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IDENTIFICATION OF FACTORS AFFECTING FOOD WASTE PROCESSING USING BLACK SOLDIER FLIES (BSF) LARVAE

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ABSTRACT:
The research aims to review the factors that influence food waste processing using BSF larvae. Black soldier fly (BSF) larvae have shown promise in processing food waste. Several factors affect the processing of food waste using BSF larvae, including the bacterial dynamics in the residue, substrate nutrient contents, larval gut microbiota, and the nutritional prerequisites of the larvae. Research has focused on identifying groups of bacteria potentially associated with BSF larvae residues and their rearing performance. Additionally, studies have evaluated the efficacy of different substrates, such as tofu by-products, food waste, and vegetables, in promoting black soldier fly growth and conversion efficiency. The moisture content of food waste, salinity, and the source of diets have also been identified as factors affecting the treatment efficiency of food waste by black soldier fly larvae. These factors are essential to consider when optimizing the use of BSF larvae for food waste processing.

Keywords: Black soldier fly, food waste, bactery

INTRODUCTION

The problem that is often faced in all countries globally is waste. Indonesia is one of the countries that has a waste problem because Indonesia's population ranks 4th in the world. The increase in population means that the amount of waste produced will continue to increase.

Based on the national waste information system (SIPSN), the amount of waste generated in 2022 consisting of 137 districts/cities in Indonesia will reach 16,927,520 tons/year (SIPSN, 2022). The annual growth rate of Indonesia's population continues to increase, causing the population to continue to increase and of course the amount of waste generated will continue to increase. Based on the central statistics agency, the growth rate in Indonesia in 2022 will increase by 1.17%. Efforts must be made so that the SDGS target 12.5, which states that countries substantially reduce waste generation through prevention, reduction, recycling and reuse, can be achieved.

Based on the National Waste Information System (SIPSN), the composition of waste is based on the type of waste, namely food waste at 42.5%, wood/twig/leaf waste at 12.2%, paper waste at 11.2%, plastic waste at 18.5%, rubber/leather waste by 1.8%, cloth waste by 2.6%, glass waste by 1.8%, metal waste by 2.8%, and other waste by 6.7% (SIPSN, 2022).

Based on the percentage above, it can be seen that food waste generation is very high if it is thrown directly into a landfill without prior processing. According to (Winnie et al., 2023) food waste is waste that is easily decomposed and if not handled quickly it will rot easily, cause odors and if thrown into the environment can pollute the environment. And decomposing waste will produce leachate which can pollute ground water. Waste processing efforts in Indonesia include sending most of the waste to landfill (69%), 7.5% composting and recycling, 5% open burning, 10% landfilling and 8.5% no treatment (SIPSN, 2022). Supported by these factors, the use of Black Soldier Fly (BSF) larvae to reduce food can be developed.

The government's steps are contained in PEPRES 97 of 2017 which targets reducing and processing household waste and similar household waste. This means that the government has set a waste management target that it wants to achieve, namely 100% of waste managed properly and correctly by 2025. This target is measured by reducing waste by 30% and waste handling by 70%.

The ability of the Black Soldier Fly (BSF) to eat food waste can be used as a decomposer agent. From Diener et al. (2011) Black Soldier Fly (BSF) can digest food waste with a reduction in food waste of 65.5% to 78.9% per day based on the amount of food it eats. Biological decomposition that occurs during composting is generally assisted by bacteria, actinomycetes, fungi, protozoa, worms, and several types of larvae. However, this microbial community is largely determined by the mesophilic phase and thermophilic phase during the composting process and is also determined by the physical properties of the starting waste material (Varma et al., 2017).

The Black Soldier Fly (BSF)'s ability to process food is due to its digestive system which has natural microbes which help the decomposition process of food. Based on Yu et al. (2011), Black Soldier Fly (BSF) has a variety of symbiotic bacteria including bacillus sp. These microbes are useful as helpers in controlling plant pathogens. Apart from that, these bacteria can also be useful as rizhobacteria in plants. So the compost used by Black Soldier Fly (BSF) larvae can be used as a fertilizer mixture.

