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Effectiveness of mahogany seed flour (*Swietenia macrophylla*) as a bio insecticide against mortality of Sitophilus zeamais motsch in post-harvest grains

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A B S T R A C T

Research has been conducted on the effect of giving Mahogany seed meal (Swietenia macrophylla) on the mortality of the beetle Sitophilus zeamais Motsch. The method used is an experimental method with a complete randomized design consisting of 6 treatments and 4 repeats. The treatment consisted of controls A0 (0%), A1 (2%), A2 (4.8%), A3 (7.4%), A4 (13.0%), and A5 (17.4%). Mahogany seed flour with a concentration in each treatment was mixed with granulated corn to a weight of 50 grams, placed 20 Sitophilus zeamais beetles and observed for 24, 48, 72, and 96 hours. Data were analyzed by ANOVA calculation and BJND test at 24-hour observation, BNT test at 48-hour observation, and BNJ test at 72- and 96-hour observations. The concentration of 17.4% gave the greatest beetle mortality effect, namely 75% at 24 hours, 81.25% at 48 hours, 91.25% at 72 hours, and 100% at 96 hours from the number of 20 beetles tested. This study also produced KL50 values for mahogany seed flour, namely 11.90% at 24 hours, 10.41% at 48 hours, 8.69% at 72 hours, and 7.23% at 96 hours.

1. INTRODUCTION

1.1. Research Background

The maize crop (*Zea mays* L.) is one of the second most important food commodities after rice. Corn is one plant that has a lot of beneficial content for life including carbohydrate, fat, protein, mineral, water, and vitamin compounds. The function of nutrients contained in corn can also provide energy, form tissues, and regulate functions, and biochemical reactions in the body so that all parts of the corn plant can be taken advantage of [1]

The condition of the warehouse where the storage is humid makes this pest still attack corn because water in the environment will enter the corn, causing pests to multiply even in the state of corn that was dried before. Humid conditions in warehouses and moisture content in corn can invite beetles to come and develop quickly at optimum humidity of about 75% [2]. Therefore, another way to control this pest is sought by using vegetable pesticides which can be used as a way to control beetles even in humid warehouse conditions. One part of the plant that is thought to be used as a vegetable pesticide is mahogany seeds.

Mahogany seeds can be used as natural pesticides because they contain flavonoids, saponins, and terpenoids which are all compounds that can be used as pesticides for insects [3]. The results of research by Abni et al., (1999) quoted by Ref. [4] stated that a solution squeezed from mahogany seeds with a concentration of 3% is very effective for controlling aphids (Macrosiphoniella Sanborn) on chrysanthemum plants [4]. From the content of mahogany and the results of Abni's research which states that mahogany seed extract can be used as a pesticide, mahogany seeds can be used as an alternative natural pesticide to kill *S. zeamais* warehouse pests.

1.2. Literature Review

Corn commodities have a multipurpose function (4F), namely for feed, food, industrial raw materials (fiber), and fuel (fuel). In the feed ration on farms, especially poultry, corn is the main component with a proportion of about 60% of the total main function in corn. It is estimated that more than 58% of corn needs in Indonesia are used for feed and others are used for food needs only around 30%, then the rest for other industrial needs and seeds [5]

S. zeamais pests attack corn so it is called corn powder. Corn beetles that are larger than rice beetles also attack rice, wheat, and sorghum [6]. This pest attack causes seeds to perforate, quickly break and crumble into flour, this is characterized by the presence of flour in the affected granules, then seeds and flour are united by saliva so that the quality of the seeds decreases or is damaged [7]. Therefore, this pest must be controlled so that there are no losses due to damage to corn grains.

Farmers generally use more drying methods to control this beetle, but this method is less effective considering this pest is a warehouse pest. The way of drying done by farmers is not an effective way to control this pest. The moisture content on the surface of the material is influenced by the relative humidity (RH) of the surrounding air. If the moisture content of the material is low while the RH around is high, there will be absorption of water vapor from the air so that the material becomes moist or the water content is higher and vice versa if the temperature of the material is lower (cold) than the surface of the material and can be a good medium for mold growth or bacterial development [8]

1.3. Research Objective

The purpose of this study was to determine the effect of mahogany seed flour on the mortality of Sitophilus zeamais Motsch beetles.

