

Efficacy of mosquito traps baited with citric acid and baking soda for catching *Aedes aegypti* (Diptera: Culicidae)

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Abstract

The effectiveness of mosquito traps containing CO₂-producing agent as the attractant is depending on many factors, among others is the type of material used. This research was conducted to find out whether materials that have been proven effective in trapping mosquitoes of various species such as sugar + yeast and citric acid + baking soda are also effectively used to catch the vector of dengue hemorrhagic fever, *Aedes aegypti*. A total of 48 traps made from empty 1.6 liter plastic bottles were prepared in this study. The yeast + sugar (YES) and citric acid + baking soda (CABS) attractants were applied to be compared with control (well water). The traps containing three different liquid (16 traps each) were set in 16 selected houses in a settlement named Pinang Jaya. Traps were set for 14 days and were observed every two days. Parameters observed were the pH of the attractant liquid and the number of female *Ae. aegypti* mosquitoes caught. The results are revealed that the attractant made from citric acid reacted with baking soda was the most effective in attracting female mosquito of *Ae. aegypti* compared to the attractant composed of brown sugar fermented with cassava yeast. Citric acid reacted with baking soda did not immediately attract *Ae. aegypti* mosquitoes until the day-6 and the effectiveness the attractant continues to increase up to 5 times on the day-14. It is suggested that mosquito traps containing citric acid and baking soda attractants are feasible to be applied in controlling the population of dengue vector mosquitoes.

Keywords: Mosquito Control; Dengue Hemorrhagic Fever; *Aedes aegypti*; Mosquito Traps; Mosquito Attractant

1. Introduction

Trapping mosquito is a technique for attracting, capturing and killing the vector mosquitoes in a local setting. Mosquito traps is highly recommended because they are environmentally friendly and proven to be useful in reducing the number of mosquitoes. However, the effectiveness of the traps is limited and depending on the type of attractants used. Apart from effectiveness, there are other criteria for mosquito traps that must meet the requirements recommended by WHO, namely duration of efficacy, non-target effects, and ease of maintenance [1].

To produce mosquito traps that meet the recommended standards, researchers around the world continue to seek and test various types of attractants for the trap baits. Among the various attractants that have been extensively studied are attractants using olfactory cues including: carbon dioxide, lactic acid, octenol, and pheromone [2]. Some of the electric mosquito traps available today, such as The Mosquito Magnet (Model: Independence; Manufacturer: Woodstream Corp., USA), also have the main function of producing olfactory attractants, especially carbon dioxide (CO₂) [3].

The presence of CO₂ in a mosquito trap is not a guarantee of its effectiveness in collecting mosquitoes. There are still other factors that have an effect, namely the CO₂-producing source material. The study reported by Hoel *et al.* (2015)

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showed that CO₂ from dry ice was the most effective at catching mosquitoes compared to CO₂ from compressed gas, citric acid + sodium bicarbonate, yeast + sugar, and vinegar + sodium bicarbonate [4].

So far, the effectiveness of mosquito traps baited with CO₂ from various materials is based on the quantity of mosquitoes caught, so the specific type of mosquito that is easiest to catch is unknown. Hoelat *al.* (2015) in their study indeed succeeded in trapping 20 species of mosquitoes namely *Ae.atlanticus*, *Ae.dupreei*, *Ae.fulvuspallens*, *Ae.infirmatus*, *Ae.mitchellae*, *Ae.taeniorhynchus*, *Ae.triseriatus*, *Ae.vexans*, *An.crucians*, *An.quadrimaculatus*, *Cx.erraticus*, *Cx.nigripalpus*, *Culiseta melanura*, *Orthopodomyia signifera*, *Psorophora ciliata*, *Ps.columbiae*, *Ps.ferox*, *Ps. howardii*, *Uranotaenialowii*, and *Ur. Sapphirina*. However, it is not so clear whether the type of CO₂-generating material used determines the type of mosquitoes attracted [4].

Rosanti et al (2017) in their experiments using yeast + sugar as bait succeeded in trapping *Anopheles indefinitus*, *Cx. quinquefasciatus*, *Cx.vishnui*, *Cx tritaeniorhynchus*, *Cx bitaeniorhynchus*, *Aedes aegypti* [5]. The use of lactic-acid based chemical baits is known to be successful in attracting and trapping *Cx. quinquefasciatus*, *Ae. aegypti* and *An. minimus* mosquitoes [6].