Black Soldier Fly (BSF) larvae can also process food ingredients into products that are used as fertilizer. The nutritional content contained in commercial products on the market means that these solid products can be used as a substitute for compost fertilizer (Sastro, 2016). Black Soldier Fly (BSF) larvae have a good ability to degrade food waste as indicated by the nutritional content of Black Soldier Fly (BSF) larvae (Fahmi, 2015). The quality of nutrition given to Black Soldier Fly (BSF) larvae during cultivation is important because it affects the body mass and individual size of the Black Soldier Fly (BSF) larvae produced. This makes it possible to maximize sustainable mass egg production in black soldier fly cultivation

The use of larvae from BSF flies as organisms that decompose food waste is a breakthrough for processing food waste. The advantage of using BSF technology is that it can help reduce the amount of food waste by up to 80%, because food waste becomes food for BSF larvae. Processing food waste using the BSF larvae method will reduce the cost of transporting waste, reduce the use of landfill land, residual residue from processing using BSF such as compost, contains nutrients and food elements that can help in the agricultural sector, the operation of this facility does not require complicated technology so it can be applied for areas with low income. Judging from these advantages, this research aims to review the factors that influence food waste processing using BSF larvae.

RESEARCH METHODS

The location of this research was carried out in the Final Project laboratory and behind the Environmental Engineering study program building, National Institute of Technology (ITENAS), Bandung. The research period was carried out from November 2022 to February 2023.

The object studied in this research is food waste processed using Black Soldier Flies (BSF) larvae which will pay attention to the parameters of temperature, humidity, pH of the medium and weight of the BSF larvae.

Method for carrying out research on food waste processing using larvae *Black Soldier Flies*(BSF)carried out on a laboratory scale and. This research was conducted to determine the factors that influence the growth of BSF larvae, temperature, humidity and pH of the growth media for BSF larvae. The process carried out in this research is continuous. This research was conducted in 3 (three) stages, namely the preparation stage, preliminary literature stage, core research stage, and analysis.

RESULTS AND DISCUSSION

Weight of BSF Larvae Produced

The weight of BSF larvae/gram eggs is based on variations in container type to analyze whether there is a difference in BSF larval weight/gram eggs between the maggobox container and tray. Changing the weight of BSF larvae into the weight of BSF larvae / gram of eggs by the weight of BSF larvae divided by the weight of eggs. The following is the weight of BSF larvae / grams of eggs based on the type of maggobox container and tray can be seen in Figure **1** and **Figure 2**.

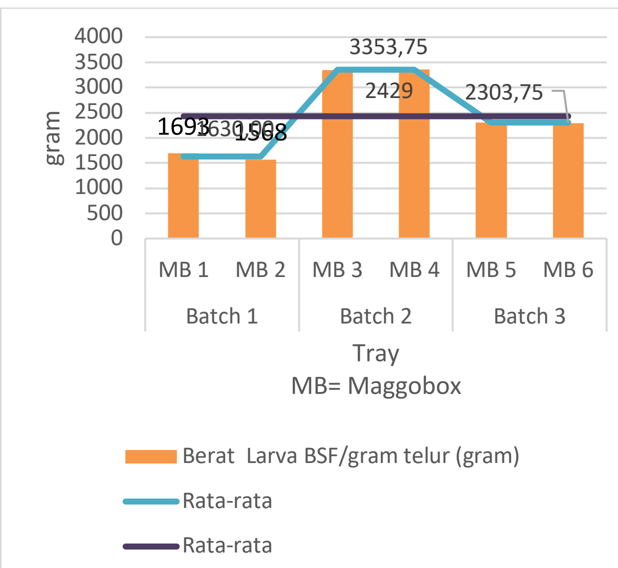

Figure 1. BSF Larva Weight (grams)/gram of eggs in Maggobox
(Source: Research Results, 2023)

Based on Figure 1, the average value of larval weight BSF / gram eggs in MB 3 &; MB 4 (3353.75 grams) is higher than MB 5 &; MB 6 (2303.75 grams) and MB 1 &; MB 2 (1630.00 grams). This can happen allegedly because MB 3, MB 4, MB 5, and MB 6 use a food waste system 1 day 1 time, while MB 1 and MB 2 with a system of 3 days 1 time. So it is suspected that the use of maggobox containers with a feed system 1 day 1 time better than a feed system 3 days 1 time. However, the weight of BSF larvae (grams)/gram eggs in MB 5 and MB 6 (2303.75 grams) was lower than in MB 1 and MB 2 (3353.75 grams). This is thought to be influenced by breeding conditions in MB 5 and MB 6 in indoor conditions while MB 1 and MB 2 in outdoor conditions.

In batch 2 in the maggobox 1 container using fresh waste which has a larval weight (1693 grams) higher than maggobox 2 using unfresh waste (1568 grams). It is suspected that maggobox containers using fresh waste is better than using unfresh waste.

