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Antifeedant activity and toxicity of pontianak citrus peel extract (pcpe) againts *spodoptera litura.* Fab (lepidoptera: noctuidae)

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The armyworm, *Spodoptera litura* F. Is one of the main leaves pests in agricultural crops. It has a broad host range species, and cosmopolite. Control of *S. litura* generally still use synthetic pesticides which have a negative impact on the environment and ecosystems. Therefore, an effective and environmentally friendly alternative control strategy is needed. One of alternative pest control that is potential to develop is by using botanical pesticide. Citrus fruit peel oil extracts, is a large citrus juice industrial waste and known as a chemical compound that can affect the pest. Utilization that has a high economic value as a botanical insecticide. Limonene in citrus fruit peel oil can decrease feeding activity and increase the mortality of *S. litura*. This research was conducted in Sub-Laboratory of Toxicology and Rearing, Plant Pest and Disease Department, Agriculture Faculty, Brawijaya University, Malang. The results showed that Pontianak citrus peel extract was able to decrease the feeding activity of *S. Litura* larvae as much as 80.11% and resulted in larvae mortality up to 76.25%. LC_{50} values obtained by the 4% and LT_{50} were 79 hours.

Keywords: *Spodoptera litura*, Botanical Pesticides, Pontianak citrus peel extract, Feeding Activity, Mortality

INTRODUCTION

The armyworm, *Spodoptera litura,* is one of the broadest destructive insect pest of agricultural crops. It is polyphagous pest which attacks more than 150 host plant species (Xue et al., 2010) in India, Japan, China, Australia, Southeast Asia and Indonesia (Zhou et al., 2010; Ashokaraj et al., 2013). *S. Litura* invades plant cultivation both in the vegetative and generative phase. In the vegetative phase the larvae feed in the nursery and leaf vein, whereas in generative phase by feeding on early pods. The *S. Litura* attacks cause great damage of about 26% until 86% (Navasero et al., 2013).

Generally, *S. Litura* was controlled by applying a chemical insecticide, because farmers consider this method as the easiest and most effective control. In contrast, many research indicates that the use of synthetic pesticides inappropriately has some negative impacts, such as killing non-target organisms, causing pest resistance, and adversely affecting the environment (Aktar et al., 2009). Therefore, an effective and environmentally friendly alternative control strategy is needed. One of alternative pest control that is potential to develop is by using botanical pesticide because it is decomposed easily in the environment (Siva et al., 2017). Botanical pesticides can control pests and diseases through a unique mode of action, which can be a mix of different or single compounds. The specific mode of action inhibits the development of eggs, larvae and pupa, act as feeding repellent, affect feeding behaviour, inhibit

the reproduction of female insects, expelling insects, disturb the molting process and inhibit the development of disease pathogens (Rachmawati and Eli, 2009). The use of botanical pesticides, in addition to reducing environmental pollution, is also relatively cost-effective when compared with chemical pesticides (Moreno et al., 2013) and could support the development of sustainable agriculture and food security.

The use of Pontianak citrus peel extract as a botanical pesticide is an effort to utilize industrial waste of citrus fruit juice that can be used as a new botanical pesticide. The largest component of Pontianak citrus (*Citrus* nobilis) peel oil is a limonene compound with a percentage of about 95% and includes terpenoids. Limonene compounds are chemical compounds that can be both toxic and also respiratory toxins (Hollingworth, 2005). This compound has been proven in several studies by giving an insecticidal effect on some aphid (*Aphis* sp.) (Homoptera: Aphididae) (Ibrahim, 2005). At concentrations of 10% Pontianak citrus peel extract is also capable of raising mortality by 50% in *Coptotermes curvignathus* (Isoptera: Termitidae) termite (Mashek and Quarles, 2008). Based on the development of research that has been done, it is still little known about the assessment of actifeedant activity from PCPE to armyworm *S. Litura*. Therefore in this study aim to investigate the antifeedant activity of PCPE to the armyworm *S. Litura*, so it could provide scientific information to the public about the potential of Pontianak citrus peel as a botanical insecticide.

