Growth Performance and Nutrient Content of Carp (Cyprinus Carpio) With the Feeding of Maggot Meal Substitution Cultivated in Different Media

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Abstract. High price of fish meal for artificial feed provides an alternative solution to use maggot meal as fish meal substitute for decreasing production cost, because it is cheaper and easier to be obtained. The study aimed to determine and analyze the substitution of fish meal with maggot meal derived from various wastes as artificial feed, for improving carp (Cyprinus carpio) production and quality. The study used experimental method with completely randomized design (CRD). This study used four treatments and three replications. About 120 of carps with 0.62±0.14 g/fish of average individual weight maintained at 1 fish/L of stock density for 45 days. Pellet-shaped feed with 30% of protein content was used. The feed was given to tested fish with fixed feeding rate three times a day. The treatments conducted in this study were: 150g/L tofu waste (A); 50g/L fruit waste + 100g/L tofu waste (B); 50g/L vegetable waste + 100g/L tofu waste (C); 50g/L chicken manure + 100g/L tofu waste (D). Primary data were Total Feed Consumption (TFC), Feed Utilization Efficiency, Protein Efficiency Ratio (PER), Specific Growth Rate (SGR), and Survival Rate. The result of fish meal substitution with maggot meal which cultured with 50g/L chicken manure + 100g/L tofu waste gave a significant effect (P<0.05) on Feed Utilization Efficiency, PER, SGR, and Survival Rate, but did not give significant effect (P>0.05) on TFC. The results were 74.93±0.91 of feed utilization efficiency, 2.24% of protein efficiency ratio, 2.81% of specific growth rate, and 91.11% of survival rate. The best lysine amino acid profile was 32.83%, and the highest linoleic fatty acid was 7.26%.

1. Introduction
Carp is a freshwater fish that has higher economic value compared to tilapia and African catfish. The increasing demand for carp in traditional and modern markets makes a very promising prospect for market. The increasing demand for carp is not compensated by an increase in supply, it can be concluded that the high demand for carp has not been maximally utilized by farmers. The demand for carp is not maximally fulfilled due to lack of availability of fish meal to meet the needs of carp cultivation, one of the problems is the decreasing of fish meal supply [1]. The decreasing of fish meal
make its price is more expensive. Nowadays, some raw materials which are agricultural and livestock waste such as soybean meal, corn gluten, meat meal, and bone meal are also widely used, but the amount is not much because it competes with animal livestock feed. This condition causes the substitution of fish meal is still being sought [2]. One alternative substitution for fish meal is using maggot meal, it is because the nutrient content especially amino acids of maggot meal is higher than fish meal. The nutritional quality of maggot is very dependent on its cultivation media.

Maggots are larvae of a black soldier fly (Hermetia illucens) which grows widely in animal waste such as cow manure, goat manure, poultry manure, and organic waste under good conditions. Maggot which is used as meal for fish meal substitution is the pre-pupa phase maggot. Aniebo et al. [3] stated that maggot meal (H. illucens) contains 5.8% of arginine, 3.09% of histidine, 3.06% of isoleucine, 6.04% lysine, 2.28% methionine, 3.96% of phenylalanine, 2.03% of threonine, 3.61% of valine, and 6.35% of leucine. According to Li et al. [4] maggot meal (H. illucens) contains 0.55% of tryptophan. Study on fish meal substitution with maggot meal that has been done were on pangas catfish [5], bala shark fish [6], and african catfish [7] with satisfying results. Therefore, it is still necessary to conduct study to determine the effect of fish meal substitution with maggot meal on feed utilization efficiency and growth of carp (C. carpio).

This study aimed to determine the potential of substitution of fish meal with maggot meal from various wastes as maggot culture media to increase production and quality of carp (C. carpio). This study was conducted in January 2018 until May 2018 at the Laboratory of Aquaculture at Diponegoro University and Temanggung, Central Java.

2. Research Methods

2.1. Materials

The fish used in this study are carp fish seeds (C. carpio) about 3 – 4 cm length and 0.62 ± 0.14 grams/fish of average weight. Tested fish are 120 fish from a hatchery in the Central Java. Stocking density in a container of 15 L water is 15 fish or equal to 1 fish/L. The basis for selecting carp seeds as test animals for this study was based on previous study conducted by Li et al. [4] which stated that maggot meal substitution has been done on Jian Cap with juvenile size. Acclimatization was done for 1 hour to prevent fish stress. Tested fish are kept for 14 days so that fish can adapt to their new environment.