2. MATERIALS AND METHODS

2.1. Materials

The method used in this study was an experimental method with a Complete Randomized Design (RAL) consisting of six treatments and four repeats. The treatment consisted of A0 (0%), A1 (2%), A2 (4.8%), A3 (7.4%), A4 (13.0%), and A5 (17.4%). Mahogany seeds that are still wrapped in skin are opened from the skin so that the seeds are obtained which are white and slightly brownish. Mahogany seeds are dried for 1 week by aerating so that the substances contained in mahogany seeds are not damaged. Then the dried mahogany seeds are blended so that they become flour. The flour is sifted with a sieve so that we get fine flour. The flour is stored in jars and then put in plastic. Mahogany seed flour can be used for insecticides.

2.2 Methods

The jar is prepared and filled with 500 grams of granulated corn and 100 parental imago. The jars are date-labeled, covered with plastic given small holes, and then placed in the room for ± 30 days. On day 7 the parental imago is removed then on day 30 the first offspring of the parental imago will be produced, and that imago is used as a test insect in the study. The granulated corn chosen is granulated corn that is not hollow and still good. The granulated corn used is granulated corn of relatively the same size. For breeding prepare 500 grams of granulated corn and for each treatment prepare ±50 grams.

Jars filled with granulated corn + and mahogany seed flour with a total weight of 50 grams are prepared. 20 S. zeamais imago put in jars. The jars are labeled with captions, covered with gauze and put in a luminous chamber. The death of the imago will be observed and counted every 24 hours to 96 hours, by moving the dead imago into an empty jar. The data obtained were analyzed using fingerprint analysis followed by further tests of BNJ, BNT, and BJND.

3. RESULT AND DISCUSSION

3.1 Result

3.1.1 Mortality of beetles Sitophilus zeamais Motsch.

The test results of giving mahogany seed flour (Swietenia macrophylla) with concentrations of A0 (0%), A1 (2%), A2 (4.8%), A3 (7.4%), A4 (13.0%), and A5 (17.4%) against Sitophilus zeamais beetles experienced an increase in mortality percentage which was directly proportional to the increase in mahogany seed flour concentration and length of treatment. Mortality of beetles for 24, 48, 72, and 96 hours can be seen in Table 1.

Table 1. Mortality percentage of imago beetle Sitophilus zeamais due to mahogany seed meal for 24; 48; 72; and 96 hours.

flour concentration ∑ Mahogany seed imago		Mortality / Duration of Treatment (%)			
		24 hour	48 hour	72 hour	96 hour
A0	20	0	0	0	0
A1	20	8.75	17.50	25	31.25
A2	20	18.75	23.75	32.50	42.50
A3	20	31.25	40	46.25	55
A4	20	52.50	58.75	68.75	77.50
A5	20	75	81.25	91.25	100

Table 1 shows that the mortality percentage of S. beetles. zeamais has been seen in A1 treatment at a concentration of 2% at 24 hours onwards experiencing an increase in the mortality rate of S. zeamais beetles along with increasing concentrations and duration of observation. It can be seen that mortality will increase from 0% to 17.4% concentration and there will be an increase from 24 to 96 hours of treatment observation. The relationship of mortality with the length of treatment time can be seen in Figure 1.

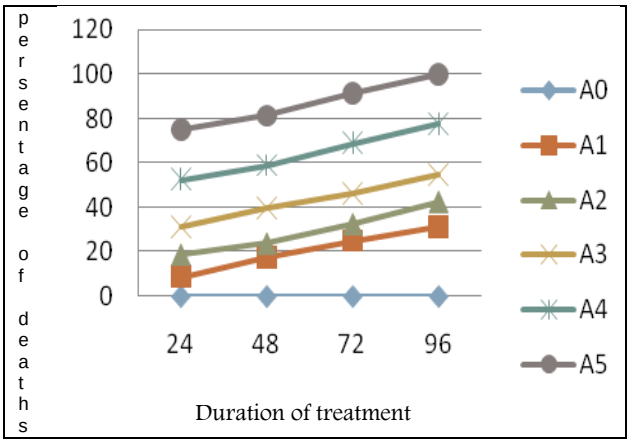

Figure 1. Mortality graph of S. zeamais beetles treated with A0 to A5 (0% to 17.2%) for 24, 48, 72 and 96 hours.

