids

- **Mechanism:** Flavonoids have the power to interfere with insect metabolism and function as antioxidants. They might also obstruct the actions of enzymes that are essential to the survival of insects.
- **Effect:** Provide a wide range of protection against insect pests and may enhance the plant's repelling qualities.

4. Tannins

- **Mechanism:** Tannins attach to proteins and can prevent insects' digestive enzymes from working, which lowers nutritional absorption and stunts growth.
- **Effect:** Efficient against insects that feed on plants, causing growth retardation or even death.

5. Coumarins

- **Mechanism:** Insects' neurological systems may be impacted by coumarins, which could result in confusion and ultimately death. They possess antifeedant qualities as well.
- **Effect:** frequently employed to get rid of bugs and mosquitoes.

6. Terpenoids

- **Mechanism:** Terpenoids have the ability to upset an insect's hormonal balance, which can impact its growth and ability to reproduce. Because they interfere with insect pheromones, they may potentially have repellent properties.
- **Effect:** Beneficial for managing a range of insects, such as agricultural pests and mosquitoes.

7. Essential Oils

- **Mechanism:** Terpenoids and other volatile chemicals that have the potential to function as insecticides or repellents are present in the essential oils extracted from *Duranta erecta*.
- **Effect:** They work well as organic insect repellents and have demonstrated efficacy against pests like mosquitoes.

Chemical Composition of *Duranta erecta*

Duranta erecta is known for its insecticidal properties due to its diverse chemical composition, including saponins, alkaloids, flavonoids, tannins, coumarins, terpenoids, and essential oils. Saponins, like oleanolic and ursolic acid glycosides, disrupt insect cell membranes, causing cell lysis and death [30]. The alkaloid durantin induces neurotoxicity and paralysis [31]. Flavonoids, such as luteolin and apigenin, interfere with enzyme functions, while tannins slow insect growth by inhibiting digestive enzymes [32, 33]. Coumarins, like umbelliferone, act as repellents by affecting the nervous system, and terpenoids like limonene and β-caryophyllene alter hormonal balance and repel insects [34, 35]. Essential oils, containing camphor and eucalyptol, deter insects and harm larvae, making *D. erecta* a powerful natural pesticide [36].

Preparation and Extraction of Plant Material

The leaves and fruits of *Duranta erecta* were first cleaned with tap water to remove dust and debris, then shade-dried for four weeks. The dried plant parts were finely ground using a grinder. To extract the bioactive compounds, 60 g of the ground samples were cold macerated in 50% ethanol for 48 hours at room temperature on a rocking shaker. The mixture was centrifuged, and the supernatant was evaporated under low pressure using a rotary evaporator. The extracts, derived from leaves and both ripe and unripe fruits, were freeze-dried using a vacuum freeze dryer. To further isolate components, 15 g of each crude extract was sequentially treated with solvents of increasing polarity-petroleum ether, ethyl acetate, and methanol-leaving a hydro fraction as the residue. All fractions were air-dried at room temperature for use in experiments [37].

General Formulations

Table 1: Formulation table [38]

Sr. No.	Ingredients	Importance
1.	*Duranta erecta* Extract	Mosquito repellant
2.	Carbopol 940	Gel former
3.	Propylene glycol	Sulubiliser
4.	Methyl paraben	Preservative
5.	Propyl paraben	Preservative
6.	Triethanolamine	Ph adjustment
7.	Water	Hydration of gelling agent

Evaluation of Mosquitocidal Gel

Homogeneity: The produced gels were all visually checked for homogeneity after being put inside the container. They conducted exams to look for aggregates and assess their appearance [39].

Grittiness: The four definitions were infinitesimally tested for the existence of particles in the unlikely event that no visible particulate matter was observed with a light magnifying lens. The gel structure so clearly satisfies the requirement for any effective preparation to be independent of specific substance and from coarseness as desired [39].

Extrudability: A slight tension given to the gel is ideal for a successful gel expulsion. Details from aluminum folding cylinders were extrudable using a standard cylinder filling procedure. A folding aluminum cylinder with 10g gels inside was held in place by two clamps. In terms of the weight in grams needed to release a 0.5 cm gel lace from a packed cylinder in 10 seconds, extrudability was not entirely predicted [39].

pH assurance: Gel's pH can be changed with the aid of a computerized pH metre. After dissolving 100 cc of purified in 1 gramme of gel, the mixture was chilled for two hours. Three estimates of each definition's pH were made, and average attributes were calculated [40].

Viscosity: The pre-assembled gel's consistency was assessed using a Brookfield Viscometer. Shaft number 64 was used to rotate the gel at speeds of 20 and 30, and the accompanying dial reading was noted [40].

Skin irritancy study: Guinea pigs (weighing between 400 and 500g) of both sexes were utilized in order to test for skin disturbance. The creatures had unlimited access to the water and were given typical creature food. The animals were housed according to custom. After the guinea pigs' back hair was removed, 4 cm2 of space was marked off on each side, with one side acting as the test and the other as the control. After applying gel (500 mg/guinea pig) twice a day for seven days, the site's responsiveness and any reactions were recorded [40].

Drug content assurance: The medication was concentrated by precisely measuring a gel (about 100 mg) and dissolving it in 100 ml of phosphate support 7.4. After that, the mixture was constantly mixed on a visually pleasing stirrer for 24 hours. Subsequently, the entire arrangement was sonified. Fitting dilution after sonication and filtering allowed for spectrophotometric evaluation of the drug in the arrangement [41].

Spreadability: It illustrates the size of the region that the gel swiftly spreads when applied to the skin or other afflicted area. A detail's usefulness is also influenced by its level of notoriety. The amount of time it takes for two slides to separate from the gel that is placed between them when they are exposed to a specific oad is known as spreadability. Dividing two slides in less time yields better spreadability [41].

Conclusion

The development of a mosquitocidal gel using *Duranta erecta* shows promise for natural pest control. The plant's insecticidal effectiveness is due to its bioactive components, including alkaloids, flavonoids, terpenoids, saponins, and tannins, which target both mosquito larvae and adults. Incorporating these compounds into a gel matrix ensures stability, controlled release, and easy application. Initial tests suggest that the gel is more effective against mosquitoes and poses less risk to non-target species and human health compared to chemical insecticides. Despite the toxicity of *D. erecta* fruit juice, its therapeutic history calls for careful formulation. Future research should focus on improving the gel's formulation, assessing its longevity, and studying its impact on non-target species. This mosquitocidal gel presents an eco-friendly alternative for sustainable public health efforts.

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