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Utilization of Ginger Powder (*Zingiber officinale*) as Larvicide for *Aedes Aegypti*

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ABSTRACT

Aedes aegypti mosquitoes are known vectors for Dengue Fever (DF). This disease is caused by the Dengue virus, necessitating control measures that do not harm public health. One such measure is the use of ginger powder (*Zingiber officinale*) as a larvicide against *Aedes aegypti* larvae, the vector of DF. This experimental study employed a Completely Randomized Design with statistical analysis using the F-test. Four treatment concentrations and one control were tested: 5 grams, 10 grams, 15 grams, and 20 grams, with three repetitions for each treatment, observed over a 4-hour period. The study aimed to determine the effect of ginger powder (*Zingiber officinale*) as a larvicide on *Aedes aegypti* larvae. The average larval mortality at a concentration of 5 grams was 4.3 larvae, 7.6 larvae at 10 grams, and 10 larvae at both 15 grams and 20 grams. The F-test results showed that at the 1% level, Fht > Ftb. Duncan's Multiple Range Test indicated that the effective concentration was 15 grams, at which all *Aedes aegypti* larvae died within 4 hours. The utilization of ginger powder (*Zingiber officinale*) as a larvicide, with varying amounts of powder, resulted in different larval mortality rates. The higher the concentration of ginger powder (*Zingiber officinale*), the higher the larval mortality rate of *Aedes aegypti*.

Keywords: Ginger (*Zingiber officinale*), Larvicide, *Aedes aegypti*

INTRODUCTION

Aedes aegypti mosquitoes are the primary vectors of several arboviruses, such as dengue fever, Zika, chikungunya, and yellow fever. They are well adapted to urban and suburban environments and are prevalent in endemic areas, making them difficult to control (Amelia-Yap et al., 2018). Globally, *Aedes aegypti* can transmit dangerous diseases to humans, particularly in tropical and subtropical regions (Knudsen & Slooff, 1992; Weaver et al., 2016; WHO, 2012). Continuous efforts are being made to prevent the transmission and control the outbreak of these diseases (Roiz et al., 2018).

Dengue fever virus is transmitted by mosquitoes, causing millions of deaths worldwide annually. Currently, there is no specific treatment or commercially available vaccine for dengue fever, although several vaccines are still in development. Therefore, self-protection measures, good environmental management, and mosquito control remain the most crucial tools for preventing and controlling the transmission of this disease (Champakaew et al., 2015; Scott, 2016; WHO, 2016).

Mosquitoes act as carriers of various diseases, posing serious health problems for humans (Markouk et al., 2000). *Aedes aegypti*, the vector of dengue fever, is widespread in tropical and subtropical zones (Rahuman et al., 2008). Dengue fever primarily occurs in urban areas of tropical regions and is a dangerous disease that can be fatal. It is caused by one of four virus serotypes (DEN-1, DEN-2, DEN-3, and DEN-4).

These four serotypes are distributed across various regions in Indonesia. The percentage of infections by each serotype is as follows: DEN-1 at 8%, DEN-2 at 65%, DEN-3 at 15%, and DEN-4 at 12% (Hadisaputro S, 2019). Infection by one serotype results in specific antibodies against that serotype, but the antibodies generated against other serotypes are very limited, providing insufficient protection against the other serotypes. People living in dengue-endemic areas can be infected by 3 or 4 serotypes during their lifetime (Utami, 2015).

In various regions worldwide, there have been numerous reports of *Aedes aegypti* resistance to different types of insecticides. In 2001, it was reported in Brazil that *Aedes aegypti* had developed resistance to Temephos (Braga IA, Lima JB, Soares Sda S., 2004). A similar situation occurred in Thailand, where Ponlawat et al., (2005) reported that *Aedes aegypti* had shown resistance to Permethrin and

Temephos but remained susceptible to Malathion.

In 2018, Indonesia recorded 65,602 cases of dengue fever, with 467 resulting in death (Kemenkes RI, 2019). The mortality rate of *Aedes aegypti* larvae, ranging from 0 to 1.33%, has been observed in several cities due to the use of malathion insecticide in fogging over the past three decades (Haziqah-Rashid et al., 2019). In Surabaya, *Aedes aegypti* larvae were reported to be resistant to temephos, with mortality rates varying between 16% and 60% (Haziqah-Rashid et al., 2019; Mulyatno et al., 2012). Resistance to pyrethroid insecticides has been associated with mutations in *Aedes aegypti* larvae in Yogyakarta, Denpasar, Bali, and Makassar (Hamid et al., 2017, 2020; Wuliandari et al., 2015). Populations of *Aedes aegypti* in Padang Jati and Gunung Pangilun have also proven to be resistant to temephos (Hasmiwati et al., 2018). In addition to insecticide resistance, the mechanism of action may also involve metabolic detoxification. Increased levels of detoxification enzymes, such as GST, oxidase, and esterase, play a crucial role in providing resistance to DDT, malathion, temephos, or pyrethroids in mosquitoes collected from Bogor, Garut, Sumedang, Tasikmalaya, or Sumedang, Indonesia (Putra et al., 2016). Mosquitoes in Denpasar, Mataram, Kuningan, Padang, Samarinda, and East Sumba have also been reported to be resistant to d-allethrin, transfluthrin, and metofluthrin from mosquito coils (Amelia-Yap et al., 2018).

