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EFFECT OF FEED COMPOSITION ON SPONSTIC PLASTIC WASTE DEGRADATION, SURVIVALITY AND LARVA GROWTH *Tenebrio molitor* L.

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ABSTRACT
Sponge plastic is one of the plastic wastes that difficult to degrade. Recently research reported that *Tenebrio molitor* L larvae have a potential capability to degrade the plastic waste. But still lack of information according to the effect of feed composition on survival, and growth of *T. molitor* L larvae. The purpose of this study was to determine the effect of plastic feed composition on the rate of degradation of sponge plastic waste, survival, and growth of *T. molitor* L larvae. The method used in this study was an experimental laboratory using Completely Randomized Design (CRD) and using controls and six treatments with 3 repetition times. The parameters measured in this study were survival (%), body length growth (cm/week) and body biomass (gram/week) and degradation rate (gram/week). The data obtained from the research results will be analyzed using ANOVA which is then tested by Duncan. The results showed that feed composition had a significant effect (p=0.001) on the rate of degradation of plastic sponge waste, survival (p=0.000) and growth (p=0.001) of *T. molitor* L larvae. degradation, survival, and growth of *T. molitor* L. larvae.

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1. INTRODUCTION

Poly Styrene (PS) plastic is a type of plastic in the plastic category that is most often produced (Farrel *et al*., 2017) such as sponge or foam. This happens because this type of plastic has low density and is harmless, but the characteristics of this plastic make it resistant to microbial degradation (Matyja *et al*., 2020). Plastic waste is increasing, especially the type of Poly Styrene (PS) waste (Lettieri & Al-Salem, 2011). Various ways have been done to overcome the problem of plastic waste in Indonesia (Hidayat *et al*. 2019), but they are not enough to reduce the presence of plastic waste in nature, so a decomposer is needed that does not produce other substances so that it is not harmful. Several years ago, an animal that was able to degrade one type of plastic was found, namely *T. molitor* L (Yang *et al*., 2018).

Larvae of T. *molito*r L. as a biodegradator of sponge plastic waste is one way to reduce the presence of this waste (Yang *et al*., 2018a). The feed medium in this study is sponge plastic waste which is easy to obtain because it is used daily in human life. The feed used in this study were concentrate and chayote. Concentrate is to fulfill the nutritional needs of larvae and chayote is used to fulfill water and minerals. The growth of *T. molitor* larvae can be influenced by nutrition, the presence of sufficient nutritional content for *T. molitor* larvae is thought to be able to increase length, body weight and form body tissues of each larva (Yang *et al*., 2015).

The purpose of this study was to determine the effect of the composition of sponge plastic waste as feed on the survival and growth of *T. molitor* L. larvae so that the rate of degradation of sponge plastic waste could be more optimal. The results of this study are expected to provide insight to the public.

2. RESEARCH METHOD

This research was conducted from July to August 2021 at the CDAST Bioremediation laboratory at the University of Jember. This study used six treatments and a control with 3 replications. The feed ingredients used in this study included Control (K) (90% concentrate + 10% pumpkin), P1 (45% concentrate, 45% + 45%

dishwashing sponge + 10% pumpkin), P2 (20% concentrate + 70% dishwashing sponge +10% pumpkin), P3 (90% dishwashing sponge + 10% pumpkin), P4 (45% concentrate + 45% car wash sponge + 10% pumpkin), P5 (20% concentrate + 70% car wash sponge + 10% pumpkin), P6 (90% car wash sponge + 10% pumpkin). Larvae feed material in one week was calculated by the formula 0.08 × 7× total biomass of *T. molitor* L larvae.

3. RESULTS AND DISCUSSION

A. Result

1) Larvae Survival of *T. molitor* L.

Table 1. Duncan Test Results Differences in *T. molitor* Survival between Treatments.