MATERIALS AND METHODS

Insects

Insects test that was used was 2nd instar larvae of *S. litura* which were obtained from the Laboratory of Pest, Department of Pest and Disease Plant, University of Brawijaya. *S. litura* reared on cabbage leaves in the plastic containers (Dimensions: 18 cm height and 15 cm diameter) covered with a screened window with stencil paper. Larvae were fed with fresh cabbage leaves daily until full maturity. Armyworm, *S. litura* took 16.70 ± 0.54 days to complete larval period. After, the full-grown larvae were transferred to other plastic pots filled with sterilized soil for pupation. A pupal period was found to be 12.70 ± 0.56 days. After emergence, the adult moths were kept inside a plastic container (11 cm diameter and 10 cm high) for mating and provided with sheet of papers for oviposition. The Cotton swab soaked in 10% sucrose solution was provided as a source of food for adult moths. Adults lived for 8.10 ± 0.28 days and the oviposition period was found to be 4.50 ± 0.17 days. Egg masses laid on the papers were collected daily and placed in clean containers (12 cm diameter x 6.5 cm high). Eggs were incubated at a temperature of 25 ± 1 °C and relative humidity of 70–80%. The incubation period was observed to be 4.60 ± 0.16 days. After hatching, neonate larvae were released on the tender cabbage leaves and reared to maturity as explained above. On an average, *S. litura* takes 42.10 ± 0.77 days to complete life cycle on cabbage in controlled laboratory conditions. The larvae from the third and subsequent generations were used for the experiments (Kaleeswaran et al., 2018).

Preparation of Pontianak Citrus Peel Extract (PCPE)

Extracting method was done based on Lestari and Arreneuz (2014) which 7 kg of citrus peel were cut into pieces and then put into the water vapor distillation which consists of kettle 1 as water container and kettle 2 as the sample container. The steam and water vaporized process was carried out for 5 hours at 95 °C. After that the water layer was removed and the essential oil layer from the citrus peel was also removed and put into the bottle. Essential oils were then supplemented with anhydrous sodium sulfate to absorb the aquades that still present in the essential oil. Obtained essential oils were nonpolar, so it needed to be dissolved into a liquid soap with a ratio of 4: 1. Non-polar oils were then stored in small glass bottles and then sealed tightly. The essential oil was then ready to be used for research by adding aquades according to the concentration at each treatment.

Assay of Pontianak Citrus Peel Extract Application (PCPE) to Feeding Activity of *S. litura*

The study was arranged using a randomized block design with 6 treatments and 4 replications. The treatments used were Pontianak citrus peel extract (PCPE) with concentration of 0; 1; 2; 3; 4; 5; and 6%. The application of Pontianak citrus peel extract on *S. litura* was done by leaf dip method (Tohir, 2010). Cabbage leaves that had been cut 20 sheets dipped in the extract suspension in accordance with each treatment concentration, while for the leaves on the control just dipped into the water without extract. The leaves were immersed in the extract for 30

seconds and were dried, then the leaves and larvae that had been exposed for 3 hours were put into plastic jars. On one container of a plastic jar containing 1 cabbage leaf and 1 larvae of *S. litura*. The plastic containers were labeled according to the concentration of extract solution given to each treatment. The parameters observed in the test were feeding activity, larval mortality, the number of pupae formed, and the number of emerging imago. The implementation of the research was carried out continuously ie the test larvae were not replaced and continue to be used until all parameters were observed.

