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The several of Jengkol peel extract (*Pithecellobium lobatum Benth*) against corn armyworm (*Spodoptera frugiperda J. E. Smith*) in the laboratory

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Abstract

Spodoptera frugiperda J. E. Smith is an invasive insect that has become a pest on corn plants in Indonesia. *S. frugiperda* attacks maize plants from the vegetative to generative phases. Leaves of corn plants attacked by *S. frugiperda* larvae. with plant populations affected by 55-100% causing yield losses of 15-73%. The usual control is the use of synthetic insecticides, but the use of synthetic insecticides continuously or unwisely will have a negative impact on humans and the environment, therefore a safe and environmentally friendly alternative control using vegetable insecticides is jengkol plants (*Pithecellobium lobate Benth*). This study aims to obtain an effective concentration of jengkol bark extract to control armyworm pests *Spodoptera frugiperda* J.E. Smith in the laboratory. The study was conducted experimentally using a complete randomized design (RAL) consisting of five treatments with four repeats so that 20 experimental units were obtained. The concentration of jengkol bark extract used is 0 g.l-1 water, 25 g.l-1 water, 50 g.l-1 water, 75 g.l-1 water, and 100. g.l-1 water. The parameters observed were an initial time of death (hours), lethal time 50 (hours), lethal concentration (LC50 and LC95) (%), total mortality (%), temperature, and humidity. Jengkol bark extracts with a concentration of 100 g.l-1 water is an effective concentration in controlling corn plant pests (*Spodoptera frugiperda* J. E. Smith) in the laboratory because this concentration is able to cause total mortality of 90% with an initial time of death of 17.25 hours after application and lethal time of 50 at 60.75 hours after application.

Keywords: Jengkol bark extract; Corn; *Spodoptera frugiperda* J. E. Smith

1. Introduction

Spodoptera frugiperda J. E. Smith is an invasive insect that has become a pest on corn plants in Indonesia [1]. These insects come from America and have spread to different countries. In early 2019, this pest was found on corn plants in the Sumatra area which attacked plant growing points and could result in failure to form young leaves of plants. *S. frugiperda* larvae attack maize plants from vegetative to generative phases, resulting in attack symptoms such as holes and larval feces left inside the leaves [2]. Maize leaves infested by *S. frugiperda* larvae with 55-100% infested plant populations caused yield losses of 15-73% [3].

A pest control strategy that has been carried out today is the use of synthetic insecticides. The use of synthetic insecticides is considered by farmers as the main choice because it can control pests quickly and practically. However, the use of synthetic insecticides continuously or unwisely will cause negative impacts, such as environmental pollution, death of natural enemies, the emergence of secondary pests, death of non-target organisms, pest resistance, and resurgences [4]. An alternative control that is appropriate enough to be applied in reducing these negative impacts is to use plant-based insecticides. Planting potential as a vegetable insecticide is the jengkol plant (*Pithecellobium lobate* Benth).

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Jengkol plants that can be used as vegetable insecticides are jengkol bark with ingredients such as alkaloids, flavonoids, tannins, and saponins [5]. Alkaloids are contact toxins and stomach toxins that can disrupt the digestive tract and nervous system of larvae [6]. Flavonoids are stomach toxins and antifeedants, so they will affect the feeding power of larvae and inhibit larval feeding activities [7]. Tannins are stomach toxins that work as antifeedants and can bind to proteins in the digestive system of insects so that proteins are not available to insects [8]. Saponins work by decreasing the activity of protease enzymes in the digestive tract so that it can interfere with the process of food absorption which results in feces being directly excreted because food cannot be absorbed. In addition, saponins can also bind sterols to the digestive system so as to interfere with the process of insect molting [9].

Based on the results of research conducted by [10] jengkol bark extract was able to control *S. exigua* pests with a concentration of 100 g.l-1 water which caused a total mortality of 92.5%. This is in accordance with the opinion [11] vegetable insecticides are said to be effective if they are able to kill ≥80% of pest populations at a maximum concentration of 10% by using water solvents. The study aimed to obtain an effective concentration of jengkol bark extract (Pithecellobium lobate Benth) to control *Spodoptera frugiperda* J. E. Smith corn armyworm pests in the laboratory.