Treatment	Mean ± SD (notation)
K	61,30 ±1,15[d]
P1	46,00 ±2,00[c]
P2	36,67 ±4,16[a]
P3	32,67 ±3,05[a]
P4	46,67 ±1,15[c]
P5	43,30 ±2,30[bc]
P6	42,86 ±11,54[ab]

Based on Table 1, Duncan's further test shows that each treatment gives different results. The control with a mean survival rate of 61.3% and P4 46.67% gave the highest and most significant results on survival. P4 was not significantly different from P1 (45%). P3 showed the smallest survival result with a result of 32.67%.

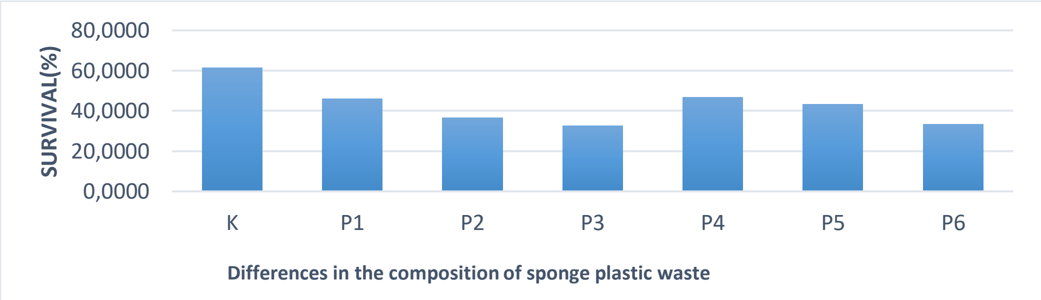

Figure 1 Histogram of the Mean Survival of *T. molitor* L.

Figure 1 shows that the survival of *T. molitor* L was significantly different from the largest to the smallest, as follows: control (0% sponge plastic waste) was 61.3%, P4 (45% of car wash sponge) was 46.67%, P1 (45% of dishwashing sponge) was 46%, P5 (70% of car wash sponge) was 43.3%, P2 (70% of dishwashing sponge) was 36.67%, P6 (90% of car wash sponge) was 33.3% and P3 (90% of dishwashing sponge) was 32.67%. It shows that increasing composition of plastic sponge on the feed affected on decreasing of the survivorship, and different type of sponge waste (P3 and P6) gives no different response on the larvae survivorship.

Table 2. ANOVA test results the effect of feed composition on survival T. molitor L.

Source of diversity	Sum of square	Db	Mean square	F	P
Treatment	1796,571	6	299,429	12,186	0,000
Error	344	14			
Total	40712				

Description:
db : degrees of freedom
F : Fisher's test result
p : probability

Based on the results of data from Table 2, it shows that differences in feed composition have a significant effect ($p = 0.000$) on the survival of *T. molitor* L.

2) Larvae Growth of *T. molitor* L.

Table 3. Duncan test results differences in larval body length growth *T. molitor* L. between treatments.

Treatment	Mean± SD (notation)
K	0,505 ± 0,990^{e}
P1	0,348 ± 0,089^{bcd}
P2	0,300 ± 0,042^{abc}
P3	0,202 ± 0,092^{a}
P4	0,439 ± 0,020^{ed}
P5	0,370 ± 0,049^{cd}
P6	0,223 ± 0,076^{ab}

Based on the results from Table 3 shows that it is significantly different. Average of body length of the most significant effect is Control (0% sponge) with a length of 0.505 cm/week and the smallest is P3 (90% dishwashing sponge) with a length of 0.202 cm/week.

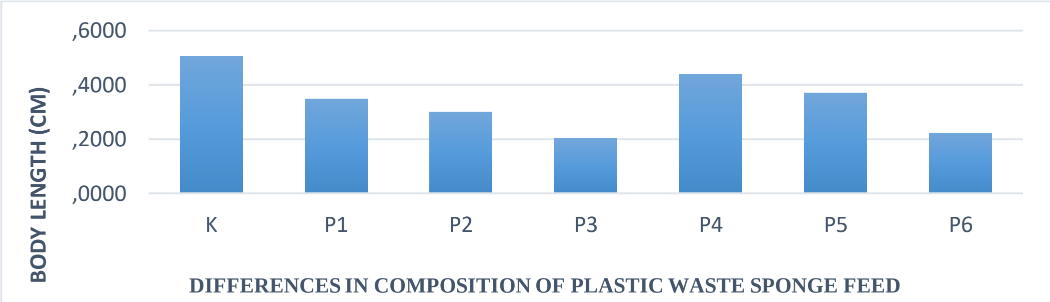

Figure 2. Histogram of the average body length growth of *T. molitor* L.

