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Potential of Bay Leaf as Tablet Fumigant against *Cadra cautella* (Walker) (Lepidoptera: Pyralidae)

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ABSTRACT

Bay leaf contain active ingredients that have potential as a botanical fumigant against stored product pests. Using bay leaves as tablet fumigant has been limited to controlling stored product pests from the order Coleoptera. It has not been used to control stored product pests from the order Lepidoptera. Therefore, this research aimed to determine the effect of bay leaf tablet fumigants on the developmental stages of *C. cautella*. This research consisted of six different concentration levels (i.e., 0; 1; 2; 3; 4; and 5 ml l^{-1} air) repeated five times and arranged with a Completely Randomized Design (CRD). The observed variables were the mortality on the developmental stages of *C. cautella*. The results showed that mortality of eggs, larvae, and adults of *C. cautella* was higher (100%) at 3, 4, and 5 ml l^{-1} air than other concentrations. The LC_{50} values on eggs, larvae, and adults of *C. cautella* were (0.956, 0.982, 1.221 ml l^{-1} air at 24 hours), (0.912, 0.952, 0.895 ml l^{-1} air at 48 hours), and (0.502, 0.938, 0.880 ml l^{-1} air at 72 hours), respectively.

Keywords: Bay leaf; Botanical fumigant; *Cadra cautella;* Stored product pest; Tablet fumigant

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INTRODUCTION

Cadra cautella (Walker) (Lepidoptera: Pyralidae), commonly known as the almond moth, is one of the primary pests associated with stored products (Rees 2004). *C. cautella* is a polyphagous and cosmopolitan pests (Hill 2002), capable of damaging stored goods due to larval feeding. This pest can infest various stored products, including dates, barley, maize, rolled oats, peanuts, cowpeas, almonds, soybean flour (Hagstrum et al. 2013), cashew nuts (Rahayu et al. 2024), rice (Lin et al. 2023), rice flour, flour (Hill 2002), and cocoa (Astuti et al. 2024). The attack of *C. cautella* can lead to the formation of holes and contamination (i.e. silk, frass, and exuvia) (Hill 2002; Rees 2004), reduced nutrition, molding of infested stored products, and products being rejected by consumers (Wilbur 1971). The attack of *C. cautella* resulted in yield losses of cacao ranging from 1.21 to 6.53% during 4 months of storage (Oyewo and Amo 2018). The damage caused by *C. cautella* needs control techniques. Typically, the control method employed to manage *C. cautella* involve chemical fumigants, such as phospine (Nayak et al. 2020; Machuca-Mesa et al. 2024) and methyl bromide (Paul et al. 2020). However, the use of chemical fumigants can lead to various adverse effects on the environment (Mantzoukas et al. 2019), so alternative controls are required, such as botanical fumigants.

Thus far, botanical fumigants have been confined to powders, essential oils, and extracts. However, Weaver and Subramanyam (2000) and Stejskal et al. (2021) noted that botanical fumigants can also be powders, essential oils, and tablets. Fumigants in tablet form offer several advantages, including being easy and safe to apply and the ability to penetrate stored products to eliminate stored product pests (Kathirvelu et al. 2019). One of potential plants with have ideal characteristics as a botanical fumigant is the bay leaf plant (*Syzygium polyanthum* (Wight) Walp.) (Sartika et al. 2022). The part of the bay plant utilized as a botanical fumigant is the leaf due to its toxic and repellent compounds, which are suitable for controlling stored product pests. Studies have indicated that the leaves of bay plants contain more compounds than other parts, such as stems, bark, fruit, and roots (Nurlely et al. 2024). Ahmad et al. (2024) reported that the compound content of bay leaf includes cis-4-decanal (43.48%), α-pinene (30.88%), 1-decyl aldehyde (19.75%), octanal (18.30%), capryl aldehyde (14.09%), and α-caryophyllene (6.22%).