2. Material and methods

The research was carried out at the Plant Pest Laboratory, Faculty of Agriculture, Riau University, Bina Widya KM 12.5 Campus, Simpang Baru Village, Handsome District, Pekanbaru. The tools used in the study were plastic gela s diameter of 6 cm and height of 12 cm, plastic jars diameter of 1.7 cm and height of 1.9 cm, plastic jars diameter of 20 cm and height of 22 cm, brushes, rubber bands, scissors, blender, analytical scales, gauze, 40 mesh sieve, stirring rod, label paper, analytical scales, funnel, thermohygrometer, 250 ml hand sprayer, and documentation tools. The material used in the study was *S. frugiperda* instar III, jengkol skin, water, liquid soap, young corn, cornelobot, sterile aquades, honey, cotton, tissues,, and sawdust.

The study was conducted experimentally using a complete randomized design (RAL) consisting of five treatments with four repeats so that 20 experimental units were obtained. Each experimental unit consisted of 10 larvae of *S. frugiperda* instar III. The treatment used was the concentration of jengkol bark extract 0 g.l-1 water, 25 g.l-1 water, 50 g.l-1 water, 75 g. 1-1 water, and 100 g.l-1 water.

Daily mortality data obtained from the results of the study were analyzed descriptively using graphs. Lethal concentration data (LC50 and LC95) were probit analyzed using the POLO-PC program. Preliminary data on mortality, total mortality, and lethal time (LT50) were statistically analyzed using fingerprints. The fingerprint data was further tested with the smallest real difference test (BNT) at the level of 5%.

3. Results and discussion

3.1. Time of Initial Death

The fingerprint results showed that treatment of several concentrations of jengkol bark extract (*P. lobate*) had a significant effect on the initial time of death of *S. frugiperda*. The average results of BNT follow-up trials at the time of initial death of *S. frugiperda* at the level of 5% can be seen in Table 1.

Table 1 Time of initial death of *S. frugiperda* after application of multiple concentrations of jengkol bark extract (hours)

Extract concentration jengkol bark (g.1-1 water)	Time of initial death (jam)
0	120.00 a
25	48.75 b
50	41.25 bc
75	30.00 cd
100	17.25 d

The numbers in the column of each treatment followed by unequal lowercase letters differ markedly according to the BNT test at the level of 5% after being transformed by $\sqrt{y}$.

Table 1 shows that application of jengkol bark extract concentration of 100 g.l-1 water causes the fastest onset time of death which is 17.25 hours after application and differs insignificantly with a concentration of 75 g.l-1 water which is 30.00 hours. This is suspected because of the high concentration of jengkol bark extract used, the active ingredient content of alkaloid compounds will be higher, so that S. frugiperda larvae will die faster. This is in accordance with the opinion [12] the higher the concentration, the more toxic the content, and will work quickly in killing insects.

Treatment of jengkol bark extract with a concentration of 25 g.l-1 water caused the initial time of death of S. frugiperda longer at 48.75 hours after application but differed not significantly with the treatment of 50 g.l-1 water. It is suspected that the low concentration of jengkol bark extract given, the lower the active ingredient contained in it, so it takes a long time to kill S. frugiperda. This opinion corresponds to [13] that a low concentration produces a low active ingredient in it so that its effectiveness is lower in proportion to the low concentration used.

The most content found in jengkol skin is alkaloids and saponins [14] Alkaloid compounds enter the body of larvae through the cuticle and work as nerve poisons by inhibiting the work of the acetylcholinesterase enzyme it will cause the accumulation of acetylcholine which causes disruption and damage to the nervous system, over time the larvae will experience death [15]. Alkaloids can also disrupt the digestive system of larvae by entering the digestive tract and destroying the cell membranes of the digestive tract so that the digestive process stops [16].

Early symptoms of death of S. frugiperda larvae after applying jengkol bark extract are characterized by changes in behavior, such as decreased eating activities, less active movement, and slow movements. Morphological changes in S larvae. Frugiperda is characterized by a body color that is initially bright brown with black spots on the abdomen turning reddish-yellow and wrinkled and the caterpillar's body turning black (melanizing the cuticle) after 24 hours of application. The discoloration of Spodoptera frugiperda J. E. Smith after treatment can be seen in Figure 1.

Figure 1 Changes in larval morphology of *Spodoptera frugiperda* J.E. Smith (a) surviving larvae (b) dead larvae (c) larvae turn black, wrinkled and soft (Research Documentation, 2022).

3.2. Lethal Time 50 (LT50)

The results of various fingerprints showed that treatment of several concentrations of jengkol bark extract (*P. lobate*) had a significant effect on lethal time 50 (LT50) *S. frugiperda*. The average result of Lethal time 50 (LT50) *S. frugiperda* after the BNT test at 5% level can be seen in Table 2.