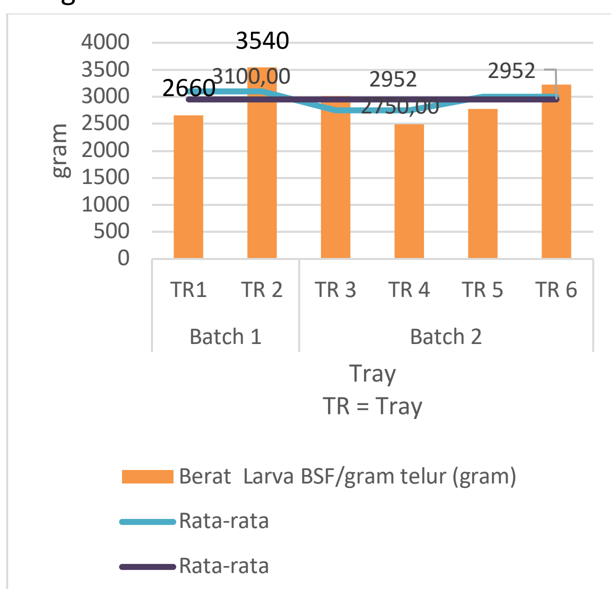

Figure 2. BSF Larva Weight (grams)/gram eggs (grams) in the Tray
(Source: Research Results, 2023)

Based on Figure 2, in the tray, the average value of larval weight BSF / gram eggs in TR 1 &; TR 2 (3100.00 grams) is higher than TR 3 &; TR 4 (2750.00 grams) and TR 5 &; TR 6 (2952 grams). This can happen allegedly because TR 1 uses a feed system 3 days 1 time, while TR 3, TR 4, TR 5, and TR 6 use a feed system 1 day 1 time. So it is suspected that the use of tray containers with a 3 days 1 time feed system is better than a 1 day 1 time feed system.

In batch 2 in tray 2 containers using unfresh waste which has a larval weight (3540 grams) higher than tray 1 using fresh waste (2660 grams). It is suspected that the tray container using unfresh garbage is better than using fresh garbage.

The average weight of BSF/gram larvae in the tray (2952 grams) was higher than in the maggobox (2429 grams).

Weight of the resulting castot

The percent graph to determine the proportion of each casgot weight and the remaining waste generated from each maggobox container and tray is shown in **Figure 3**.

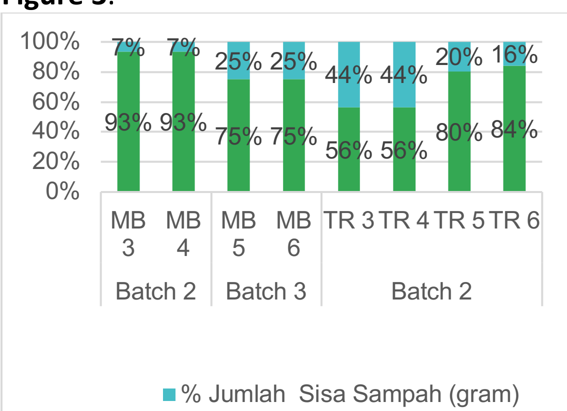

Figure 3. Components of the Weight of the Castots and the Residual Waste Produced

(Source: Research Results, 2023)

Based on graph above, all containers have 77% of the weight of the casscule, relatively higher than the 23% amount of waste residue. The maggobox container has an average weight component of the sewer and the rest of the waste by 84% and 16%. While the tray container has an average weight component of the sewer and the rest of the waste by 69% and 64%. This indicates that the weight of the castot produced in the mggobox is higher than the tray. As for the rest of the garbage in the tray, it is higher than the maggobox.

Based on the weight of BSF larvae / gram eggs and the number of castots produced shows that food waste processing using BSF larvae is included in *Resource Recovery.* Because the waste that has been processed produces products in the form of BSF larvae and castots that can be used for alternative animal feed and composting. According to (Arief &; Priscilia, 2018), protein from BSF larvae can be used as animal feed ingredients, either used directly, or through further processing. While kasgot which is the remaining waste that can be used as compost (Dormants, 2017).

BSF Larval Protein Content

The results of the BSF larval protein content test before being given bran feed can be seen in **Table 1**.