Based on the results of Figure 2 shows that it is significantly different. Body length from longest to shortest is K (0% sponge) 0.505 cm/week, P4 (45% car wash sponge) is 0.439 cm/week, P1 (45% dishwashing sponge) is 0.348 cm/week, P5 (70% car wash dishwashing sponge) is 0.370 cm/week, P2 (70% dishwashing sponge) is 0.300 cm/week, P6 (90% scar wash ponge) is 0.233 cm/week and P3 (90% dishwashing sponge) is 0.202 cm/week. It shows similarly with previous data that increasing composition of plastic sponge on the feed affected on decreasing of the body length.

Table 4. ANOVA test results the effect of feed composition on body length growth *T. molitor* L.

Source of diversity	Sum of square	db	Mean square	F	P
Traetment	0,217	6	0,03	6,9	0,001
Eror	0,073	14			
Total	2,735				

Description:
db : degrees of freedom
F : Fisher's test result
p : probability

Based on the results from Table 4, it shows that the difference in the composition of the waste feed sponges had a significant effect (p=0,001) on the body length growth of *T. molitor* L. larvae.

3) Effect of Feed Composition on Biomass Growth of *T. molitor* L.

Table 5. Duncan test results difference larval biomass growth *T. molitor* L. between treatments.

Treatment	Mean± SD (notation)
K	0,0142 ± 0,0021^{d}
P1	0,0082 ± 0,0013^{c}
P2	0,0074 ± 0,0001^{bc}
P3	0,0029 ± 0,0020^{a}
P4	0,0085 ± 0,0014^{c}
P5	0,0055 ± 0,0006^{ab}
P6	0,0032 ± 0,0011^{a}

Based on the results (Table 5) showed that the control with an average biomass growth of 0.0142 gram/week showed the most significant mean biomass and the results were significantly different from all treatments. While P3 shows the smallest results among all treatments. P3 is not significantly different from P6.

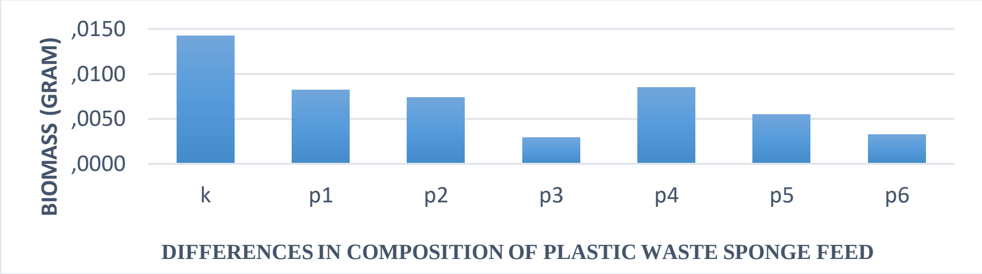

Figure 3 Average biomass growth *T. molitor* L

Based on the results of Figure 3 shows that it is significantly different. Body biomass from the largest to the smallest, namely K (0% sponge) of 0.0142 grams/week, P4 (45% sponge) of 0.0085 grams/week, P1 (45% sponge) of 0.0082 grams/week, P5 (70% sponge) of 0.0055 grams/week, P2 (70% sponge) was 0.0074 grams/week, P6 (90% sponge) was 0.0032 grams/week and P3 (90% sponge) was 0.0029 grams/week. When we compare with Figure 1 and Figure 3, It shows similarly trends that increasing composition of plastic sponge on the feed affected on decreasing of the biomass growth, and different type of sponge waste (P3 and P6) tends to show no different response on the larvae biomass growth.