Sartika et al. (2022) reported that tablet fumigant of bay leaves increased mortality, inhibited growth rates, and reduced yield loss due to *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) infestation. Furthermore,

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(Hasby et al. 2024) also reported that tablet fumigant of bay leaves could enhance mortality, inhibited growth rates and feeding activity, and possessed repellent properties against *Araecerus fasciculatus* (De Geer) (Coleoptera: Anthribidae). Currently, using bay leaves as a tablet fumigant remains limited to controlling stored product pests from the order Coleoptera. It has not been applied to stored product pests from the order Lepidoptera. Therefore, further studies are needed to investigate the impact of botanical fumigants based on bay leaves in tablet form on the mortality of one of the lepidopteran insects, *C. cautella*. This research aimed to determine the effect of bay leaf tablet fumigants on the developmental stages of *C. cautella*.

MATERIALS AND METHODS

The research was conducted at the Plant Pest Laboratory, Department of Plant Pest and Diseases, Faculty of Agriculture, Universitas Brawijaya, Malang, East Java, from November 2024 to April 2025.

Insect culture

C. cautella was obtained from the collection in Plant Pest Laboratory, Department of Plant Pests and Diseases, Universitas Brawijaya, Malang. The colonies of *C. cautella* were obtained from farmer stored at Malang and raised in the laboratory under condition at 26.8 ± 0.76°C and 43.2 ± 4.04% RH. The rearing of *C. cautella* was conducted using modified method refer to (Lin et al. 2023). A total of 250 g of flour was put into a rearing box (l= 19 cm; w= 19 cm; h= 9.5 cm) and infested 25 pairs *C. cautella* for 14 days. The insect was removed from the rearing box after 14 days and awaited until F1 progeny emerged. After the F1 progeny emerged, 25 pairs of *C. cautella* were placed into a mating cage (d=10 cm; h=20 cm) for 24 hours. After 24 hours, eggs were collected for the experiment. The eggs used in this experiment were 0–24 hours old (Nazari et al. 2022b).

Preparation of tablet fumigant

Bay leaf was collected from farmers at Turen Subdistrict of Malang Regency. Bay leaves were extracted according to the method described by Sartika et al. (2022) and (Hasby et al. 2024). Bay leaf powder was placed into an Erlenmeyer and added solvent (96% ethanol) with ratio of 1:10 (Sartika et al. 2022). The solution was homogenized using an orbital shaker at 100 rpm for 72 hours. After 72 hours, the solution obtained was filtered using a Whatman filter paper. (Ikawati et al. 2017; Sartika et al. 2022; Hasby et al. 2024). Then, the filtered solution was separated from the solvent using a rotary vacuum evaporator at 60°C and 100 rpm until the extraction results were obtained. Subsequently the extraction results were placed into the bottle and tightly sealed, then stored in a refrigerator at 4°C (Damayanti et al. 2013; Ikawati et al. 2017; Sartika et al. 2022; Hasby et al. 2024). The bay leaf extract was used to make a tablet fumigant measured according to the treatment concentration, mixed with 4 g of talc and homogenized. Then, the mixture of bay leaf extract and talc was formed into tablets using the manual tablet tool. The tablets were put into a spunbond cloth shaped like a tea bag (l=7 cm; w=5.5 cm) and into the treatment tube (Sartika et al. 2022).

Fumigant activity.