Table 1. Test the protein content of BSF larvae before garbage feed (bran feed)

Batch	Sample ID	Protein Levels (%)
Batch 3	MB 5 Wet	12.36
	MB 6 Wet	11.64

(Source: Research Results, 2023)

Table 1 is the result of protein tests conducted on BSF larvae before and given food waste feed.protein content of BSF larvae between before and after being given garbage feed. From BSF larvae between before and after being given feed, the litter has a relatively similar protein content. Maggobox 5 is done with indoor breeding, while maggobox 6 is done with outdoor breeding. The protein content in maggobox 5 is 12.36% higher than naggobox 6 of

11.64%. This indicates that the treatment of maggobox 5, namely with indoor breeding has a better protein content than outdoor conditions in maggobox 6. Then there is atest of the protein content of BSF larvae after being given food waste feed can be seen in **Table 2**.

Table 2. Test the protein content of BSF larvae after bran feed

Batch	Sample ID	Kadar Protein (%)
Batch 2	MB 3 Fresh	10.78
	MB 3 Dry	26.55
	Tray 4 Fresh	12.09
	Tray 4 Dry	28.9

(Source: Research Results, 2023)

Pin **Table 2** is the result of protein tests conducted on BSF larvae after being given BSF food waste feed at the completion of the productive phase. The results of BSF larvae were tested in the condition of fresh larvae and dried larvae that had gone through the drying process by roasting. The nutritional content in this study using hotel waste sources had an average protein content of fresh conditions after the productive phase of 11.34%, while dry conditions were 27.72%. Dried larvae have an average higher protein content than fresh larvae.

The protein content of BSF larvae fresh and dried conditions in tray breeding containers has protein levels of 12.09% and 28.9% higher than in maggobox which is 10.78% and 12.09%.

Analysis of the influence of variations in container, type of waste, and room conditions on the weight of BSF larvae/gram of eggs

This analysis was carried out to determine the effect of variations in container, type of waste, room conditions, and waste feeding system on the weight of BSF larvae by conducting an independent sample t test analysis.

1. **Analysis of the Effect of Container Variations**

The data used in the analysis of the influence of container variations is data on the weight of BSF larvae/grams of eggs which is divided based on container variations, namely maggobox and tray, which can be seen in Figure 4.

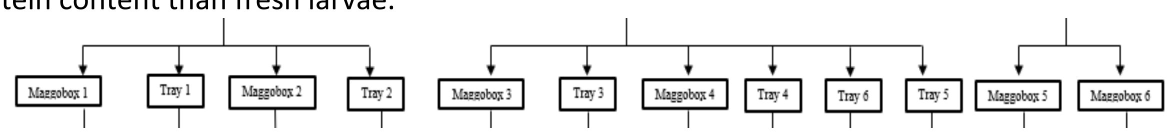

Figure 4. Container Variation Research Design

(Source: Analysis Results, 2023)

The data used in the analysis of the influence of container variations is data on the weight of BSF larvae/grams of eggs which is divided based on container variations, namely maggobox and tray, which can be seen in table 3.

Table 3. Container Variation Analysis Data

BSF Larvae Weight (grams)	
Maggobox	**Tray**
1692.50	2660.00
1567.50	3540.00
3345.00	3010.00
3362.50	2490.00
2310.00	2780.00
2297.50	3230.00

(Source: Research Results, 2023)

Before carrying out the independent sample t test, it is necessary to carry out an assumption test, namely the normality test and homogeneity test. The independent sample t test is used to determine whether there is a difference in the means of two unpaired sampleson BSF larvae weight/gram egg weight data under the influence of container variations.

Normality test

Before carrying out the independent sample t test, a normality test needs to be carried out. According to Ramdhani, et al. (2020) stated that the normality test using the Shapiro-Wilk method is carried out to assess the distribution of data in a group of data or variables, whether the data distribution is normally distributed or not. According to Razali and Wah (2011) stated that the Shapiro and Wilk test was initially limited to a sample size of less than 50. The test results can be seen in Figure 5.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Variasi wadah	Statistic	df	Sig.	Statistic	df	Sig.
Berat larva BSF/gram telur maggabox dan tray	Maggobox	.228	6	.200*	.866	6	.211
	Tray	.171	6	.200*	.970	6	.890

*. This is a lower bound of the true significance.

Figure 5. Container Variation Normality Test Results

(Source: Analysis Results, 2023)

Hypothesis:

H0: Data is normally distributed

H1: Data is not normally distributed

Significance Level:

α = 0.05

Critical Area:

Reject H_0, P-value <α

Test Statistics:

Obtained p-value > α where 0.211 > 0.05for weight of BSF larvae/gram maggabox eggs. Meanwhile, 0.890 > 0.05 for the weight of BSF larvae/gram egg tray

Decision:

Because p-value > α, so withα = 0.05 then the decision is to fail to reject H0.

Conclusion :

With a 95% confidence level there isIf the decision fails to reject H0, it can be concluded that the data is normally distributed.