Table 6. ANOVA test results influence feed composition on biomass growth *T. molitor* L.

Source of diversity	Sum of square	db	Mean square	F	P
Treatment	0,000	6	4,5 x10^{-5}	21,977	0,001
Eror	4,8x10^{-5}	14	2,03 x10^{-6}		
Total	0,001				

Description:
db : degrees of freedom
F : Fisher's test result
p : probability

Based on the results of data from Table 6, it shows that differences in feed composition have a significant effect (p=0.000) on the biomass growth of *T. molitor* L.

4) Effect of Feed Composition on the Degradation of *T. molitor* L.

Table 7 Duncan test results of differences in levels of sponge plastic waste degradation Intertreatment by *T. molitor* L larvae.

Treatment	Mean± SD (notation)
K	0,000 ± 0,000[a]
P1	0,506 ± 0,352[bc]
P2	0,405 ± 0,304[bc]
P3	0,317 ± 0,252[b]
P4	0,583 ± 0,382[bc]
P5	0,469 ± 0,327[bc]
P6	0,352 ± 0,270[bc]

Based on the results from the table above, it shows that P4 gives the most significant results on the level of degradation of sponge plastic waste, while P3 gives the smallest results among all treatments.

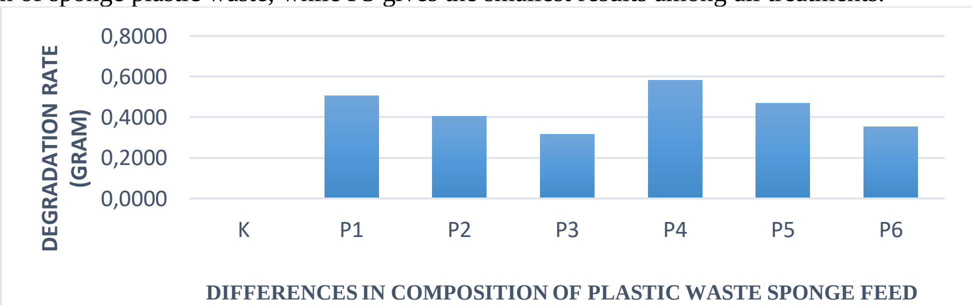

Figure 4. Histogram Mean level degradation of *T. molitor* Larvae.

From Figure 4. it can be seen that the level of degradation by *T. molitor* L. larvae was significantly different from the largest to the smallest, namely P4 (45% car wash sponges) of 0.583 grams/week, P1 (45% dishwashing sponges) of 0.506 grams/week, P5 (70% car wash sponge) was 0.469 grams/week, P2 (70% dishwashing sponge) was 0.405 grams/week, P6 (90% car wash sponge) was 0.352 grams/week and P3 (90% dishwashing sponge) was 0.317 grams/week. The interesting result from the data shows that the high degradation occurs on P4 and P1 which have same proportion of sponge waste but different type of sponge. It indicates that different type of sponge waste has no different response on the plastic sponge degradation by the larvae.

Table 8. ANOVA test results influence
feed composition on sponge waste degradation.

Source of diversity	Sum of squares	Db	Mean square	F	P
Treatment	3,63	7	0,6	7,2	0,001
error	8,5	101	0,08		
Total	26,5				

Description:
db : degrees of freedom
F : Fisher's test result
p : probability

Based on the results, the table above shows that differences in feed composition have a significant effect (p=0.000) on sponge waste degradation by *T. molitor* L. larvae.