Brengues et al. (2003) noted that *Aedes aegypti* from the Semarang area had shown 296-fold resistance to permethrin. Cases of *Aedes aegypti* resistance to pyrethroids and the mechanisms of resistance have also been reported by Ahmad I., Astari, S., and Tan (2007). They stated that Aedes aegypti from Bandung had shown 79.3-fold resistance to permethrin, while *Aedes aegypti* from Palembang had shown 23.7-fold resistance to deltamethrin. Concerns about *Aedes aegypti* resistance to malathion and temephos in Indonesia are reasonable because these two insecticides have been used in various locations in Indonesia for more than 32 years. According to Georghio (1983), insect resistance to any insecticide type will emerge after 2 to 20 years of continuous use. Insecticide use can act as a natural selection agent that maintains a population of insects with resistant genes, which will be passed on to the next generation. As a result, the percentage of resistant insects will continue to increase, while susceptible insects will be eliminated due to insecticide exposure. Ultimately, insecticide use becomes ineffective as the number of resistant insects far exceeds that of susceptible insects.

A critical indicator in the dengue vector control program is the Breteau Index (BI). A decrease in BI or a level below the program target indicates an increase in mosquito density, which in turn increases the risk of dengue transmission. Nationally, the BI target is set at a minimum of ≥95% to control the density of dengue-transmitting mosquitoes. High mosquito density is a serious threat to the increased transmission of dengue fever in the future (Kemenkes RI, 2019).

Dengue vector control employs various methods, one of which is using temephos at the larval stage. Temephos has been part of the dengue vector eradication program since the 1980s and continues to be used today (Cahyati & Siyam, 2019). However, long-term use of temephos can have negative impacts such as environmental pollution and the emergence of resistance (Widyastuti et al., 2019). Research has reported resistance of *Aedes aegypti* larvae to temephos in several countries, including Brazil, Bolivia, Argentina, Cuba, French Polynesia, the Caribbean, and Thailand. In Indonesia, studies have also reported temephos resistance in *Aedes aegypti* larvae in Surabaya and Banjarmasin (Chrisna Pambudi et al., 2018). This resistance results in less effective vector control. Additionally, the use of temephos poses health risks to humans, such as causing cancer in various parts of the body (Khusna AM, 2017).

Using chemical compounds in efforts to control mosquito vectors, such as larvicides, adult mosquito population control, attractants, preventive measures, and repellents, is crucial in minimizing disease transmission (Badolo et al., 2004; Monnerat et al., 2012; Waliwitiya et al., 2009).

The use of natural larvicides has shown significant benefits as a new alternative in vector control efforts. The development of natural larvicides continues through research on various plants suspected of having potential as larvicides. The potential of these larvicides is assessed based on the value of Lethal Concentration 50 (LC50), which measures the concentration of extract needed to kill 50% of the tested larvae. Several studies have been conducted to evaluate natural larvicides against *Aedes aegypti* populations (Rohmah et al., 2020).

Various efforts have been made to control mosquito populations. Dengue vector control can be achieved through various methods such as chemical use, physical approaches, biological methods, and environmental manipulation. Research and trials conducted by researchers have found that crude extracts from the bintaro plant, both from its leaves and seeds, have a significant impact on naturally killing mosquito larvae. The higher the concentration of the extract, the faster the larvae are killed, inhibiting their development into pupae (Didi Tarmadi, 2018; Wahyuni D, Jasril J, Makomulamin M, n.d.). Another pathogen vector, Culex quinquefasciatus, responsible for spreading arboviruses, has also gained attention. Experiments using bintaro seed extracts with ethyl acetate and n-hexane showed high larvicidal activity against Culex quinquefasciatus, indicating that bintaro extracts can be used in larval control (D Meisyara, D Tarmadi, A Zulfitri, A Fajar, M Ismayati, S K Himmi, T Kartika, 2020). The effectiveness of bintaro fruit seed extract against *Aedes aegypti* mosquitoes as a bioinsecticide has also been proven, with the killing speed of mosquitoes increasing with higher extract concentrations (Aziz et al., 2024).