Figure 1 shows an increase in mortality percentage directly proportional to the increase in concentration and length of treatment. At A0 concentrations, there is no mortality in beetles due to treatment (control). The mortality of new *S. zeamais* beetles was seen in the 24-hour A1 treatment with average mortality on each repeat of 8.75%, the mortality percentage continued to increase at 48, 72, and 96 hours at 17.50%, 25%, and 31.25% respectively. Data on increased mortality in every 24, 48, 72, and 96 hours were also seen in the treatment of A2, A3, A4, and A5. The increase in mortality was also strongly influenced by the increase in treatment concentration seen in A1 to A5 data which continued to increase at 24 hours at 8.75%; 18.75%; 31.25%; 52.50% and 75%. The data in Table 4.1 can be said that the concentration and time of treatment are directly proportional to the number of mortality, the higher the concentration and the longer the treatment, the number of mortality of S. zeamais beetles also increases.

The results of Ansira (fingerprint analysis) showed that beetles treated with the addition of mahogany seed flour and observed with a time of 24, 48, 72, and 96 hours showed a very noticeable difference with beetles that were not treated with mahogany seed flour (control). Comparison of the calculated F and F values of the Ansira table at 24, 48, 72, and 96 hours which are decomposed in Table 2.

Table 2. Comparison of F count and F table based on Fingerprint analysis and Diversity Coefficient mortality of S. zeamais beetles for 24, 48, 72, and 96 hours.

Beetle mortality/ duration of treatment	F count	F table		Diversity coefficient (%)
		95%	99%	
24	320.35 **	2.77	4.25	10.14
48	349.2 **			8.55
72	938.55 **			4.80
96	1318.93 **			3.82

Description: ** = very real different

Table 2 shows that at each treatment duration of 24, 48, 72, and 96 hours the effect of mahogany seed flour is very real, as seen in the results of F count > F table on each treatment duration, then the alternative hypothesis (Ha) which states that mahogany seed flour affects the mortality of S. zeamais Motsch beetles on corn media is accepted.

The Diversity Coefficient at each treatment duration showed different results, then further tests were carried out by the results of the diversity coefficient of each treatment duration, namely at 24 KK > 10%, then a further Duncan Significant Distance Difference (BJND) test was carried out, at 48 hours the Least Significant Difference (BNT) test was carried out because KK was 5% - 10%, then at 72 and 96 hours had a 5% KK, an Honest Significant Difference (BNJ) test was carried out. These advanced tests are shown in Table 3.

Table 3 shows the results of BNJD, BNT and BNJ follow-up tests on beetle mortality for 24, 48, 72, and 96 hours which all showed that A0 (0%) did not affect beetles because A0 was not treated, while A5 treatment was the most lethal treatment for beetles so it became the best concentration.

Table 3. BJND, BNT and BNJ Test Results on the Average Mortality of S. zeamais Motsch Beetles for 24, 48, 72 and 96 hours

Treatment	Mortality 24 hour (99%) $\bar{X} \pm Sd$	BJND	Mortality 48 hour (99%) $\bar{X} \pm Sd$	BNT	Mortality 72 hour (99%) $\bar{X} \pm Sd$	BNJ	Mortality 96 hour (99%) $\bar{X} \pm Sd$	BNJ
A0	0 ± 0	a	0 ± 0	a	0 ± 0	a	0 ± 0	a
A1	1.75 ± 0.50	b	3. 5 ± 0.58	b	5 ± 0	b	6.25 ± 0.50	b
A2	3.75 ± 0.50	c	4.75 ± 0.50	b	6.50 ± 0.58	c	8.50 ± 0.58	c
A3	6.25 ± 0.96	d	8 ± 0.82	c	9.25 ± 0.5	d	11 ± 0	d
A4	10.5 ± 0.58	e	11.75 ± 0.50	d	13.75 ± 0.5	e	15.50 ± 0.58	e
A5	15.0 ± 0.82	f	16.25 ± 0.96	e	18.25 ± 0.5	f	20 ± 0	f