Feeding activity was calculated by weighting the weight of the feed and calculating the difference between initial and final feed weight then subtracted by a correction factor. Observations were recorded every 24 hours for 5 days. After 48 hours, the feed was replaced with cabbage leaves without being treated. The percentage of feeding activity was calculated using the following formula (Zhang et al., 1998): The percentage of feeding activity was calculated by the following formula (Zhang et al., 1998):

$$Feeding\ activity\ (\%)\ =\ 1 - \frac{a}{b} x\ 100\%$$

Description:
a: the weight of the feed eaten in the treatment,
b: the weight of the feed eaten on the control.
If the percentage of feeding activity was known, the mean of the feeding activity would be classified based on the criteria of percentage decrease in activity of feeding on Park et al., (1997).
The calculation of larval mortality was similar to the feeding activity of larvae of *S. litura*. The number of larval mortality of *S. litura* was observed by counting the number of dead larvae. Characteristics of dead larvae were dried body, blackish brown colour and did not move if touched with a brush. The observed percentage of larval mortality was performed at 24, 48, 72, 96, and 120 hours after application (JSA) (Hollingworth, 2005). Larval mortality was calculated using the formula:

$$Po\ =\ \frac{a}{b} x\ 100\%$$

the Po is the percentage of deaths observed, a is the number of dead larvae in each treatment group, and b is the total number of larvae of each treatment (Holling worth, 2005).
If there was a controlled death of no more than 20%, then the percentage of deaths of *S. litura* larvae were corrected using the Abbott (1987) formula as follows:

$$P\ =\ \frac{X - Y}{X} x\ 100\%$$

The survival test larvae in the mortality test were maintained until the next stage for use in testing the formation of pupae *S. litura* and the number of emerging imago. The pupae formed were studied in more depth to determine the morphological changes after PCPE application. The percentage of pupae formed was calculated from each treatment, since one day the larvae enter the prepupa phase until the pupae are formed. The percentage of pupae formed was calculated using the following formula (Park et al., 1997):

$$\%\ Pupae\ =\ \frac{Number\ of\ \ pupae\ formed}{Number\ of\ live\ larvae} x\ 100\%$$

The emerging percentage of imago was calculated from each treatment since one day the larvae formed pupae until imago appeared. The percentage of imago were calculated using the formula (Park et al., 1997):

$$\%\ Imago\ =\ \frac{Number\ of\ \ imago\ formed}{Number\ of\ pupae\ formed} x\ 100\%$$

Imago formed were studied in more depth to evaluate the morphological changes after application.

Data analysis

Data obtained from observation of larval feeding activity, larval mortality, a percentage of pupae formation, and imago emergence were analyzed by using F test at 5% level. If there were a significant difference among the treatment of the variance analysis then it was further tested by Duncan Multiple Range Test.

The probit analysis was performed to determine the 50% lethal concentration (LC50) and 50% lethal time (LT50) by methods developed by Hsin Chi (1925). Furthermore, the equilibrium test of the probit regression line of each treatment was done. If the value of a coefficient of determination (R^2) has been known then the value of R was inserted in the table of correlation coefficient values to determine the level of closeness of the increase of concentration and time-sensitive to the increase in percentage mortality.

RESULTS AND DISCUSSION

Effect of Pontianak Citrus Peel Extract Application to *S. litura* Feeding Activity

The larvae feeding activity of *S. litura* after application of PCEP showed a significant effect because of the number of leaves at treatment significantly lower than control (Table 1).

Table 1. The Average of feeding activity of larvae of *S. litura* after PCPE application

Concentration (%)	Feeding activity (g) (x ± SE)				
	24 HAT	48 HAT	72 HAT	96 J HAT	120 HAT
0	3.68±0.05 e	3.16±0.07 c	3.07±0.03 c	3.02±0.02 c	3.29±0.02 f
1	3.50±0.05 de	2.68±0.03 bc	2.47±0.04 b	2.31±0.04 b	2.07±0.04 e
2	3.38±0.05 cde	2.65±0.05 bc	1.98±0.05 a	1.81±0.06 b	1.67±0.07 d
3	3.31±0.05 bcd	2.56±0.05 b	1.92±0.06 a	1.55±0.08 a	1.46±0.06 cd
4	3.16±0.03 bc	2.54±0.04 b	1.87±0.05 a	1.50±0.09 a	1.18±0.04 bc
5	3.03±0.03 b	2.26±0.04 ab	1.72±0.07 a	1.15±0.04 a	0.98±0.02 b
6	2.71±0.04 a	2.02±0.05 a	1.64±0.08 a	1.02±0.04 a	0.63±0.06 a