Our study aims to find out whether CO₂-producing ingredients that have known efficacy in trapping mosquitoes, namely sugar + yeast and citric acid + baking soda are effective in trapping female *Aedes aegypti* mosquitoes that will lay eggs. We deliberately made *Aedes aegypti* the target of this study because this mosquito is a transmitting agent for one of the deadly diseases, namely Dengue Hemorrhagic Fever. As is well known, in the last 50 years the incidence of dengue hemorrhagic fever in Indonesia has tended to increase with a cyclic pattern that peaked approximately every 6 to 8 years [7].

2. Materials and Methods

2.1. Study site and traps setting

This study was carried out in Pinang Jaya Settlement of Kemiling District, Bandar Lampung City, the province of Lampung, Indonesia. Determination of the house to be used as a place to set the trap is done by interviewing residents about whether or not their family members have been infected with DHF. The houses of residents who claimed to have been infected with DHF were then used as the center point for setting traps and were given the number 1 label. Furthermore, the other houses adjacent to the No.1 house were designated as trap sampling sites that represented the settlement. The number of houses that were eventually assigned to set up mosquito traps in this study was 16.

2.2. The traps

A total of 48 traps were prepared in this study. The traps were made from empty 1.6 liter plastic bottles that were sliced into two parts. The funnel-like parts of the bottle were put upside down in the other half and were glued together with duct tape. The traps were then wrapped in black polyethylene plastic.

2.3. The attractants and experimental design

Two types of attractants were prepared to be tested and compared for their efficacy with the control (containing only well water), namely Yeast + Sugar (YES) and Citric Acid + Baking Soda (CABS). The YES attractant-bait was made by fermenting brown sugar (800 g) with cassava yeast (16 g) in 3200 ml of hot water. Meanwhile, CABS bait is made by dissolving 1200 g of citric acid in 4000 l of water then 2000 g of baking soda is added little by little. Each of the selected houses (16 in total) was fitted with 3 traps containing different attractants: YES, CABS and well water (WELL, as control).

2.4. Harvesting and observed parameter

Traps were set for 14 days. Trap harvesting is done every two days. Parameters observed were the pH of the attractant liquid and the number of female *Aedes aegypti* mosquitoes caught. The pH value of attractant is measured using a digital pocket pH meter (PH20, range 0.01-14.00). The taxonomic determination of *Aedes aegypti* species was carried out by referring to Ruedo's pictorial keys for the identification of mosquitoes [8].

2.5. Data presentation

The data obtained in this study is presented descriptively, as it is.

3. Results and Discussion

The number of individual mosquitoes caught during 14-day trapping in each site (house) by type of attractant used is presented in Table 1.

Table 1 Total individual of female *Aedes aegypti* trapped in each site during 14-day trials by type of attractant used

No. Site	Number of caught by type of attractant *			Σ
	CABS	YES	WELL	
1	9	3	0	12
2	6	2	0	8
3	10	3	0	13
4	7	2	0	9
5	8	4	0	12
6	11	2	0	13
7	22	4	0	26
8	7	3	0	10
9	13	4	1	18
10	22	6	0	28
11	5	0	0	5
12	15	3	0	18
13	12	3	2	17
14	0	0	1	1
15	11	2	0	13
16	0	0	0	0
Σ	158	41	4	203

*) CABS: citric acid + baking soda; YES: Yeast+ brown sugar; WELL=well water

The data in Table 1, where we managed to catch a total of 203 female *Ae.aegypti* mosquitoes, confirmed the residents' statement that there had been cases of dengue hemorrhagic fever in the settlement studied. The presence of mosquitoes that transmit the dengue virus in these settlements is very likely related to the appropriate condition of the backyard. As can be seen from the photos in Figure 1, in the backyard of these houses there are many objects that have the potential to be flooded which are suitable places for *Ae. aegypti* to lay their eggs such as potted plant, water container and ditches filled with water.

Our previous research showed that several types of plants can function as phytotelmas for insects, including the *Ae aegypti* mosquito. There are at least six types of plant part that potent to serve as phytotelmata namely leaf axils, tree holes, tree stumps, fallen spathe, fruit shells, and fallen leaves [9]. Furthermore, there have been too many reports proving that various types of water-holding objects in the living and workplace environments are favored by the *Ae. aegypti* mosquito for laying eggs. These water-holding objects can be discarded tire, mud pots, mud dishes, ditches, and plastic containers [10].