Note - SD (average standard deviation)
- The letter after the standard deviation is the result of the BJND, BNT, and BNJ tests, the same letter shows a very unreal different value (99%)

3.1.2 Lethal Concentration (KL50)

A lethal concentration of 50 is the concentration of toxins that are outside the animal's body or found in the environment of the experimental animal such as water and air which causes 50% death in test animals [9]. The KL50 value is useful for determining the level of toxins in pesticides. KL50 values were determined using the probit analysis formula with calculated KL50 values at 24, 48, 72, and 96 hours of treatment shown in Table 4

Table 4 informs that the KL50 value of mahogany seed flour (Swietenia macrophylla) will be smaller with greater or greater length of treatment. As seen in Table 4, when the treatment period is 24 hours, 11.90% of the concentration of mahogany seed flour is needed to kill 50% of the 20 beetles, and when the concentration decreases to 7.23%, it takes a longer time of 96 hours to kill 50% of the 20 test animals.

3.2 Discussion

3.2.1 Mortality of beetles Sitophilus zeamais Motsch.

The results of testing mahogany seed flour with corn media for 24, 48, 72, and 96 caused the death of S. zeamais beetles at mortality levels that were directly proportional to the increase in the percentage of mahogany seed flour concentration and treatment time. The increase in mortality seen in Table 1 shows an increase in mortality from 24 hours to 96 hours and from treatment without flour concentration to the highest concentration of 17.4% the increase in beetle mortality is also very visible in Figure 1 which shows an increase. The fingerprint analysis (Ansira) shows F count > F table at each treatment time with a very noticeable difference, this means that the application of mahogany seed flour is very influential on the death of S. Zeamais beetles

The results of further tests, namely BNJD at 24 hours, BNT at 48, and BNJ at 72 and 96 hours (Table 3) obtained the same information that the highest concentration (17.4) was the best concentration to kill S. zeamais beetles because at a concentration of 17.4% (A5) it was seen that the number of dead S. zeamais beetles had a very real difference with a concentration of 0% (A0). Other information shows that each concentration has a real difference except for the concentration of 2% (A1) and 4.8% (A2) of the 48-hour BNT test which has no real difference between treatments.

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Further tests were used to determine the difference in influence between treatments so that it was known that the treatment had no effect on beetle mortality and which greatly affected beetle mortality.

In addition to concentration, the length of treatment also plays a role in increasing beetle mortality due to the increasing number of toxic compounds in mahogany seed flour that enter the beetle's body. It is suspected that S. zeamais beetles are unable to live because they are unable to eat due to the presence of sweitenin compounds which include antifeedant limonoid compounds [10]. Antifeedant properties are generally produced by plant chemical compounds that can affect insect taste organs such as the mouth, hypopharynx, or olfactory organs of insects such as the maxillary palpus and antennae so that they can be recognized by insect chemical receptors then insects also recognize these compounds that have a bitter taste. Other compounds that are thought to be able to exert a mortality effect on S. zeamais beetles are flavonoids, saponins, and terpenoids.

Flavonoid compounds that work as insecticides are rotenoids. Rotenoids are toxins that inhibit metabolism and the nervous system which works slowly. It is suspected that insects that die due to starvation due to paralysis of the mouth apparatus [11]. Other information states that blood cells damaged by saponin compounds show hemolysis action on blood cells [3]. The interaction between saponins and cell membranes due to the active nature of saponins on the cell surface, so that saponins can bind to phospholipids and cholesterol which results in disruption of cytoplasmic membrane permeability which can lead to leakage of intracellular material and cause cell lysis and finally the immune system in the insect body is damaged. As a result, insects die because their body's defenses are broken.