Remarks: Different letters in a column indicate significant difference at P≤ 0.05 Duncan test with 5% level, SE: standard error; HAT: Hour After Treatment

The weight of the leaves eaten by the larvae decreased with the addition of PCPE concentration. This showed that PCPE application could decrease the feeding activity of *S. litura*. However, at observations of 72 to 120 HATs with a concentration of 4 to 6%, larval feeding activity did not significantly affect treatment. It was suspected that the larvae were able to neutralize the toxins present in PCPE, so that the feeding activity was no longer disturbed. PCPE was classified as volatile oil and resulted in reduced toxicity, hence larvae were easier to neutralize toxins present in PCPE. Moky (2014) states that volatile oils are volatile, as a consequence the level of toxicity is easily decreased.

The highest reduction percentage in feeding activity at 24 to 120 HAT were obtained in the PCPE application with 6% concentration (Table 1). The higher concentration of PCPE given, will lead to the higher decrease in the activity of *S. litura* larvae feeding. This suggests that PCPE could act ad anti-feeding against *S. litura* larvae. According to Hollingworth (2005), in the citrus peel contained linalool compounds that had a stinging aroma were not favored by insects. This component was known as secondary insect repellent metabolite compound.

The decrease occurring in the feeding activity of *S. litura* larvae were also affected by terpenoid compounds which contained in PCPE. Kamal et al (2011) explains that terpenoids are compounds that have a sense of sensilla and useful as an antifeedant against insects. Anti-feeding compounds did not kill or trap pests but only inhibited the feeding activity alone. If the percentage of feeding activity were included in the criteria of the percentage of feeding activity (Table 2), then PCPE was considered to be strong in decreasing the feeding activity of *S. litura*.

Table 2. Percentage reduction criteria of feeding activity (Park et al., 1997)

Percentage of feeding activity Criteria	Criteria
>80 %	High
61 – 80 %	Medium
40 – 60 %	Low
<40 %	No

The mortality percentage of *S. litura* larvae were obtained from the accumulation of larval mortality in each treatment from each observation hour. The results showed that the PCPE application caused the mortality of *S. litura* larvae to be significantly higher than the control (Table 1). At 24 HAT, a 6% concentration of PCPE became the most effective concentration as it increased the percentage of mortality by more than 50%. The percentage of larval mortality at 96 and 120 HAT were the same at each treatment. It was shown that the number of dead larvae at 96 and 120 HAT had the same value. Percentage of fixed mortality at 96 and 120 HAT appeared to be due to there was a toxicity reduction of PCPE compounds. The chemical compounds contained in PCPE were classified in botanical materials, hence they have a low persistence rate which only was 1-3 days. According to Tong et al., (2013), botanical materials can quickly decompose and its residues easily disappeared because the compound was easily degraded by the environment. In 120 HATs,

Table 3. The decreased percentage of feeding activity of *S. litura* larvae after PCPE application

Concentration (%)	Feeding activity (%) (x ± SE)				
	24 HAT	48 HAT	72 HAT	96 J HAT	120 HAT
0	0.00±0.00 a	0.00±0.00 a	0.00±0.00 a	0.00±0.00 a	0.00±0.0 a
1	4.90±0.00 ab	13.50±0.07 ab	19.00±0.06 b	20.05±0.05 b	36.47±0.08 b
2	8.14±0.01 abc	14.40±0.09 ab	34.50±0.12 c	36.83±0.12 c	48.74±0.12 c
3	10.00±0.01 bcd	17.10±0.11 b	36.60±0.12 cd	45.80±0.13 cd	55.01±0.10 cd
4	13.80±0.03 cd	17.80±0.08 b	38.30±0.12 d	47.41±0.16 d	63.78±0.06 de
5	17.10±0.04 d	26.30±0.11 bc	43.10±0.14 e	60.04±0.05 e	70.12±0.02 ef
6	24.50±0.07 e	33.10±0.13 c	44.70±0.14 e	65.40±0.03 e	80.11±0.03 f