It is also clearly depicted in the Table 1 that the attractant made from citric acid reacted with baking soda was the most effective in attracting female mosquito of *Ae.aegypti* compared to the attractant composed of brown sugar fermented with cassava yeast (*Saccharomyces cerevisiae*). Even so, the bait is quite useful for trapping mosquitoes when compared to traps that only contain well water.

The factor that is thought to make CABS baited traps more effective at catching mosquitoes is that a mixture of citric acid and baking soda can maintain its attractant properties longer. As can be seen from Figure 2, the attractant function of CABS baited traps tended to increase from day 8 to day 14 indicated by the increasing number of mosquitoes caught. In contrast, traps baited with yeast and brown sugar were only effective at catching mosquitoes on the fourth day but continued to decrease after that.

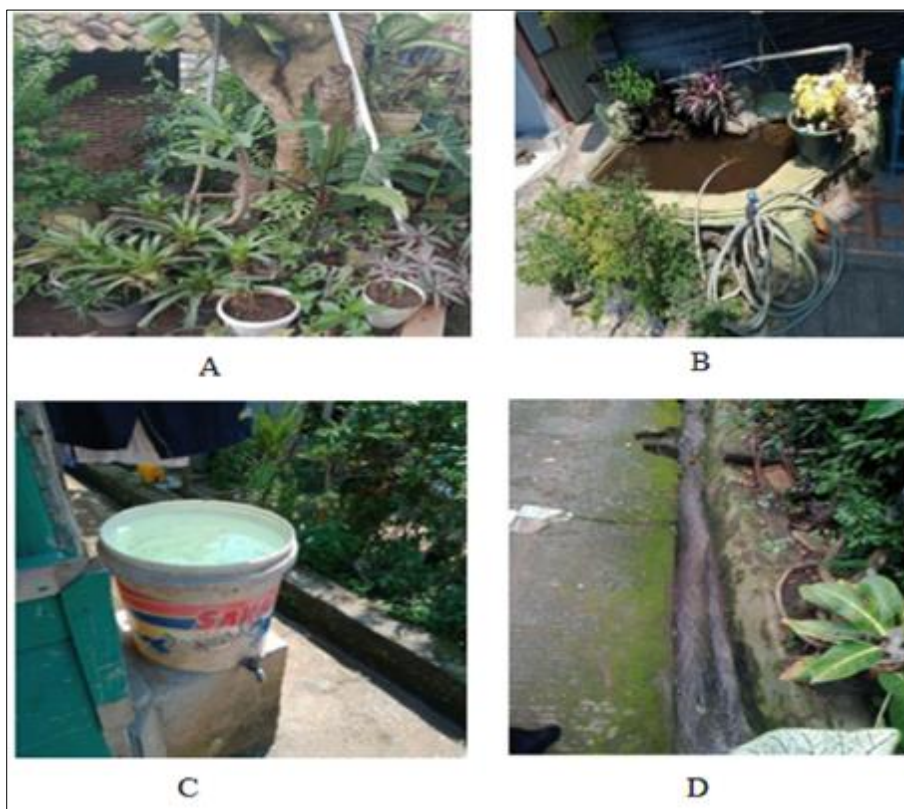


Figure 1 Photos depicting the usual conditions in the backyards of houses where traps are set. A. lots of potted plants; B. small water pool; C. water containers, D. ditches filled with water