This research was conducted by infesting eggs, larvae, and adults of *C. cautella* on six different concentrations of tablet fumigants (i.e., 0; 1; 2; 3; 4; and 5 ml l^{-1} air) with three different fumigant exposures (24, 48, and 72 hours). Each treatment was repeated five times and arranged using a Completely Randomized Design (CRD). A total of 30 *C. cautella* eggs (0–24 hours) were placed in vials (d=3 cm; h=3.5 cm), then the vials were put into treatment jars (v=400 ml) which contained bay leaf-based tablet fumigants according to the treatment. The treatment jar was sealed to prevent air exchange in the treatment jar. Fumigant exposure was carried out for 24, 48, and 72 hours. A total of 15 pairs of adults (1–2 days) *C. cautella* were infested into treatment jars (v = 400 ml) containing 30 g of flour and a tablet fumigant of bay leaf according to the treatment. The treatment jars were sealed to prevent air exchange in the treatment jars. Fumigant exposure was carried out for 24, 48, and 72 hours. A total of 30 larvae (third instar) *C. cautella* were infested for mortality treatment. Mortality treatment of *C. cautella* larvae was carried out as same as in the mortality treatment of *C. cautella* adults. The mortality of eggs was observed using a stereo microscope and unhatched eggs were considered dead (Ikawati et al. 2017). Observation of larvae mortality was carried out with a stereo microscope and larvae that did not move when touched were considered dead (Ikawati et al. 2017). Adult mortality was observed every 3 hours to observe the movement of *C. cautella* adults (Hasby et al. 2024). Furthermore, total adult mortality was observed using a stereo microscope at the end of the exposure time (Sartika et al. 2022; Mario et al. 2023). The mortality of eggs, larvae, and adults was calculated according to Damayanti et al. (2013) [1]:

$$\%Mt = \frac{\textit{number of dead}}{\textit{Total infested}} \times 100 \text{ ....[1]}$$

With *%Mt* is a mortality percentage of eggs, larvae and adults *C. cautella*

The data were analyzed using analysis of variance (ANOVA) at the 5% error level and significant differences were determined by the Least Significance Difference (LSD). The LC_{50}, LC_{90}, LT_{50}, and LT_{90} of fumigant were analyzed using Probit analysis. The software used for ANOVA data analysis is R statistic software version 4.3.0 and Probit analysis is IBM SPSS 25.

RESULTS AND DISCUSSIONS

Bioactivity of bay leaf tablet fumigants against egg mortality

The results showed that the concentration levels of tablet fumigants of bay leaf significantly affect the mortality of *C. cautella* eggs at 24 ($F= 11,467$; $P<0.001$), 48 ($F= 45,842$; $P<0.001$), and ($F= 9.13$; $P<0.001$) 72 hours (Table 1). The mortality of eggs at concentrations of 2, 3, 4, and 5 ml l^{-1} air was higher and significantly different compared to concentrations of 0 and 1 ml l^{-1} air at 24 and 48 hours. Furthermore, the mortality of eggs at a concentration of 0 ml l^{-1} air was lower and significantly different from the other concentrations at 72 hours. The results showed that the concentration level and exposure time caused an increase in *C. cautella* egg mortality.

Based on the regression test results, there was a positive relationship between concentration levels (R^2 = 0.59; $P < 0.01$) and exposure time (R^2 = 0.79; $P<0.01$) with egg mortality. This indicates that the concentration level and exposure time significantly influenced the mortality of *C. cautella* eggs by 59% and 79%. This finding align with results by Ayvaz et al. (2009) that various essential oils (*Satureja thymbra* L., *Laurus nobilis* L., *Myrtus communis* L., *Citrus limon* L., and *Origanum majorana* L.) with the highest dose (200 µl l^{-1} air) and length of exposure (96 hours) can increase the egg mortality of *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) and *Plodia interpunctella* (H ü bner) (Lepidoptera: Pyralidae). Nazari et al. (2022a) reported that the higher concentration (60 µl l^{-1} air) and duration of exposure (72 hours) of *Murraya paniculata* L. fumigant which applied would increase the egg mortality of *C. cautella*. In insect eggs, air exchange between the egg and the environment can be through aeropyles (Gautam et al. 2014), which can influence the mortality of eggs.

According to Gautam et al. (2014) reported that the number of aeropyles in eggs differs by species, the number of eggs in *Carphopilus hemipterus* (L.) (Coleoptera: Nitidulidae) (2 aeropyles) is less than *E. elutella* (H ü bner) (Lepidoptera: Pyralidae) (17.4 aeropyles). Furthermore, Arbogast et al. (1980) reported that the aeropyles in *C. cautella* eggs are spread over almost the entire egg surface. The presence of aeropyles spread over almost on the entire surface of *C. cautella* eggs is thought to cause volatile compounds that have more toxic properties to enter and cause ovicidal effects. This finding align with Singh et al. (2021) that application of botanicals on eggs could tremendously reduce the number of adult emergence which is probably due to either chemical toxicity and/or physical properties.