Homogeneity Test

According to Usmadi (2020) homogeneity test is used to find out whether there are several variantspopulations are the same or not. The equality of two variances test is used to test whether the data distribution is homogeneous or not, namely by comparing the two variances. The test uses the Levene method. The test results can be seen in Figure 6.

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Berat larva BSF/gram telur maggabox dan tray	Based on Mean	3.057	1	10	.111
	Based on Median	1.625	1	10	.231
	Based on Median and with adjusted df	1.625	1	6.751	.244
	Based on trimmed mean	2.998	1	10	.114

Figure 6. Homogeneity Test Results for Container Variations
(Source: Analysis Results, 2023)

Hypothesis:
H0: Homogeneous data distribution on the use of maggobox and tray
H1: Data distribution is not homogeneous when using maggobox and tray
Significance Level:
α = 0.05
Critical Area:
Reject H0, P-value $\leq \alpha$
Test Statistics:
Obtained p-value > α, where 0.111 > 0.05.
Decision:
Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.

Conclusion :
With a confidence level of 95%, there is a decision that H0 has failed, so it can be concluded that the data distribution is homogeneous when using maggobox and tray.

Independent T Test

According to Ramdhani, et al. (2020) that the independent sample t-test is a test of the difference between two unpaired samples. Unpaired samples are the same object but experience different treatment. The independent sample t test in this research was used to answer the problem formulation "Is there a difference in the results of the weight of BSF larvae/grams of eggs between the use of maggoboxes and trays?". The test uses the method*Two-Sample Assuming Equal Variance*.The test results can be seen in Figure 7.

	Maggobox	Tray
Mean	2429.166667	2951.666667
Variance	605309.1667	150936.6667
Observations	6	6
Pooled Variance	378122.9167	
Hypothesized Mean D	0	
df	10	
t Stat	-1.471737726	
P(T<=t) one-tail	0.085924697	
t Critical one-tail	1.812461123	
P(T<=t) two-tail	0.171849393	**>0,05 Ho diterima (tidak ada perbedaan)**
t Critical two-tail	2.228138852	

Figure 7. Independent Sample T Test Results of Container Variations
(Source: Analysis Results, 2023)

Hypothesis:

H0: There is no difference in the use of maggobox and tray

H1: there is a difference in the use of maggobox and tray

Significance Level:

α = 0.05

Critical Area:

Reject H0, P-value ≤α

Test Statistics:

Obtained p-value > α, where 0.171 > 0.05.

– Decision

Because p-value > α, so withα = 0.05 thenthe decision is to fail to reject H0.

Conclusion :

With a confidence level of 95%, there is a decision that H0 failed to be rejected, so it can be concluded that there is no difference in the weight of BSF larvae/grams of eggs when using the maggobox and tray.

2. Analysis of the Effect of Varying Types of Waste

The following is a schematic part of the research design for various types of waste, which can be seen in Figure 8.

Figure 8. Research Design for Varying Types of Waste
(Source: Analysis Results, 2023)

The data used in the analysis of the influence of variations in waste types is data on the weight of BSF larvae/grams of eggs which are divided based on the type of waste, namely fresh and unfresh, which can be seen in table 4.

Table 4. Data Analysis of Variation in Types of Waste

BSF larvae weight (grams)	
Fresh Trash	**Trash Unfresh**
1692.50	1567.50
2660.00	3540.00
3345.00	
3362.50	
3010.00	
2490.00	
2780.00	
3230.00	
2310.00	
2297.50	

(Source: Research Results, 2023)

Before carrying out the independent sample t test, it is necessary to carry out an assumption test, namely the normality test and homogeneity test. The independent sample t test was used to determine whether there was a difference in the average of two unpaired samples in the BSF larvae weight/gram egg data under the influence of variations in waste type.

Normality test

Before carrying out the independent sample t test, a normality test needs to be carried out. This test uses the Shapiro-Wilk method to assess the distribution of data in a group of data or variables, whether the data distribution is normally distributed or not. The test results can be seen in Figure 9.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Berat larva BSF/gram telur sampah fresh dan unfresh	.131	12	.200*	.939	12	.490
Variasi Jenis Sampah	.499	12	<,001	.465	12	<,001

Figure 9. Normality Test Results for Variations in Waste Types
(Source: Analysis Results, 2023)

Hypothesis:
H0: Data is normally distributed
H1: Data is not normally distributed
Significance Level:
α = 0.05
Critical Area:
Reject H0, P-value $<\alpha$
Test Statistics:

Obtained p-value > α where 0.490 > 0.05
Decision:
Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.
Conclusion :
With a confidence level of 95%, there is a decision that H0 has failed, so it can be concluded that the data is normally distributed.