Fish meal is substituted with maggot meal which is cultivated using different culture media, they were: A is 150 g/L of tofu waste; treatment B is 50 g/L of fruit waste + 100 g/L of tofu waste; treatment C is 50 g/L of vegetable waste + 100 g/L of tofu waste; treatment D is 50 g/L of chicken manure + 100 g/L of tofu waste. The fermented maggot meal of each treatment was added by other ingredients (fish meal, soybean meal, corn starch, rice bran flour, wheat flour, fish oil, palm oil, vitamin mix, and CMC). Maggot meal had 4.04 g/100 g of feed composition so that the feed formulation has 30% protein content. Feed sample used in this study was pellet-shaped artificial feed which had been formulated with maggot meal and other ingredients with 30% protein content, according to Takeuchi (2002), protein needs of carp seeds are 30-35%.

Feeding on tested fish was by fix feeding rate method for about 5%. Feeding is carried out 3 times a day, in the morning (08:00), noon (12:00), and afternoon (16:00). Tested feed ingredients composition and its analysis results is presented in Table 1.

| Table 1. Composition of feed ingredients and proximate analysis of feed used during the study (% Dry Weight) |
|---------------------------------------------------------------|
| **Type of Feed Ingredients** | **Feed Composition (g/100 g of Feed)** |
| Fish meal | 21.87 |
| Maggot meal | 4.04 |
Soybean meal 33
Corn starch 3
Rice bran flour 13.84
Wheat flour 14.25
Fish oil 3
Palm oil 3.5
Vit-min mix 2.5
CMC 1

TOTAL (%) 100
Protein (%)* 30.08
Nitrogen-free extract (NFE) (%)* 32.92
Fat (%)* 13.22
Energy (kcal) 294.66
E/P Ratio 9.79

Notes:

a. It was calculated based on Digestible Energy according to Wilson (1982) for 1 g of protein is 3.5 kcal/g, 1 g of fat is 8.1 kcal/g, and 1 g of carbohydrate is 2.5 kcal/g.
b. According to De Silva [8], E/P value for optimal growth of fish ranges between 8 – 12 kcal/g.
c. * Laboratory of Animal Feed Sciences, Faculty of Animal and Agricultural Sciences, Diponegoro University (2018)

2.2. Methods
This study was conducted using Completely Randomized Design (CRD) with 4 treatments and 3 replications. The treatment in this study is the substitution of fish meal with maggot meal which is cultivated in different culture media, they were: treatment A is 150 g/L of tofu waste; treatment B is 50 g/L of fruit waste + 100 g/L of tofu waste; treatment C is 50 g/L of vegetable waste + 100 g/L of tofu waste; treatment D is 50 g/L of chicken manure + 100 g/L of tofu waste.

This treatment is based on previous study on fish meal substitution of Jian Carp by Li et al. [4], which stated that the dose used in fish meal which substituted with maggot meal in Jian Carp is 25%. The best result was resulted from 25% composition of maggot meal protein dose from fish meal protein, so that 25% composition of fish meal protein substitution was made as median of maggot meal dose in this study.

2.3. Data Collection
The measured variable of the study were the value of Total Feed Consumption (TFC), Feed Utilization Efficiency (FUE), Protein Efficiency Ratio (PER), Specific Growth Rate (SGR), and Survival Rate (SR).

2.4. Total Feed Consumption
According to Pereira et al. [9] Total Feed Consumption (TFC) calculated using the following formula:

\[ TFC = F1 - F2 \]  

Where:
TFC = Total Feed Consumption
F1 = Initial amount of feed (g)
F2 = Amount of leftover feed (g)
2.5. Feed Utilization Efficiency
According to Watanabe [10], Feed Utilization Efficiency calculated using the following formula:

\[ \text{FUE} = \frac{W_t + D - W_0}{F} \times 100\% \]  

Where:
- FUE  = Feed Utilization Efficiency (%)
- \( W_t \)  = Tested fish biomass weight at the end of observation (g)
- \( W_0 \)  = Tested fish biomass weight at the beginning of observation (g)
- D  = Dead fish weight (g)
- F  = The amount of fish meal given during observation (g)