Table 2 Lethal time 50 (LT_{50}) of *S. frugiperda* after application of multiple concentrations of jengkol bark extract (hours)

Extract concentration jengkol bark (g.1-1 water)	Lethal time 50 (jam)
0	120.00 a
25	120.00 a
50	102.00 b
75	74.25 c
100	60.75 d

The numbers in the column of each treatment followed by unequal lowercase letters differ markedly according to the BNT test at the level of 5% after being transformed by $\sqrt{y}$.

Table 2 shows that the treatment concentration of jengkol bark extract of 100 g.l-1 water is the best concentration that causes a lethal time of 50% of *S. frugiperda* pests of 60.75 hours and differs markedly from all other treatments. This is consistent with results at the time of initial death (Table 1) which showed that the concentration of jengkol bark extract of 100 g.l-1 water led to a faster time of death of *S. frugiperda* larvae at 17.25 hours after application in contrast to 75 g.l-1 water with an initial time of death at 30.00 hours after application. This is suspected when observing LT50 saponin compounds in jengkol bark extract has worked well in the body of *S. frugiperda* larvae as a stomach poison.

According to [17] saponins have a bitter taste that can decrease the appetite of larvae, so that larvae will starve and experience death. [18] states that saponins can inhibit the work of chymotrypsin enzymes which can cause disruption of the digestive system, inhibition of development and growth, and can cause death if the level of digestive inhibition is too high.

Tables 1 and 2 show that the concentration of jengkol bark extract of 100 g.l-1 water showed the fastest time of early death of *S. frugiperda* larvae at 17.25 hours after application and the fastest LT50 at 60.75 hours after application. This happens because the concentration of 100 g.l-1 water is the highest concentration used in the application, so the level of active compounds from jengkol skin is also higher and can accelerate the death of *S. frugiperda* larvae compared to other treatments. This opinion is reinforced by [19] the higher the concentration of the extract, the more concentrated and many toxins contained in the insect's body, causing faster mortality.

The concentration of jengkol bark extract of 50 g.l-1 water caused LT50 to be slower and significantly different from all tested treatments at 102.00, hours after application. This is due to the low concentration of jengkol bark extract so the time needed to kill 50% of the *S. frugiperda* larva population is longer. According to [13] the low concentration causes the active ingredients contained in the extract to be reduced so that its effectiveness in killing insects will be low which is proportional to the smaller the concentration used.

The concentration of jengkol bark extract of 0 g.l-1 water and 25 g.l-1 water was not able to kill 50% of *S. frugiperda* larvae until the end of observation, which is 120 hours. This is thought to be because the increased concentration of the active ingredient of jengkol bark extract can still be tolerated by larvae *S. Frugiperda*. This statement is supported by [20] that insects are able to tolerate bioactive compounds contained in their bodies with the metabolic ability to decompose these toxic materials.

3.3. Lethal Concentration (LC50 and LC95)

Based on the results of probit lethal concentration (LC) analysis using the POLO-PC program, the concentration of jengkol bark extract showed LC50 and LC95, namely- 4.45% and 19.38%, respectively. The results of the probit analysis can be seen in Table 3.

Table 3 Lethal concentration of jengkol bark extract (*P. lobatum* Benth) against *S. frugiperda* larvae

Lethal concentration (LC)	Concentration (%)	SK 95% (%)
LC_{50}	4.45	2.20 – 6.91
LC_{95}	19.38	10.44 – 348.75

SK= Confidence Lapse

Table 3 shows that the appropriate concentration of jengkol bark extract to kill 50% of the *S. frugiperda* larva population is 4.45% or equivalent to 44.5 g.l-1 jengkol bark extract water, while the appropriate concentration to kill 95% of the *S. frugiperda* larva population is 19.38% or equivalent to 193.8 g.l-1 jengkol bark extract water. The results showed that jengkol bark extract was appropriate in controlling *S. frugiperda* larvae, but not in accordance with the condition [20] that LC 95 vegetable insecticide using water solvent was said to be appropriate if the concentration used was not more than 10% or 100 g.l-1 water in killing 95% of test insects.

3.4. Total Mortality

The results of the fingerprints showed that treatment with several concentrations of jengkol bark extract (P. lobate) had a significant effect on the total mortality of larvae *S. frugiperda*. The average yield of total mortality of larvae *S. frugiperda* after the BNT test at 5% level can be seen in Table 4.