Currently, the primary focus in mosquito control remains on the use of synthetic chemical insecticides due to their efficient performance and immediate impact. However, repeated use of insecticides has led to negative consequences, such as killing non-target insects and causing resistance in vectors. A safer alternative is the use of natural insecticides, which are more environmentally friendly as they are derived from natural materials. These larvicides decompose easily in nature, thus not polluting the environment, and are safe for humans and livestock as their residues dissipate quickly.

Synthetic insecticides also contribute to environmental pollution in soil and water and can cause health problems in humans (Remor et al., 2009). Therefore, safer and more environmentally friendly control alternatives should be considered instead of synthetic insecticides, one of which is the use of botanical insecticides. Botanical insecticides, made from plant secondary metabolites, are part of the plant's defense mechanism against herbivore attacks and pathogens (El-Wakeil, 2013).

One method to control dengue vectors is by reducing the density of *Aedes aegypti* larvae using insecticides as larvicides. One commonly used larvicide is abate (temephos) by the community. However, the use of temephos, a chemical larvicide, has been proven to cause human poisoning with symptoms like nausea, dizziness, and other nervous disorders if the dose is too high, and it can also pollute the environment. Continuous use of temephos can also lead to resistance in dengue disease vectors. Due to the negative impacts of using chemical larvicides, research on the use of natural larvicides is gaining more attention, one of which is ginger powder. The use of natural larvicides from plants is becoming an alternative insecticide both now and in the future for vector control (Muangmoon et al., 2018).

One of the plants that serve as an environmentally friendly natural insecticide is ginger (*Zingiber officinale*). Ginger can easily grow in tropical areas like Indonesia, making it commonly found in households and often used as a cooking spice. Ginger is available in several forms, including fresh ginger, dried ginger, and processed products such as essential oils and oleoresins. The essential oil content in dried ginger ranges from 1% to 3%, while fresh ginger has a higher essential oil content, especially if it is not peeled (Syukur, 2006).

RESEARCH METHODOLOGY

Tools and Materials

This study utilized 150 grams of ginger powder *(Zingiber officinale*), 150 *Aedes aegypti* larvae obtained from a breeding site, and distilled water (aquadest). Each treatment group comprised five groups, with each group containing 10 *Aedes aegypti* larvae, and the experiment was repeated three times. The tools used included a scale, aluminum foil, a clock, basins, beakers, pipettes, and sample bottles.

Design

The research was an experimental study using a Completely Randomized Design (CRD) and was analyzed using F-test (Analysis of Variance). There were four treatments and one control group, with the concentrations being: 0 grams (control), 5 grams, 10 grams, 15 grams, and 20 grams. Observations were conducted over a period of 4 hours, with each treatment being repeated three times.

RESULTS AND DISCUSSION

The ginger drying material here used a tray dryer method. The ginger drying treatment was carried out at a temperature of 50°C and the material was dried for approximately 12 hours until dry, marked by a color change from white to dark brown and a crispy texture (easily crumbled) when squeezed with a moisture content of about 3-5%. During the drying process, the material in the tray dryer was regularly flipped and arranged to ensure even heat distribution for perfect heat effects on the material, resulting in uniform dryness and faster drying time.

Table 1. Number of *Aedes aegypti* Larvae Dead After Being Exposed to Ginger Powder (*Zingiber officinale*) at Different Concentrations for 4 Hours

Concentration	Number of *Aedes aegypti* Larvae Dead (individuals)					
	Repetition			Total	Mean	Post-transformation Mean $\sqrt{Y+0.5}$
	1	2	3			
0 gram as control	0	0	0	0	0	0.71
5 gram	4	5	4	13	4.3	2.91
10 gram	8	7	8	23	7.6	2.85
15 gram	10	10	10	30	10	3.24
20 gram	10	10	10	30	10	3.24

From the results of using ginger powder (*Zingiber officinale*), it can be concluded that it can be used as a larvicide against Ae larvae with four concentrations: 5 grams, 10 grams, 15 grams, and 20 grams, with three repetitions for each concentration over a period of 4 hours, there was an increase in the number of dead larvae with the increase in the amount of ginger powder used.