Homogeneity Test

The homogeneity test is used to determine whether several population variants are the same or not. The equality of two variances test is used to test whether the data distribution is homogeneous or not, namely by comparing the two variances. The test uses the method*Levene.*The test results can be seen in Figure 10.

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Berat larva BSF/gram telur sampah fresh dan unfresh	Based on Mean	.332	1	10	.577
	Based on Median	.090	1	10	.770
	Based on Median and with adjusted df	.090	1	7.525	.772
	Based on trimmed mean	.293	1	10	.600

Figure 10. Homogeneity Test Results for Variations in Waste Types
(Source: Analysis Results, 2023)

Hypothesis:
H0: Homogeneous data distribution on the use of fresh and unfresh waste types
H1: Data distribution is not homogeneous regarding the use of fresh and unfresh waste types
Significance Level:
α = 0.05
Critical Area:
Reject H0, P-value ≤α
Test Statistics:
Obtained p-value > α, where 0.577 > 0.05.
Decision:
Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.
Conclusion :
With a confidence level of 95%, there is a decision that fails to reject H0, so it can be concluded that the data distribution is homogeneous in the use of fresh and unfresh waste types.

Independent T Test

The independent sample t test in this research was used to answer the problem formulation "Is there a difference in the results of the weight of BSF larvae/grams of eggs between the use of fresh and unfresh types of waste?". The test usesTwo-Sample Assuming Equal Variance method
The test results can be seen in Figure 11.

	Sampah Fresh	Sampah Unfresh
Mean	2717.75	2553.75
Variance	290004.7917	1945378.125
Observations	10	2
Pooled Variance	455542.125	
Hypothesized Mean Di	0	
df	10	
t Stat	0.313692367	
P(T<=t) one-tail	0.38010018	
t Critical one-tail	1.812461123	
P(T<=t) two-tail	0.76020036	**>0,05 Ho diterima (tidak ada perbedaan)**
t Critical two-tail	2.228138852	

Figure 11. Independent Sample T Test Results for Variations in Waste Types

(Source: Analysis Results, 2023)

Hypothesis:

H0: There is no difference in the use of fresh and unfresh waste types

H1: there is a difference in the use of fresh and unfresh waste types

Significance Level:

α = 0.05

Critical Area:

Reject H0, P-value ≤α

Test Statistics:

Obtained p-value > α, where 0.760 > 0.05.

Decision:

Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.

Conclusion :

With a confidence level of 95%, there is a decision that H0 has failed, so it can be concluded that there is no difference in the weight of BSF larvae/grams of eggs when using fresh and unfresh waste types.

3. Analysis of the Effect of Varying Room Conditions

The following is a schematic part of the research design for variations in room conditions, which can be seen in Figure 12.

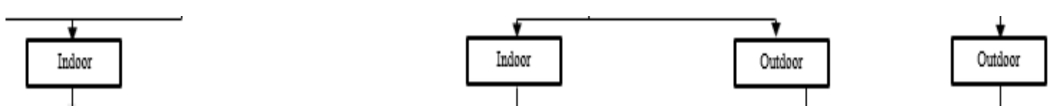

Figure 12. Research Design for Variations in Room Conditions

(Source: Analysis Results, 2023)

The data used in the analysis of the influence of variations in room conditions is data on the weight of BSF larvae/grams of eggs which are divided based on room conditions, namely indoor and outdoor, which can be seen in table 5.

Table 5. Data Analysis of Variation in Room Conditions

BSF Larvae Weight (grams)	
Indoor Room	**Outdoor Room**
1692.50	2310.00
1567.50	2297.50
2660.00	2780.00
3540.00	3230.00
3345.00	
3362.50	
3010.00	
2490.00	

(Source: Research Results, 2023)

Before carrying out the independent sample t test, it is necessary to carry out an assumption test, namely the normality test and homogeneity test. The independent sample t test was used to determine whether there was a difference in the average of two unpaired samples in the BSF larvae weight/gram egg data under the influence of variations in room conditions.

Normality test

Before carrying out the independent sample t test, a normality test needs to be carried out. This test uses the Shapiro-Wilk method to assess the distribution of data in a group of data or variables, whether the data distribution is normally distributed or not. The test results can be seen in Figure 13.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Variasi Ruangan	Statistic	df	Sig.	Statistic	df	Sig.
Berat larva BSF/gram telur ruangan indoor dan outdoor	Ruangan Indoor	.175	8	.200*	.894	8	.256
	Ruangan Ooutdoor	.281	4	.	.872	4	.305

*. This is a lower bound of the true significance.