Table 4 Total mortality of *S. frugiperda* after application of multiple concentrations of jengkol bark extract (%)

Extract concentration jengkol bark (g.1-1 water)	Total mortality (%)
0	00.00 d
25	35.00 c
50	55.00 b
75	60.00 b
100	90.00 a

The numbers in the column of each treatment followed by unequal lowercase letters differ markedly according to the BNT test at the level of 5% after being transformed by the arcsin formula $\sqrt{y + 0{,}5}$.

Table 4 shows that treatment of jengkol bark extract concentrations with several different concentrations exerts different effects on the total mortality of *S. frugiperda* in the range of 35-90%. The concentration of jengkol bark extract of 100 g.l-1 water was able to cause total mortality of 90% which was significantly different from the treatment of 75 g.l-1 water with total mortality of 60%, treatment of 50 g.l-1 water with total mortality of 55%, treatment of 25 g.l-1 water caused total mortality of 35%, and 0 g.l-1 water that did not cause total mortality until the end of the observation.

Application of jengkol bark extract concentration of 100 g.l-1 water showed the highest percentage of mortality of larvae *S. frugiperda* which is 9.0%. This is because the higher the concentration given, the more active compound content will also increase so that the mortality of *S. frugiperda* larvae is greater. This is supported by [21] that the high concentration given is directly proportional to the increase in the percentage of death, so the higher the concentration of treatment, the higher the death of insects because more toxic compounds act on the body of insects.

The ability of jengkol bark extract to kill *S. frugiperda* larvae is caused because jengkol bark contains alkaloids and saponins. [14] states that jengkol skin contains a lot of alkaloids and saponins, as well as sufficient flavonoids and terpenoids, and a small tannin content. The compounds contained in jengkol bark extract are toxic and can inhibit appetite, resulting in death of *S. frugiperda* larvae. Compounds contained in jengkol skin such as alkaloids and saponins enter the body of larvae as contact toxins and stomach poisons.

Alkaloids will act as neurotoxins, digestive toxins, and antiifeedants, while saponins act as digestive toxins. Alkaloid compounds as neurotoxins have the potential to inhibit the work of the acetylcholinesterase enzyme to break down acetylcholine into choline as a conductor of nerve impulses so that it can cause paralysis and cessation of the digestive process [15]. Alkaloids are salts that are able to degrade cell membranes to enter the digestive tract causing irritation of the larval digestive tract by damaging the peritrophic membrane of the digestive tract [16].

The very bitter taste of alkaloids can also cause larval feeding activity to decrease (antifeedant) [22]. Saponins are a group of triterpenoids that can degrade protease enzymes in the food tract and interfere with food absorption [23]. Saponins can also inhibit the productivity of the chymotrypsin enzyme which results in disruption of the digestive system and can cause death if the level of digestive inhibition is too high [18].

The mortality rate of *S. frugiperda* larvae in the study was 90%, while in [10] the mortality rate in *S. exigua* larvae was 92.5%. This is due to differences in larval body size. *S. frugiperda* larvae have a fairly large body size compared to *S. exigua* larvae. [11] states that insects with larger sizes will be more resistant to bioactive compounds compared to insects of smaller sizes. This is supported by the opinion [24] that the difference in the surface area of the target tissue greatly affects so that small-size insects with sufficient bioactive compounds will work faster to meet the target tissue part to cause death compared to larger-size insects.

Giving jengkol bark extract was effective in controlling *S. frugiperda* larvae at 100 g.l-1 water treatment with total mortality reaching 90%. This is in accordance with the opinion 11] that vegetable insecticides are said to be effective if they are able to kill insect pests ≥80% by using water solvents at concentrations not exceeding 10%.

4. Conclusion

Based on the results of the research conducted, it can be concluded that jengkol bark extracts with a concentration of 100 g.l 1 water is an effective concentration in controlling corn plant pests (*Spodoptera frugiperda* J. E. Smith) in the

laboratory because this concentration is able to cause total mortality of 90% with an initial time of death of 17.25 hours after application and lethal time of 50 at 60.75 hours after application. Then the right concentration of jengkol peel extract in killing 50% of corn armyworms is 4.45% or equivalent to 44.5 g.l-1 water. The proper concentration to kill 95% of armyworms is 19.38% or equivalent to 193.8 g.l-1 water

Compliance with ethical standards

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Disclosure of conflict of interest

There are not any conflicts of interest of this study.

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