Remarks: Different letters in a column indicate significant difference at P≤ 0.05 Duncan test with 5% level, SE: standard error; HAT: Hour After Treatment

Table 4. Effect of Pontianak Citrus Peel Extract Application to *S. litura* Mortality

Concentration (%)	Mortality of larvae (%) (x ± SE)				
	24 HAT	48 HAT	72 HAT	96 J HAT	120 HAT
0	10.00±0.00 a	10.00±0.00 a	10.00±0.00 a	10.00±0.00 a	10.00±0.00 a
1	20.00±0.03 b	20.00±0.03 a	21.20±0.04 ab	26.20±0.05 b	26.20±0.04 b
2	22.50±0.05 bc	28.70±0.03 b	31.20±0.06 bc	31.20±0.06 bc	31.20±0.06 bc
3	21.50±0.02 bc	32.50±0.03 bc	38.70±0.06 cd	38.70±0.06 bc	38.70±0.06 bc
4	31.20±0.04 cd	45.00±0.05 cd	47.50±0.07 cd	48.70±0.07 cd	48.70±0.06 cd
5	37.50±0.03 d	48.70±0.04 d	55.00±0.05 d	57.50±0.05 de	57.50±0.05 de
6	50.00±0.05 e	72.50±0.04 e	75.00±0.05 e	76.20±0.05 e	76.20±0.05 e

Remarks: Different letters in a column indicate significant difference at P≤ 0.05 Duncan test with 5% level, SE: standard error; HAT: Hour After Treatment

the percentage of mortality had not reached 80%, while according to the statement from Divya (2016) pesticides can be said to be effective if it has a kill power of more than or equal to 80%. However, these criteria were more suitable for chemical pesticides that have direct contact effects on target organisms. As for botanical pesticides, effectiveness assessment was more emphasized on its influence on the biology of the test insects that were inhibited the growth, longer the life cycle, infertility, and insects produced eggs that can not hatch. Thus, it seemed that PCPE can be used as an alternative control of *S. litura* because it was capable to decrease the larvae feeding activity and inhibited the growth and development of the insects

Effect of PCPE on mortality of larvae *S. Litura*

The higher the PCPE concentration used, the higher its toxicity and will lead to the higher dead of larvae (Table 4). Similarly with the previous statement, Roger (1997) stated that the higher the concentration of pesticides used, the content of active ingredients in the solution was greater, hence the pesticide toxicity was also higher. Mortality that occurred in each treatment was due to the content of limonene compounds present in PCPE could be toxic activity. According to Abdel and Mossa (2006), limonene compounds successfully identified as stomach poison. Kirani et al., (2017) argue that as a stomach poison, limonene can enter the body of the larvae to the digestion through an inedible concentration of essential oils. Insecticides will enter the digestive organs of insects and absorbed by the intestinal wall and circulate with blood that will disrupt the metabolism of the larvae. Larvae that have been disrupted its metabolism, will lack energy for life activities and cause convulsions until death.

The characteristics of *S. litura* larvae that died because of were contaminated with PCPE botanical pesticides, had specific characteristics i.e. their bodies became dry, the size of their body shrank, and the color became blackish. These

results were in consistent with Divya et al., (2016) statement that indicates the dead larvae due to botanical pesticides show the characteristics of their body drying up, the color being black and the body size shrinking. As for the healthy larvae, its body will be light green and always move actively. Agreeing with the previous statement, Hollingworth (2005) stated that the characteristics of healthy larvae are light green body color with a length of 3-10 mm.