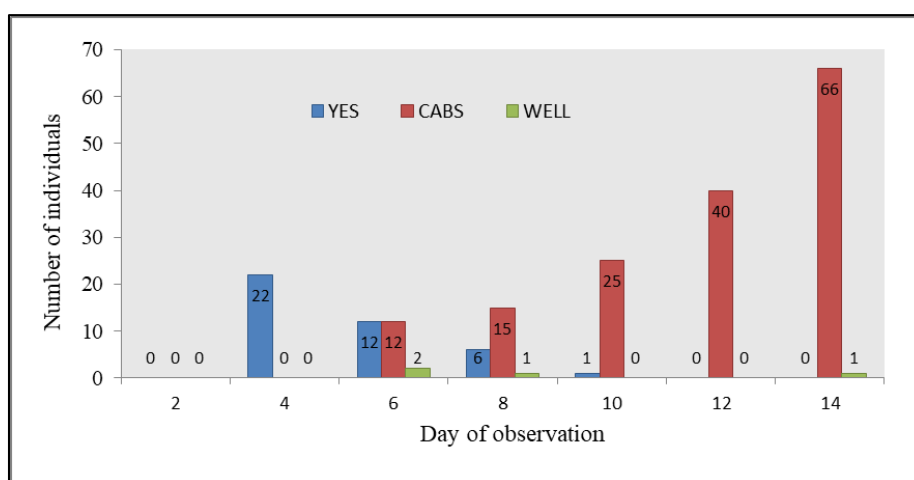


Figure 2 Number of *Aedes aegypti* caught in traps with different type of attractant by day of traps observation. YES: Yeast+ brown sugar; CABS: citric acid + baking soda; WELL=well water

What causes the traps containing citric acid and baking soda to last longer and effectively catch *Ae.aegypti* mosquitoes until the 14th day? To be sure, further studies are needed. However, the high effectiveness of the bait composed of citric acid and baking soda very likely is determined by pH. Measurement of pH value of the attractant liquid done in this study resulted in the data presented in Figure 3.

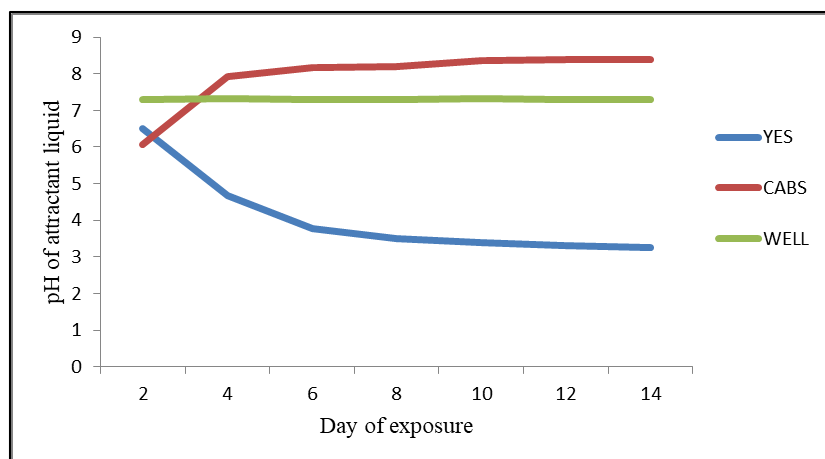


Figure 3 Trend of the pH value of the trap bait liquid (attractant) according to day of exposure. YES: Yeast+ brown sugar; CABS: citric acid + baking soda; WELL=well water

The pH value of the attractant liquid made from citric acid and baking soda tended to increase from the second day (6.08) and remained in the high range (8.17 - 8.4) until the day-14. In contrast, the pH value of the attractant liquid from fermented brown sugar continues to decrease. On the first two-day the pH value is 6.5, but on the following days it continues to decrease and remains low until the 14th day (3.26).

The phenomenon of low pH of the fermented sugar liquid also occurs in the process of making beverages. In a study on making kombucha secang drinks, Sinamo et al. (2022) found that the longer the fermentation process lasted, the pH of the drink decreased from the first day (pH=3.50) to the 13th day (pH=2.79)[11]. Not only sugar fermented products that experience a decrease in pH with increasing time, but also other fermentation processes such as lactic acid fermentation using button mushrooms. The pH value of the button mushroom fermentation decreased from 6.79 on the first day to 3.66 on the 14th day [12].

Referring to previous studies, it is known that standing water favored by female *Aedes aegypti* in laying eggs has a pH value in the alkaline range. Cahyati and Siyam (2019) found that the most preferred impounded water by the female *Ae. aegypti* mosquitoes to lay eggs has a pH value of 9 followed by water with a pH of 8 and 7 [13]. A study conducted in Kolkata, West Bengal, India revealed that during summer the pH value of breeding water of *Ae. aegypti* was ranging from 5.67 – 8.19; in monsoon season ranging from 7.64 - 8.01; and in the winter the pH values ranging from 6.98 - 7.98 [14].

4. Conclusion

Attractant formulated from citric acid reacted with baking soda did not immediately attract *Aedes aegypti* mosquitoes on the first 4-day. However from the day-6 till day-14 the effectiveness of the attractant continues to increase up to 5 times. Thus it can be concluded that mosquito traps containing citric acid and baking soda attractants are feasible to be applied in controlling population of the dengue vector mosquitoes.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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