B. Discussion

Based on the results of the study, it was found that the composition of the plastic sponge waste feed had a significant effect on the survival of *T. molitor* L larvae. The highest survival rate was control (0%) of 61.3% with an average of 27 larvae. P4 (45%) showed a mean survival rate of 46.67% with an average of 23 larvae and P3 (90%) showed the lowest survival rate of 32.67% with an average of 16 larvae. It shows that increasing the composition of plastic waste on the feed give effect on decreasing on the survival rate of the larvae. The results also shows that the treatment using 45% concentrate, 45% dishwashing sponge and 10% pumpkin shows similarly response on the larvae survivorship (Table 1), biomass growth (table 5), and sponge degradation (Table 7). The fact also shows that two type of sponge which used on the treatment affected similarly response on larvae survivorship, biomass growth, and the sponge waste degradation. The difference in the composition of the plastic sponge waste feed was significant on the survival of *T. molitor* L larvae according to research (Matyja *et al.*, 2020). This research shows that the feed given with different amounts will also have different effects on the number of survivals. Based on this study, increasing the proportion of concentrate on the feeding shows increasing the number of larvae survival, this means that the addition of nutrient to the feed was able to increase survival (Matyja *et al*., 2020).

The effect of the composition of the plastic waste sponge feed has a significant effect on the length and body biomass growth of *T. molitor* L larvae. The highest composition of 0% plastic waste sponge in the control has an average length of 0.505 cm/week and a biomass of 0.0142 grams/week and the lowest P3 has an average of 0.202 cm/week and biomass 0.0029 grams/week. Based on the results of the study showed that the control gave the best results (Hapsari *et al*., 2018). This happens because the control can meet the nutritional needs of *T. molitor* L larvae because the concentrate contains protein, carbohydrates, and potential antioxidants (Hapsari *et al*., 2018). However, feeding plastic sponge waste also provides a little energy so that it effects small increase the body length and biomass growth of *T. molitor* L larvae.

Based on the research, it was found that the composition of the plastic sponge waste feed had a significant effect on the level of degradation of *T. molitor* L larvae. The highest average degradation was P4 (45% sponge) of 0.583 grams/week and the lowest was P3 (90% dishwashing sponge) of 0.317 grams/week. The composition of the plastic sponge waste feed had a significant effect on the level of degradation of *T. molitor* L larvae. The highest level of degradation occurred in feeding with a mixture of concentrates with the highest percentage. This is in accordance with existing research which states that if the addition of nutrients will increase the rate of degradation. Meanwhile, for the lowest level of degradation, namely P3, this occurs because sponges are not like other nutrients which contain organic substances, vitamins, phosphorus and minerals needed for growth so that if there is a lack of nutrients, it will result in low biodegradability due to lack of energy sources for growth (Yang, *et al*. 2018a). Treatments 1-3 used a feed composition of polyurethane sponge plastic waste, concentrate and pumpkin while treatments 4-6 used a composition of cellulose sponge feed, concentrate and pumpkin. It shows that different type of sponge waste shows different effect on survivorship, biomass growth, and sponge waste degradation. And increasing proportion of plastic sponge in the feeding shows decreasing on the larvae survivorship, body length growth, and biomass growth. Cellulose sponges give higher yields when compared to polyurethane washing sponges. This happens because the proportion of feed ingredient give effect on the energy availability to the organism, and it is also related to the content of symbionts to digest the plastic waste in the intestine of larvae (Yang *et al*, 2015). Puls *et al.* (2011) reported that some components like polymer that can be decomposed by microorganisms.

The interesting result shows that the highest sponge plastic degradation occurs on the treatment P1 and P4, while shows a positive effect on larvae survivorship and body growth. It means that the Tenebrio molitor larvae can be used as biological agent to solve the plastic pollution using the feeding proportion 45% dishwashing sponge, 45% concentrate, and 10% pumkin or 45% car wash sponge, 45% concentrate, and 10% pumkin.

4. CONCLUSSION

The provision of plastic sponge waste had a significant effect on survival (p=0.000), length growth (p=0.001), body biomass (p=0.001) and degradation rate (p=0.001). A good feed composition after control was P4 (45% sponge plastic waste + 45% concentrate + 10% pumpkin). This proves that *T. molitor* L. larvae are able to degrade sponge plastic waste and has high potency to be used a biological agent to solve the sponge plastic pollution.

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