Effect of PCPE to Pupae and Imago formed of *S. litura*

The use of PCPE was not only affected both feeding activity and mortality, but it could also have a significant effect on the duration of *S. litura* pupae and imago when compared to controls (Table 5). The length of the pupae stadia were 6-10 days and the length of the imago stadia were 7-11 days. Meanwhile, according to Divya et al. (2016) and Murata (2001) the normal time span of the pupa stage is 5-8 days and the imago stadia is 5-9 days. The larvae remain capable of being pupae and imago even though their stages are longer.

Table 5. The average of pupae and imago of *S. litura* in various concentration of PCEP

Concentration (%)	Average of stadia (days) (x ± SE)	
	Pupae	Imago
0 (control)	6.29±0.75 a	7.22± 0.16 a
1	7.59±0.29 ab	7.53±0.25 ab
2	8.14±0.78 bc	8.00±0.25 ab
3	8.32±0.83 bc	8.60± 0.59 b
4	8.34±0.46 bc	9.83± 0.27 c
5	9.93±0.44 cd	10.22± 0.37 c
6	10.65±0.55 d	11.67± 0.47 d

Remarks: Different letters in a column indicate significant difference at P≤ 0.05 Duncan test with 5% level, SE: standard error

This condition is similar to that of Chowdari et al., (2010) which said Suren leaf extract is only able to affect the length of pupae and imago stadia only, while the percentage of pupa and imago formation remains the same.

The PCPE application gave the percentage of pupae and imago formation which were not significantly different from the control. This results indicated that no matter how much PCPE concentration is given, the number of larvae that become pupae and pupae that become imago remained the same (Table 6).

Table 6. Effect of Pontianak Citrus Peel Extract Application on Formation of Pupae and Imago *S. litura*

Concentration (%)	Percentage (%)	
	Larvae become pupae ($\overline{X}$ ± SE)	Pupae became imago($\overline{X}$ ± SE)
0 (control)	100.00± 0.00	100.00± 0.00
1	96.83±1.86	92.89± 2.22
2	100.00± 0.00	98.61± 1.38
3	97.06± 1.94	93.08± 2.72
4	98.08± 1.92	95.83± 2.16
5	100.00± 0.00	100.00± 0.00
6	100.00± 0.00	75.00± 2.50

Remarks: Different letters in a column indicate significant difference at P≤ 0.05 Duncan test with 5% level, SE: standard error

These results were not in accordance with research conducted by Utami and Haneda (2012) that stated higher concentrations of extracts contain more active compounds, resulting in less pupa and imago success. The percentage of pupae and imago formation were not in accordance with the increase of PCPE concentration because there were different tolerance level for each individual insect *S. litura*. Tamboli and Lolage (2008) stated that if the insects eat active compounds that are toxic, insects that cannot compensate it, will experience death. Conversely, tolerant insects will survive until the next phase. Insects that are sensitive to the active compound do not die immediately, but insects can survive by maximizing the use of energy sources in the body.

The consequences of this state, larvae will experience obstacles in its growth and development. Intolerant insects, foreign compounds that enter into the body can be neutralized to be inactive, so that the insects can adapt to the compound. The inactive compounds are then excreted through insect feces.

Table 7. Lethal Concentration 50% (LC50) and Lethal Off Time 50% (LT50) on *S. litura* Larvae

	Number	Regression equation
LC_{50}	4.18 %	Y= 1.590x + 3.850
LT_{50}	79.43 hour	Y= 0.483x + 4.080

Note: - y = probit persentage of larvae *S. litura* that was die (%)

- x = log10 from concentration (%) or time (hour) treatment PCPE

Based on the mortality data, we can find the relationship between concentration and mortality using probit analysis. The probit analysis is a method of calculation to obtain the toxicity value

of an insecticide type to the experimental insects which can be known from the amount of LC50 and LT50 (Table 7). The LC50 value is the amount of concentration required to kill 50% of the insect test population whereas LT50 is the length of time it takes an insecticide to kill 50% of the insect test population. LC50 was calculated from the relationship between mortality and the concentration given while LT50 was obtained from the model of mortality relationship with time.

The regression equation obtained for LC50 was Y = 1.590x + 3.850 which means that every 1% increase in concentration will increase the number of *S. litura* larvae mortality by 1.59% (Figure 1).