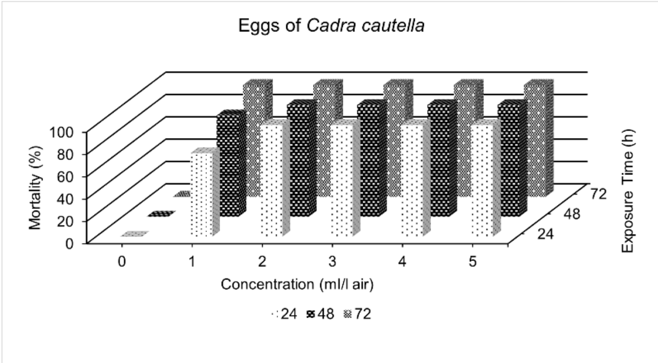

Figure 1. Mortality of *C. cautella* eggs at various concentration levels with exposure time 24, 48, and 72 hours

Based on Probit analysis, the LC_{50} and LC_{90} values obtained were 0.956 and 1.044 ml l^{-1} air at 24 hours, 0.912 and 0.997 ml l^{-1} air at 48 hours, and 0.502 and 0.547 ml l^{-1} air at 72 hours. The present research shows that the LC_{50} and LC_{90} values will be lower depending on the length of exposure time. The low LC_{50} and LC_{90} values indicate that the bay leaf tablet fumigants effectively increases the mortality of *C. cautella* eggs. In line with Ikawati et al. (2020) reported that the smaller the LC_{50} value obtained, the more toxic the fumigant used and vice versa. Following to (Nazari et al. 2022b) stated that the LC_{50} and LC_{90} values for egg mortality of *C. cautella* could be lower depending on the length of exposure (57.4 and 722.3 µl l^{-1} air at 48 hours and 41.5 and 131.6 µl l^{-1} air at 72 hours).

Table 1. Mean of mortality of *C. cautella* eggs at various concentration levels of bay leaf tablet with exposure time 24, 48, and 72 hours

Concentration (ml l^{-1} air)	Exposure (hours)	Mortality (%)[a] ($\bar{x}$ ± SD)
0		0.00 ± 0.00 c
1		74.67 ± 8.36 b
2	24 h	100.00 ± 0.00 a
3		100.00 ± 0.00 a
4		100.00 ± 0.00 a
5		100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}
0		0.00 ± 0.00 c
1		90.67 ± 4.94 b
2	48 h	100.00 ± 0.00 a
3		100.00 ± 0.00 a
4		100.00 ± 0.00 a
5		100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}
0		0.00 ± 0.00 b
1		100.00 ± 0.00 a
2	72 h	100.00 ± 0.00 a
3		100.00 ± 0.00 a
4		100.00 ± 0.00 a
5		100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}

Remarks: [a] Numbers followed by the same letter in the same column show not significantly different based on the LSD test with an error level at 5%; The data were transformed using arcsine for analysis purposes; SD is the standard deviation

Bioactivity of bay leaf tablet fumigants on larvae mortality

The results showed that the concentration levels of tablet fumigants of bay leaf significantly affect the mortality of *C. cautella* larvae at 24 (F= 1,114; P<0.001), 48 (F= 2,844; P<0.001), and (F= 4,479; P<0.001) 72 hours (Table 2). The mortality of larvae at concentrations of 2, 3, 4, and 5 ml l^{-1} air was higher and significantly different to concentrations of 0 and 1 ml l^{-1} air at 24, 48, and 72 hours. The results show that the concentration level and exposure time cause an increase in *C. cautella* larvae mortality.