2.6. Protein Efficiency Ratio
Calculation of protein efficiency ratio is using following formula by Tacon [11]:

\[ \text{PER} = \frac{W_t - W_0}{P_i} \times 100\% \]  

Where:
- PER  = Protein Efficiency Ratio
- \( W_t \)  = Tested fish weight at the end of observation (g)
- \( W_0 \)  = Tested fish weight at the beginning of observation (g)
- \( P_i \)  = Weight of feed consumed × % feed protein

2.7. Specific Growth Rate
According to Abdel-Tawwab et al. [12] Specific Growth Rate (SGR) of fish is calculated using following formula:

\[ \text{SGR} = \frac{\ln W_t - \ln W_0}{t} \times 100\% \]  

Where:
- SGR  = Specific Growth Rate (%)
- \( W_t \)  = Average fish weight at the end of the study (g)
- \( W_0 \)  = Average fish weight at the beginning of the study (g)
- t  = Time of the study (day)

2.8. Survival Rate
According to Effendi [13] survival rate calculated using the following formula:

\[ \text{SR} = \frac{N_t}{N_0} \times 100\% \]  

Where:
- SR  = Survival Rate (%)
- \( N_t \)  = Number of fish at the end of the study (fish)
- \( N_0 \)  = Number of fish at the beginning of the study (fish)

2.9. Proximate analysis
The proximate chemical composition of the samples was determined using a standard procedure [14], [15]. The crude protein content was calculated by multiplying the total nitrogen factor. The carbohydrate content was estimated by the difference.

2.10. Essential amino acid profile
The amino acid composition of the sample was determined using High Performance Liquid Chromatography (HPLC) (Shimadzu LC-6A) [14], [15].

2.11. Fatty acid profile
The fatty acid composition of the sample was determined using a gas chromatograph (Shimadzu) [14], [15].

2.12. Water Quality Parameters
Observation of water quality parameters were temperature, dissolved oxygen (DO), acidity level (pH) and ammonia content (NH₃). Water quality observation of ammonia content (NH₃) conducted at the beginning and end of the study. Water quality observation of temperature, dissolved oxygen (DO), and pH is carried out every day in the morning, afternoon, and evening. Measurement of ammonia content was analyzed at Laboratory of the Department of Environmental Engineering, Diponegoro University, and temperature measurement using a thermometer, while pH measurements are carried out using a pH meter by dipping the pH meter in the maintenance container and see the results listed on the pH meter. Dissolved oxygen measurement (DO) using DO meters by dipping the probe into the water then wait until it is constant then record the value.

2.13. Data Analysis
Data of the results of the study were TFC, SGR, FUE, PER, and SR which analyzed using Analysis of Variance (ANOVA). The data obtained were first carried out by several tests called normality test, homogeneity test and additivity test before Analysis of Variance (ANOVA) to the observed variables. If the analysis of variance is found to have a significant effect (P<0.05) or a very significant effect (P<0.01) then Duncan's Multiple Range Test is done to find out the difference in middle values between treatments. SPSS version 23.0 Application were used for Homogeneity Test, Normality Test, Analysis of Variance (ANOVA), and Duncan's Multiple Range Test, while for additivity testing was using Microsoft Excel. Water quality data were analyzed descriptively.

3. Results and Discussion
Study result of Total Feed Consumption (TFC), Specific Growth Rate (SGR), Feed Utilization Efficiency (FUE), Protein Efficiency Ratio (PER), and Survival Rate (SR) are presented on Table 2.

| Treatments | Observed Variables |
|------------|--------------------|
|            | TFC (g) FUE (%) PER (%) SGR(%) SR (%) W₀ Wt FBW |
| A          | 19.85± 40.05± 1.13± 1.96 ± 88.89± 9.84± 16.98± 7.14± |
| B          | 17.76± 40.54± 1.07± 1.73 ± 86.67± 9.43± 15.16± 5.73± |
| C          | 2.66 1.95± 0.41 0.18± 3.67± 0.53 0.81± 2.09± |
| D          | 18.66± 51.57± 1.51± 2.07± 88.11± 9.83± 17.68± 7.85± |
|            | 2.84± 4.57± 0.13± 0.12± 3.85± 0.72 0.18± 0.78± |
|            | 17.46± 74.93± 2.24± 2.81± 91.89± 9.81± 24.37± 14.56± |
|            | 3.23± 0.91± 0.08± 0.07± 3.85± 0.85 0.81± 2.23± |