Figure 13. Room Variation Normality Test Results

(Source: Analysis Results, 2023)

Hypothesis:

H0: Data is normally distributed

H1: Data is not normally distributed

Significance Level:

α = 0.05

Critical Area:

Reject H0, P-value <α

Test Statistics:

Obtained p-value > α where 0.256 > 0.05

Decision:

Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.

Conclusion :

With a confidence level of 95%, there is a decision that H0 has failed, so it can be concluded that the data is normally distributed.

Homogeneity Test

The homogeneity test is used to determine whether several population variants are the same or not. The test of equality of two variances is used forTest whether the data distribution is homogeneous or not, namely by comparing the two variances. The test uses the Levene method. The test results can be seen in Figure 14.

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Berat larva BSF/gram telur ruangan indoor dan outdoor	Based on Mean	1.494	1	10	.250
	Based on Median	1.298	1	10	.281
	Based on Median and with adjusted df	1.298	1	8.551	.286
	Based on trimmed mean	1.490	1	10	.250

Figure 14. Homogeneity Test Results for Container Variations
(Source: Analysis Results, 2023)

Hypothesis:
H0: Homogeneous data distribution in indoor and outdoor conditions
H1: Data distribution is not homogeneous in indoor and outdoor conditions
Significance Level:
$\alpha = 0.05$
Critical Area:
Reject H0, P-value $\leq \alpha$
Test Statistics:
Obtained p-value > α, where 0.250 > 0.05.
Decision:
Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.
Conclusion :
With a confidence level of 95%, there is a decision that fails to reject H0, so it can be concluded that the data distribution is homogeneous when using indoor and outdoor conditions.

Independent T Test

The independent sample t test in this research was used to answer the problem formulation "Is there a difference in the results of the weight of BSF larvae/grams of eggs between indoor and outdoor conditions?". The test uses the method*Two-Sample Assuming Equal Variance.*

	Ruangan Indoor	*Ruangan Outdoor*
Mean	2708.4375	2654.375
Variance	571339.1741	197693.2292
Observations	8	4
Pooled Variance	459245.3906	
Hypothesized Mean D	0	
df	10	
t Stat	0.130274102	
P(T<=t) one-tail	0.449466454	
t Critical one-tail	1.812461123	
P(T<=t) two-tail	0.898932908	**>0,05 Ho diterima (tidak ada perbedaan)**
t Critical two-tail	2.228138852	

Figure 15. Independent Sample T Test Results Room Variation
(Source: Analysis Results, 2023)

Hypothesis:
H0: there is no difference in indoor and outdoor room conditions
H1: there are differences in indoor and outdoor room conditions
Significance Level:
α = 0.05
Critical Area:
Reject H0, P-value ≤α
Test Statistics:
Obtained p-value > α, where 0.898 > 0.05.
Decision:
Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.

Conclusion :
With a confidence level of 95%, there is a decision that it failed to reject H0, so it can be concluded that there is no difference in the weight of BSF larvae/grams of eggs in indoor and outdoor conditions.

4. 4. Analysis of Variations in Feeding Systems

The following is a schematic part of the research design for variations in feeding systems, which can be seen in Figure 16.

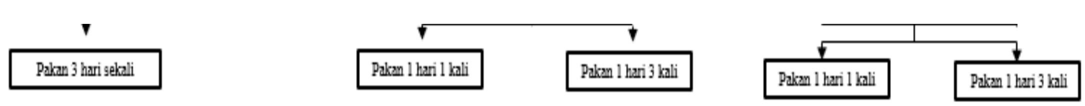

Figure 16. Research Design for Variations in Feeding Systems
(Source: Analysis Results, 2023)

The data used in the analysis of the influence of variations in feeding systems is data on the weight of BSF larvae/grams of eggs divided based on room conditionsnamely once every 3 days and once a daycan be seen in table 6.

Table 6. Data Analysis of Variations in Feeding Systems

3 days 1 time	1 day 1 time
1692.50	3345.00
1567.50	3010.00
2660.00	3230.00
3540.00	3362.50
	2490.00
	2780.00
	2310.00
	2297.50

(Source: Research Results, 2023)

Before carrying out the independent sample t test, it is necessary to carry out an assumption testnamely normality test and homogeneity test. The independent sample t test was used to determine whether there was a difference in the average of two unpaired samples in the BSF larvae weight/gram egg data under the influence of variations in the feeding system.