Terpenoids which are a group of alkaloids are compounds in mahogany seeds have a toxic effect on the nervous system. Terpenoid compounds enter through spiracles into tracheoles and then enter the bloodstream and flow into nerve cells. Terpenoid compounds that enter nerve cells work by inhibiting the work of the enzyme acetylcholinesterase (AchE). The work of the enzyme acetylcholinesterase is inhibited because AchE recognizes terpenoid compounds (lansiolid acid A) such as acetylcholine due to the presence of nitrogen elements in it. Lansiolid A containing nitrogen atoms bonds to the active side of AchE [12]. Acetylcholine cannot bind to acetylcholinesterase because the acetylcholine position has been occupied by terpenoid compounds (lanolin acid A).

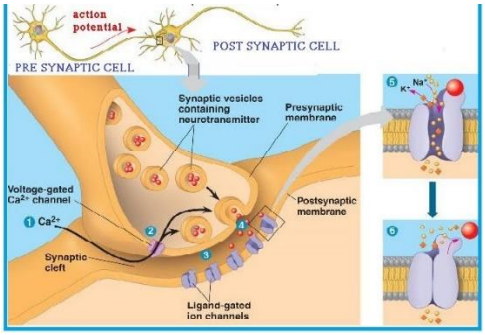

Figure 2. The general structure of synapses
(Sumber: Campbell, 2005)

The enzyme acetylcholinesterase (AchE) is an important enzyme in the nervous system of insects. AchE is an enzyme that works to break down acetylcholine into choline and acetic acid. This decomposition causes the initiation interval of the action potential. Acetylcholine is a neurotransmitter that conducts nerve impulses from presynapses to postsynapses to the next neuron. If there are substances that inhibit the enzyme acetylcholinesterase, it will greatly interfere with normal nerve activity. Disruption of the acetylcholinesterase enzyme causes nerve impulses to be transmitted continuously and will be forwarded to muscle cells resulting in incoordination, convulsions, weakness, and eventually death in beetles.

Mahogany seed flour that enters the body through the respiratory tract is thought to also play a role in beetle mortality because mahogany seed flour contains toxic compounds and has a fine structure as dust enters with oxygen through spiracles into the tracheole then mahogany seed flour is attached to intracellular hairs and attached to the tracheole wall [13]. The attachment of mahogany seed flour to the tracheole wall causes disturbed breathing because gas exchange in beetles occurs in the tracheole wall [14]. It is thought that beetles die due to disturbances in the tracheole wall which causes beetles to have difficulty breathing and eventually die.

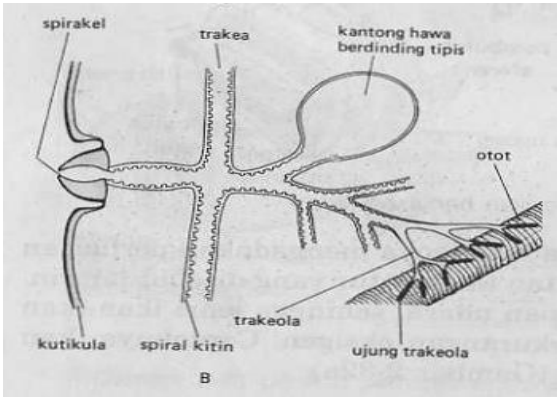

Figure 3. Respiratory system of insects
(Source: www.anakunhas.com)

3.2.2 Lethal Concentration (KL50)

The results of the probit analysis of KL50 found that the KL50 value decreased with increasing treatment time. The decrease in the percentage of mahogany flour due to increased treatment duration can be seen in Table 4 which shows a concentration of 11.90 at 24 hours; 10.41 at 48 hours; 8.69 at 72 hours and 7.23 at 96 hours. The data further shows that the more time increases, the more substances are absorbed, so that at 96 hours, there will be less concentration of substances used to kill 50% of the test beetles. This is to the statement that the toxic effect of a material is determined by the amount of poison and the length of exposure time, in general living organisms will quickly die in a short period when exposed to compounds with high concentrations, and can live long enough if exposed to compounds with lower concentrations [9]. Information about mahogany seeds that can be used as vegetable pesticides and information about the value of Kl50 in mahogany seed flour pesticides can be used as alternative contextual examples of biodiversity material.

4. CONCLUSION

Based on the results of this study, it can be concluded that mahogany seed flour has a significant influence on the mortality of *Sitophilus zeamais* beetles.

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