The highest value of final weight, Total Feed Consumption (TFC), Feed Utilization Efficiency (FUE), Protein Efficiency Ratio (PER), Specific Growth Rate, and Survival Rate was at the substitution of fish meal with maggot meal which is cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D) they are: 24.37±0.81 g; 19.85±3.23 g; 74.93±0.91%; 2.24±0.08%; 2.81±0.07%; and 91.89±3.85% respectively. Therefore, the lowest value is at the substitution of fish meal with
maggot meal which is cultivated using 150 g/L of tofu waste (A) they are 16.98±0.81 g; 17.49±0.64 g; 40.05±2.82%; 1.13±0.07%; 1.96±0.24%; and 88.89±3.85% respectively.

3.1. Protein Efficiency Ratio
Based on Protein Efficiency Ratio of carp (C. carpio) data, orthogonal polynomial tests were carried out, which is presented in Figure 3.

![Figure 1](image_url)

**Figure 1.** Histogram of Protein Efficiency Ratio orthogonal polynomials of carp (C. carpio) (%)

From orthogonal polynomial test calculation results, a quadratic pattern relationship was obtained (y = 0.0013x^2 - 0.0175x + 1.1222) and R² = 0.9974, and there is no an optimum point yet. Dosage substitution of fish meal with maggot meal obtained from the equation is 6.73%, which able to produce minimal 1.03 g of PER. R² value showed that the linearity of the graph is 99.74%.

Substitution of fish meal with maggot meal cultivated in different culture media proved to have a significant effect (P <0.05) on Feed Utilization Efficiency (FUE), Protein Efficiency Ratio and growth of carp (C. carpio), but did not have a significant effect (P > 0.05) for the Survival Rate of carp. The study results of Feed Utilization Efficiency and Protein Efficiency Ratio is showed that the treatment of fish meal substitution with maggot meal which is cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D) produces the highest FUE value of 74.93 ± 0.91% and PER value of 2.24 ± 0.08%. This is because the culture media which used chicken manure and tofu waste have the highest nutrient content compared to culture media using fruit waste and vegetable waste. Nitrogen (N), Phosphorus (P), and Potassium (K) content of chicken manure was based on Damle and Chari's [16] study, the highest value was 7% N, 0.31% P, and 0.23% K, so that the high content of nitrate and phosphate will greatly affect the protein content in maggot.

The results showed that the quality of the protein contained in maggot meal was less able to be utilized by carp, this statement was proven from the results of calculations on the feed utilization for growth that is 74.93 ± 0.91%, and protein efficiency ratio which is only 2.24 ± 0.08%. Protein Efficiency Ratio (PER) is one of methods used to evaluate protein quality in feed. This is supported by the statement of Bhilave et al. [17] that calculating protein efficiency ratio based on weight gain of tested fish divided by the amount of protein in the feed consumed by fish during the study period. The feed industry has used PER as a standard to evaluate the quality of feed protein. Protein nutritional value is used as a guide to the requirements for the effectiveness of a protein source. PER is the most popular method in quantifying protein nutritional value.

The increasing of the Protein Efficiency Ratio (PER) value is followed by an increase in the Specific Growth Rate value. The highest PER and SGR values were 2.24 ± 0.08 and 2.81 ± 0.07 resulting from the treatment of fish meal substitution with maggot meal which was cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D). The higher the PER value, the higher the specific growth rate (SGR) would be, this is because protein is being able to break down into amino acids so that it is easier to be absorbed and utilized by the fish. This is strengthened by Craig and Helfrich [18] that the high Protein Efficiency Ratio is caused by protein being able to break down into amino acids
and their components, so that the absorption of protein in the fish’s body will be easier. Good protein absorption has a positive impact on biomass weight growth. This is encouraged by Li et al. [4] that the higher the protein conversion value of a feed, indicating that the feed is more efficient because the existing protein can be used optimally.