Normality test

Before carrying out the independent sample t test, a normality test needs to be carried out. This test uses the Shapiro-Wilk method to assess the distribution of data in a group of data or variables, whether the data distribution is normally distributed or not. The test results can be seen in Figure 17.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
3 hari 1 kali	.267	4	.	.900	4	.430
1 hari 1 kali	.247	4	.	.865	4	.278

a. Lilliefors Significance Correction

Figure 17. Normality Test Results of Variations in Feeding Systems

(Source: Analysis Results, 2023)

Hypothesis:
H0: Data is normally distributed
H1: Data is not normally distributed
Significance Level:
α = 0.05
Critical Area:
Reject H0, P-value < α
Test Statistics:
Obtained p-value > α where 0.430 > 0.05
Obtained p-value > α where 0.278 > 0.05
Decision:
Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.
Conclusion :
With a confidence level of 95%, there is a decision that H0 has failed, so it can be concluded that the data is normally distributed.

Homogeneity Test

The homogeneity test is used to determine whether several population variants are the same or not. TestThe similarity of two variances is used to test whether the data distribution is homogeneous or not, namely by comparing the two variances. The test uses the Levene method. The test results can be seen in Figure 18.

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Berat larva BSF/gram telur sehari sekali dan sehari 3 kali	Based on Mean	2.565	1	4	.185
	Based on Median	.993	1	4	.375
	Based on Median and with adjusted df	.993	1	2.560	.404
	Based on trimmed mean	2.430	1	4	.194

Figure 18. Homogeneity Test Results of Variations in Feeding Systems

(Source: Analysis Results, 2023)

Hypothesis:

H0: Homogeneous data distribution on feeding systems for 3 days once and 1 day once.

H1: The distribution of data is not homogeneous when giving the feeding system once for 3 days and 1 time for 1 day.

Significance Level:

$\alpha = 0.05$

Critical Area:

Reject H0, P-value $\leq \alpha$

Test Statistics:

Obtained p-value > α, where 0.185 > 0.05.

Decision:

Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.

Conclusion :

With a confidence level of 95%, there is a decision that H0 has failed, so it can be concluded that the data distribution is homogeneous in the feeding system once a day and 3 times a day.

Independent T Test

The independent sample t test in this study was used to answer the problem formulation "Is there a difference in the results of the weight of BSF larvae/grams of eggs between the feeding system once a day and 3 times a day?". The test uses the method*Two-Sample Assuming Equal Variance.*The test results can be seen in Figure 19.

t-Test: Two-Sample Assuming Equal Variances		
	3hari 1kali	*1hari 1kali*
Mean	2365	2853.125
Variance	851970.8333	201279.9107
Observations	4	8
Pooled Variance	396487.1875	
Hypothesized Mean D	0	
df	10	
t Stat	-1.265904194	
P(T<=t) one-tail	0.117121732	
t Critical one-tail	1.812461123	
P(T<=t) two-tail	0.234243463	**>0,05 Ho diterima (tidak ada perbedaan)**
t Critical two-tail	2.228138852	

Figure 19. Independent Sample T Test Results of Variations in Feeding Systems
(Source: Analysis Results, 2023)

Hypothesis:
H0: There is no difference in the feeding system once a day and 3 times a day
H1: There is a difference in the feeding system once a day and 3 times a day
Significance Level:
α = 0.05
Critical Area:
Reject H0, P-value $\leq \alpha$
Test Statistics:
Obtained p-value > α, where 0.312 > 0.05
Decision:
Because p-value > α, so with α = 0.05 the decision is to fail to reject H0.
Conclusion :
With a confidence level of 95%, there is a decision that H0 failed to be rejected, so it can be concluded that there is no difference in the weight of BSF larvae/grams of eggs in the once-a-day and 3-times-a-day feeding systems.

CONCLUSION

The research on factors influencing food waste processing using black soldier fly (BSF) larvae has revealed several key findings. The environmental conditions, such as the type of organic waste, nutrient content, and bacterial dynamics, significantly impact the growth and development of BSF larvae and their efficiency in waste treatment. Additionally, the feeding rate has been identified as a crucial factor affecting the growth performance and waste reduction efficiency of BSF larvae. Furthermore, the nutritive substances in the organic waste play a vital role in achieving higher bioconversion performance by BSF larvae. These findings underscore the importance of considering various factors, including environmental conditions, nutrient content, bacterial dynamics, and feeding rates, when utilizing BSF larvae for food waste processing.

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