There was a positive relationship between concentration levels and larvae mortality at various exposure times of (R^2 = 0.63; P<0.01) at 24, (R^2 = 0.57; P<0.01) at 48, and (R^2 = 0.54; P<0.01) at 72 hours. This shows that the concentration level has a significant effect on the mortality of *C. cautella* larvae by 63%, 57%, and 54% at exposure times of 24, 48, and 72 hours, respectively. Following the statement of Nazari et al. (2022a) reported that *M. paniculata* fumigant at the highest concentration (60 μl l^{-1} air) could enhance the mortality of *C. cautella* larvae in ranged of 63.06%. Furthermore, Akinneye et al. (2022) reported that highest concentration of *Zingiber officinales* essential oil (25%) can cause 100% mortality of *C. cautella* larvae. Following Akinneye and Ogungbite (2016) reported that the essential oil of *Anacardium occidentale* can cause 68% mortality of *C. cautella* larvae. Exposure to bay leaf tablet fumigant can cause changes in color and malformation in *C. cautella* larvae. *C. cautella* larvae become black and shrink after exposure to bay leaf tablet fumigant. This finding aligns with results by Samsudin et al. (2016) reported that larvae that have been exposed to *Allium sativum* extract for 72 hours will turn black in color.

Probit analysis showed that the LC_{50} and LC_{90} values at 24, 48, and 72 hours were (0.982 and 1.078 ml l^{-1} air), (0.952 and 1.043 ml l^{-1} air), and (0.938 and 1.033 ml l^{-1} air), respectively. In this present research shows that the LC_{50} and LC_{90} values will be lower depending on the length of exposure time. The low LC_{50} and LC_{90} values indicate that tablet fumigants of bay leaf effectively increase the mortality of *C. cautella* larvae. According to (Nazari et al. 2022) stated that the LC_{50} and LC_{90} values on larvae mortality obtained will be lower along with the length of exposure (38.4 and 215. 5 μl l^{-1} air at 48 hours and 35.7 and 166.6 μl l^{-1} air at 72 hours).

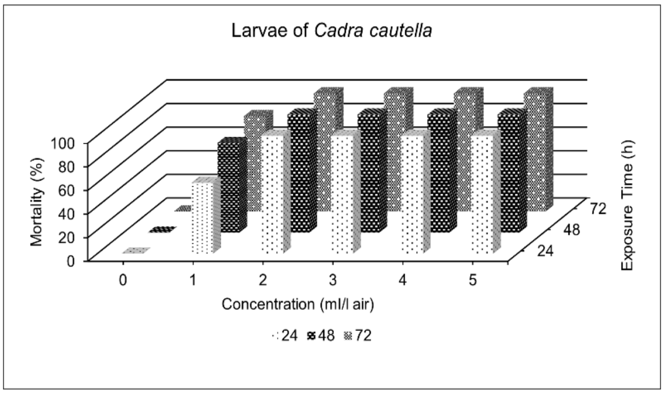

Figure 2. Mortality of *C. cautella* larvae at various concentration levels with exposure time 24, 48, and 72 hours

Table 2. Mean of mortality of *C. cautella* larvae at various concentration levels of bay leaf tablet fumigants with exposure time 24, 48, and 72 hours

Concentration (ml l^{-1} air)	Exposure (hours)	Mortality (%)[a] ($\bar{x}$ ± SD)
0	24 h	0.00 ± 0.00 c
1		60.00 ± 23.57 b
2		100.00 ± 0.00 a
3		100.00 ± 0.00 a
4		100.00 ± 0.00 a
5		100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}
0	48 h	0.00 ± 0.00 c
1		76.00 ± 13.20 b
2		100.00 ± 0.00 a
3		100.00 ± 0.00 a
4		100.00 ± 0.00 a
5		100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}
0	72 h	0.00 ± 0.00 c
1		80.66 ± 18.01 b
2		100.00 ± 0.00 a
3		100.00 ± 0.00 a
4		100.00 ± 0.00 a
5		100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}

Remarks: [a] Numbers followed by the same letter in the same column show not significantly different based on the LSD test with an error level at 5%; The data were transformed using arcsine for analysis purposes; SD is the standard deviation