The lowest PER and SGR values were found in the fish meal substitution with maggot meal which was cultivated using 150 g/L of tofu waste (A) and the highest was in the fish meal substitution with maggot meal which was cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D). The low PER and SGR values are assumed because the amino acid content in the feed does not meet the needs of amino acids of a carp, while the highest value was on fish meal substitution with maggot meal which is cultivated using chicken manure 50 g/ L + 100 g/L of tofu waste (D) because amino acid content in feed is suitable to the need for amino acids of a carp. This is highlighted by Bicudo and Cyrino [19] that feed in fish aquaculture must be complete and balanced, providing essential amino acids that are adequate for optimal growth and fish health. According to Mozanzadeh et al. [20], essential amino acids are the key molecule for building proteins, as well as the key to regulating metabolic pathways including cell signalling, appetite stimulation, growth and development, energy utilization, immunity, osmoregulation, ammonia detoxification, anti-oxidative defence, metamorphosis, pigmentation, intestines and neural development, stress response, reproduction, and emphasis in aggressive behaviour of aquatic animals.

3.2. Feed Utilization Efficiency

Based on Feed Utilization Efficiency data of carp (C. carpio), orthogonal polynomial tests were carried out during the study, which is presented in Figure 2.

![Figure 2. Histogram of Feed Utilization Efficiency (FUE) orthogonal polynomials of carp (C. carpio) during study (%)](image)

From orthogonal polynomial test calculation results, a quadratic pattern relationship was obtained (y = 0.0366x² – 0.4466x + 40.14) and R² = 0.9998, and there is no an optimum point yet. Dosage substitution of fish meal with maggot meal obtained from the equation is 6.10% which able to produce minimal 38.77 g of FUE. R² value showed that the linearity of the graph is 99.98%.

Overall, the FUE, PER, and SGR measured variables at the treatment of fish meal substitution with maggot meal which is cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D) gives a different effect with the treatment of fish meal substitution with maggot meal which is cultivated using 150 g/L of tofu waste (A). The ratio of protein energy (E/P ratio) of feed ranged from 9.38 to 9.78 kcal/g protein which is an appropriate energy ratio because it is between the optimum E/P values. According to National Research Council [21] the E/P ratio is an important criteria in fish meal formulations. Some values of E/P feed ratios in some fishes have been researched and the exact E/P estimates in range between 8.9 and 12.3 kcal/g protein. Although the E/P ratio of feed is appropriate, it produces different FUE. FUE value on fish meal substitution with maggot meal which is cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D) is significantly different to the FUE value...
in feed by substituting fish meal with maggot meal which is cultivated using 150 g/L of tofu waste (A). The highest FUE value in the treatment of fish meal substitution with maggot meal which was cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D) is 74.93 ± 0.91% while the substitution of fish meal with maggot meal which is cultivated using 150 g/L of tofu waste (A) only produces FUE value of 40.05 ± 2.82%. The treatment of fish meal substitution with maggot meal which was cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D) also produced the highest PER value of 2.24 ± 0.08 and the highest SGR value of 2.81 ± 0.07. This showed that feed is used efficiently to produce growth through energy storage in the form of body element synthesis. This is reinforced by Zonneveld et al. [22] that energy storage in the form of body element synthesis is a complicated process. Feed energy must be digested and absorbed before biosynthesis (growth) takes place. Because the body's components consist of cells that must be supplied by food (for example essential amino acids) or must be supplied in certain cases, the fish must be able to synthesize it from other compounds (for example, non-essential amino acids).

FUE value in feed by substituting fish meal using maggot meal which is cultivated using 50 g/L of fruit waste + 100 g/L of tofu waste (B); 50 g/L of vegetable waste + 100 g/L of tofu waste (C); 50 g/L of chicken manure + 100 g/L of tofu waste (D) is not significantly different from the FUE value in feed by substituting fish meal using maggot meal which is cultivated using 150 g/L of tofu waste (A) so that the results on PER and SGR variables are also did not have a significant different. It is assumed that feed energy in the treatment in the range of 285.13 - 294.66 kcal is not fully used for growth because it only produces feed utilization efficiency of 40.05 – 51.57%. The low Feed Utilization Efficiency affects the value of the Protein Efficiency Ratio. Low PER value (1.07 – 1.51%) in the treatment of maggot meal substitution using 150 g/L of tofu waste (A) as culture media; 50 g/L of fruit waste + 100 g/L of tofu waste (B); 50 g/L of vegetable waste + 100 g/L of tofu waste (C) showed that only a small amount of protein is used for growth because most of the energy from protein is used for body maintenance. This is supported by Craig and Helfrich [18] that protein requirements are generally higher in early phase of fish life. Fish grow bigger, but their protein needs tend to decrease. Protein requirements also vary depend on the environment, water temperature, and water quality, as well as genetic composition and feeding methods. Protein is used for growth when energy from fat and carbohydrates in feed is adequate. Otherwise, protein is used more for energy and body maintenance than growth.