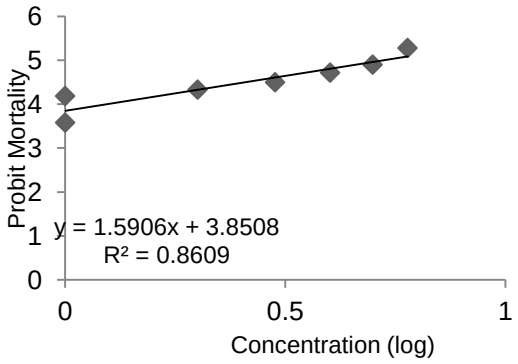

Figure 1. Graph of the relationship between the concentration of Pontianak citrus peel extract on larvae mortality of *S. litura*.

This suggests that the higher concentration was given, the higher mortality that occurred. The result of LC50 obtained was 4.18%, it can be interpreted that with 4% concentration PCPE could kill 50% of the population of insect test. The LC50 values obtained from this study were lower than those of Tong et al., (2013) that apply PCPE to *C. curvignathus* termite with LC50 value was 10%. These results indicated that PCPE were more effectively used to control *S. litura* because it had a lower LC50 value when compared to the LC50 value in the soil termites.

The regression equation obtained for LT50 was Y = 0.483x + 4.080, which means that every 24 hours after application would increase the mortality by 0.5% (Figure 2). The value of LT50 obtained was 79.43% which means that with a time 80 hours after application with PCPE concentration of 6% could kill 50% of the insect test population.

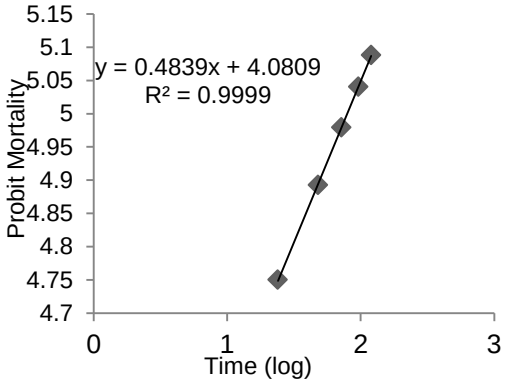

Figure 2. Graph of the relationship between the amount of time required by Pontianak citrus peel extract to increase the mortality of *S. litura* larvae

In the calculation of LC50, the coefficient of determination (R^2) was used to describe the relationship between PCPE concentration and larval mortality. While in LT50, the coefficient of determination was used to describe the closeness of the relationship between the amount of time required by PCPE to increase the mortality of *S. litura* larvae. The value of R^2 to LC50 was 0.860 so that the value of R was 0.927 and if the value is included in the correlation coefficient table (Table 8),

Table 8. Correlation Coefficient Value (Liebhold and Sherov, 1998)

Correlation Coefficient Value	Criteria
0,00-0,199	Very low
0,20-0,399	Low
0,49-0,599	Medium
0,60-0,799	High
0,80-1,000	Very high

the closeness between increasing PCPE concentrations and increasing the mortality of *S. litura* larvae could be categorized very strongly. The result of R^2 on LT50 was 0.999 so that the value of R was 0.999 which means that the relationship between the amount of time and the increase in mortality of *S. Litura* larvae belong to a very strong category.

CONCLUSION

Based on the results of the research it could be concluded that PCPE can be a plant-based pesticide by an act as a stomach poison and inhibit the insects feeding activity. The most

effective concentration assessed for lethal larvae of *S. litura* was 6% PCPE. At 6% concentration PCPE was able to decrease the feeding activity of *S. litura* larvae as much as 80.11% and effectively resulted in mortality up to 76.25%. The obtained LC50 value was 4% and LT50 was 79 HAT.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

TW and HT suggested the idea and designed the research, GA performed the experiment, TW wrote the manuscript and data analysis. HT reviewed the manuscript, All authors read and approved the final version.

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