Bioactivity of bay leaf tablet fumigants on adult mortality

The results showed that the concentration levels of tablet fumigants of bay leaf are significantly different in the mortality of *C. cautella* adults (F= 883.8; P<0.001) at 24, (F= 12,858; P<0.001) 48, and (F= 9.13; P<0.001) 72 hours) (**Table 3**

). The mortality of *C. cautella* adults at concentrations of 2, 3, 4, and 5 ml l^{-1} air was higher and significantly different compared to concentrations of 0 and 1 ml l^{-1} air at 24 and 48 hours. Furthermore, the mortality of *C. cautella* at a concentration of 0 ml l^{-1} air was lower and significantly different from the other concentrations at 72 hours. The results showed that the level of concentration and the length of exposure time caused an increase in mortality of *C. cautella* adults.

There is a positive relationship between concentration levels and exposure time with mortality of *C. cautella* adults (R^2 = 0.72; P<0.01; R^2 = 0.78; P<0.01). This result showed that the concentration level significantly affects the mortality of *C. cautella* adults by 72% and 78%. This finding align with results by (Nazari et al. 2022a) mentioned that the concentration level of *M. paniculata* essential oil and length of exposure time affect the mortality of *C. cautella* adults, where a higher concentration level and longer exposure time will increase the mortality of *C. cautella* adults. Kheloul et al. (2020) reported that dose and exposure time were significantly affected the development of *Tribolium confusum* Jacquelin du Val (Coleoptera: Tenebrionidae). According to Hasby et al. (2024), reported that bay leaf fumigant tablet had volatile compounds (terpenoids and esters), which can inhibit insect enzymes Acetylcholinesterase (AChE) (Abdelgaleil et al. 2024) and cause mortality of *A. fasciculatus*. According to Abdelgaleil et al. (2024) AChE hydrolyzes acetylecholine (ACh) and its release from synaptic vesicles depolarizes the postsynaptic cell membrane and consequently ACh is denatured by AChE into choline and acetate. AChE inhibition and acetylcholine accumulation could lead to insect mortality (Casida and Durkin 2013).

Based on Probit analysis, the 50% mortality time of *C. cautella* adults at concentrations of 4 and 5 ml l^{-1} air caused 50% mortality of *C. cautella* adults taking less than 1 hour. Furthermore, the 90% mortality time required at a concentration of 5 ml l^{-1} air was less than 2 hours against *C. cautella* adults (Table 4). The lower value of LT_{50} and LT_{90} indicated that the treatment was effective to control *C. cautella* adults. Isikber et al.(2006) reported that the lower the LT_{50} and LT_{90} values, the more sensitive the pests are to the fumigant used (*Laurus nobilis* LT_{50} = 54.78 h, LT_{90} = 67.25 h at dose 172.6 mg l^{-1} air and *Rosmarinus officinalis* LT_{50} = 24.49 h, LT_{90} = 37.54 h at dose 172.6 mg l^{-1} air). The higher value of LT_{50} (29.34 h) and LT_{90} (49.93 h) at concentration of 1 ml l^{-1} air indicated that the treatment might not be effective for controlling *C. cautella* adults. In accordance with Uwamose et al. (2017) reported that the higher value of LT_{50} (160.51 h) indicated that the treatment *Cymbopogon citratus* might not be very effective for controlling *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae).

Table 3. Mean of mortality of *C. cautella* adults at various concentration levels of bay leaf tablet fumigants with exposure time 24, 48, and 72 hours