The use of ginger powder (*Zingiber officinale*) as a larvicide had a significant effect on *Aedes aegypti* larvae at each different concentration. This significance was manifested in values well above the Range of Duncan's Multiple Range Test (DMRT) 0.01 for each concentration. The statistical analysis showed that at a 1% significance level, the use of ginger powder as a larvicide against *Aedes aegypti* larvae at a concentration of 15 grams differed significantly from concentrations of 5 grams and 10 grams, while the difference between concentrations of 15 grams and 20 grams was not significant.

The use of ginger powder (*Zingiber officinale*) affected *Aedes aegypti* larvae because it contained essential oil. The essential oil in *Zingiber officinale* provided a distinctive aroma that insects disliked. Chemically, essential oils affect nerve function by disrupting the colloidal system or through reactions with nerve function. Some components of these essential oils include zingerone, zingerol, zingiberol, zingiberene, borneol cineole, and feladrene. These compounds have poisonous properties against insects (Syukur, 2006).

Ginger generally contains two types of compounds, namely volatile oil and non-volatile oil. The main component of ginger is volatile oil, which consists of sesquiterpenes and monoterpenes. Sesquiterpene compounds contained in it include zingiberene (about 20-30%), arcurcumene (about 6-19%), and β-sesquiphellandrene (about 7-12%). Meanwhile, the monoterpenes contained include pinene, bornyl acetate, borneol, camphene, p-cymene, cineole, citral, cumene, farnesene, geraniol, limonene, linalool, myrcene, β-pinene, and sabinene. Non-volatile components consist of oleoresin containing shogaol and gingerol, which provide the spicy and bitter taste of ginger and act as phenolic antioxidants in ginger (Ravindran & Babu, 2016).

Table 2. UBJND Results of *Aedes aegypti* Larvae Mortality using Three Repetitions

Treatment Concentration (gram/l)	Mean	Difference with 2	3	4	BJND 0,01
0 gram as control	0.71				a
5 gram	2.19	1.48**			b
10 gram	2.85	2.14**	0.66**		c
15 gram	3.24	2.53**	1.05**	0.39**	d
20 gram	3.24	2.53**	1.05**	0.39**	d
P 0,01		4.48	4.37	4.88	
BJND		0.16128	0.15732	0.17568	

The active compounds found in ginger will interact with the larval cell membrane, causing damage to the membrane and resulting in lysis and disruption of plasma membrane permeability. As a result, there is leakage in the cytoplasmic membrane due to the degradation of phospholipid molecules by H+ ions from ginger compounds, such as gingerol (Robinson, 1995). Damage to the cytoplasmic membrane allows toxic compounds in ginger to easily penetrate the larval body and cause physiological disturbances, including disruptions in respiratory, hormonal, and digestive systems (Shohib, 2015). In addition, the presence of kaempferol in ginger can also penetrate the larval respiratory system and damage mitochondrial function. Damage to mitochondria inhibits the electron transport process, disrupting energy metabolism and reducing adenosine triphosphate (ATP) production. Decreased ATP production in larvae leads to weakness in the larval body (Rahajoe S, Sri M, 2012).

Zingiberene functions as a repellent sensor that triggers food rejection signals in the insect nervous system. This causes insects to lose the ability to smell and identify food in their surroundings. Disturbances in the olfactory organs and damage to the digestive tract will reduce larval appetite, causing them to become weak and die slowly (P. Wahyuningsih, 1998; Wawan Hermawan, Erik Surya Erawan, 2010).

CONCLUSION

The use of plants as natural biolarvicidal agents has proven to be effective in controlling the spread of dengue virus. Medicinal plants provide an alternative to inhibit the growth and development of *Aedes aegypti* mosquito larvae. The toxic compounds in these plants act as natural larvicides with minimal side effects, easy degradation in nature, and no harm to humans and the environment.

Ginger (*Zingiber officinale*) is an example of a medicinal plant that contains various active compounds, including essential oils and flavonoids, which can kill *Aedes aegypti* larvae. The use of ginger powder as a larvicide with various concentrations results in different levels of larval mortality. A concentration of 15 grams of ginger powder has been proven effective in killing *Aedes aegypti* larvae, and the higher the concentration of ginger powder, the higher the mortality rate of *Aedes aegypti* larvae.

SUGGESTION

To improve the effectiveness of ginger powder (*Zingiber officinale*) as a larvicide against *Aedes aegypti*, it is recommended to conduct further research on the optimal dosage and the most efficient application methods. This research should also involve field trials to confirm laboratory results in real-world conditions. Furthermore, it is important to educate the public about the use of ginger powder as an environmentally friendly alternative larvicide. Collaboration with government and health organizations can help in the dissemination and distribution of this product, thereby reducing the spread of diseases transmitted by *Aedes aegypti*, such as dengue fever and Zika.

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