Concentration (ml l-1 air)	Exposure (hours)	Mortality (%)		
		Male[a] ($\bar{x}$ ± SD)	Female[a] ($\bar{x}$ ± SD)	Total[a] ($\bar{x}$ ± SD)
0	24 h	0.00 ± 0.00 c	0.00 ± 0.00 c	0.00 ± 0.00 c
1		18.67 ± 9.89 b	30.67 ± 8.94 b	24.66 ± 9.01 b
2		97.33 ± 5.96 a	98.67 ± 2.98 a	98.00 ± 4.47 a
3		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
4		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
5		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}	2×10^{-16}	2×10^{-16}
0	48 h	0.00 ± 0.00 c	0.00 ± 0.00 c	0.00 ± 0.00 c
1		92.00 ± 11.92 b	94.67 ± 7.30 b	93.33 ± 9.43 b
2		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
3		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
4		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
5		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}	2×10^{-16}	2×10^{-16}
0	72 h	0.00 ± 0.00 b	0.00 ± 0.00 b	0.00 ± 0.00 b
1		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
2		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
3		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
4		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
5		100.00 ± 0.00 a	100.00 ± 0.00 a	100.00 ± 0.00 a
Sig. (*p*)		2×10^{-16}	2×10^{-16}	2×10^{-16}

Remarks: [a] Numbers followed by the same letter in the same column show not significantly different based on the LSD test with an error level at 5%. The data were transformed using arcsine for analysis purposes. SD is the standard deviation

Table 4. Lethal time of *C. cautella* adults at various concentration levels of tablet fumigants of bay leaf

Concentration (ml l^{-1} air)	Regression	Standart Error	LT_{50} (Hour)	LT_{90} (Hour)
1	y = -18.01 + 5.05X	0.452	29.34	49.93
2	y = -11.26 + 5.62X	0.346	1.67	2.83
3	y = -11.19 + 5.73X	0.343	1.49	2.49
4	y = -07.23 + 4.08X	0.239	0.98	2.02
5	y = -07.11 + 4.22X	0.252	0.81	1.62

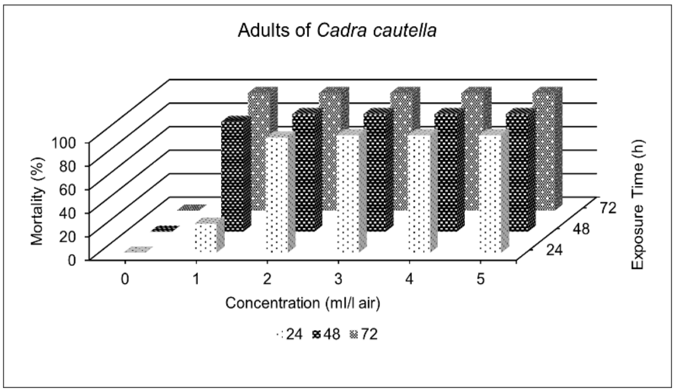

Figure 3. Mortality of *Cadra cautella* larvae at various concentration levels with exposure times of 24, 48, and 72 hours

Probit analysis shows that the LC_{50} and LC_{90} values at 24, 48, and 72 hours were (1.221 and 1.648 ml l^{-1} air), (0.895 and 0.982 ml l^{-1} air), and (0.880 and 0.970 ml l^{-1} air), respectively. This research shows that the LC_{50} and LC_{90} values will be lower depending on the length of exposure time. Suthisut et al. (2011) reported that the longer the fumigant exposure time, the smaller the LC_{50} value. Based on the LC_{50} and LC_{90} values of the bay leaf tablet, the fumigant was found to be low. This demonstrates that bay leaves can be used as botanical fumigants, which are effective and toxic to *C. cautella* adults. In accordance with Sartika et al. (2022) reported that bay leaf fumigants had LC_{50} and LC_{90} values of 4.38 and 5.21 ml l^{-1} air against *R. dominica* adults, which was at a low concentration, which means that bay leaf fumigants were effective and toxic to *R. dominica*. Regarding the comparison of the LC value of bay leaf, it could be determined that bay leaf was more effective and toxic to control *C. cautella* than *R. dominica*.

CONCLUSIONS AND SUGGESTIONS

The tablet fumigant of bay leaf was potentially used as a botanical pesticide to effectively control *C. cautella* in the storage. The effective concentration was 3 ml l^{-1} air, which could cause 100% mortality of the egg, larvae, and adults of *C. cautella*. In addition, the concentration of 3 ml l^{-1} air takes less than 3 hours to reach LT_{50} and LT_{90}.

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