The mean of the overall treatments resulted in a value of Feed Utilization Efficiency of 51.77%. This value is better than the FUE value of the study conducted by Emre et al. [23] that substitution of fish meal with livestock waste meal in carp resulted in an average Feed Utilization Efficiency of 43.63%. Atanasoff [24] stated that substitution of fish meal with Ribotricin (fish waste that was not in accordance with standards combined with wheat bran with 60:40 ratio used for the production of protein components) in carp produced a value of feed utilization efficiency of 42.37%, and the study conducted by Khan et al. [25] that substituted fish meal with soybean produced FUE values of 24.45% and substitution of fish meal with sunflower seeds produced FUE of 31.54%.

3.3. Specific Growth Rate
Based on specific growth rate of carp (C. carpio) data, orthogonal polynomial tests were carried out during the study, which is presented in Figure 4.
From orthogonal polynomial test calculation results, a quadratic pattern relationship was obtained ($y = 0.0016x^2 - 0.0353x + 1.9513$) and $R^2 = 0.9974$, and there is no an optimum point yet. Dosage substitution of fish meal with maggot meal obtained from the equation is 11%, which able to produce minimal 1.75 g of SGR. $R^2$ value showed that the linearity of the graph is 99.78%.

Carp fish meal substituted by maggot meal cultivated in 50 g/L of chicken manure + 100 g/L of tofu waste (D) produced the highest Specific Growth Rate of 2.81%. This result is higher than the substitution of fish meal with maggot meal on Jian Carp by Li et al. [4] which produced the highest Specific Growth Rate of 2.08% which resulted in 75% substitution of fish meal with maggot meal. Substitution of fish meal with waste meal in carp by Emre et al. [23] produced the highest SGR of 1.55% from the substitution of fish meal with meal livestock waste meal by 33%. Substitution of fish meal by ribotricin (fish waste that is not in accordance with the standard combined with wheat bran at a ratio of 60:40 which used for the production of protein components) at Atanasoff’s study [24] produced SGR value of 2.07%.

3.4. Amino Acids Profile and Fatty Acids Profile of Feed during the Study
The amino acid content of each treatment and amino acid requirements of carp through manual calculation is presented in Table 3.

| Essential Amino Acids | Requirements | A     | B     | C     | D     |
|-----------------------|--------------|-------|-------|-------|-------|
| Arginine              | 6.02         | 3.86±0.05 | 4.97±0.06 | 6.28±0.04 | 7.19±0.05 |
| Histidine             | 2.82         | 1.55±0.08 | 2.51±0.03 | 3.65±0.01 | 4.23±0.04 |
| Isoleucine            | 3.75         | 3.83±0.02 | 4.17±0.04 | 5.20±0.02 | 5.78±0.03 |
| Lysine                | 6.55         | 5.60±0.46 | 6.93±0.09 | 7.08±0.07 | 8.95±0.08 |
| Methionine            | 2.11         | 2.08±0.01 | 2.45±0.02 | 2.77±0.02 | 3.24±0.07 |
| Phenylalanine         | 3.78         | 3.79±0.02 | 4.19±0.04 | 5.92±0.05 | 6.39±0.05 |
| Threonine             | 1.19         | 3.25±0.05 | 3.78±0.01 | 3.92±0.02 | 4.75±0.01 |
| Tryptophan            | 0.81         | 1.98±0.01 | 2.97±0.03 | 3.06±0.06 | 3.77±0.03 |
| Valine                | 4.25         | 4.63±0.04 | 4.96±0.02 | 5.19±0.07 | 6.72±0.07 |
| Leucine               | 6.87         | 6.31±0.01 | 6.65±0.06 | 7.03±0.01 | 8.17±0.08 |

Note: amino acid requirements according to Schwarz and Kirhgessner [26] and the results of amino acid profile analysis
Fatty acid content of each treatment and the amino acids requirements of carp (C. carpio) presented in Table 4.

Table 4. Fatty acid content of feed of each treatment and the amino acids requirements of carp (C. carpio)

| Saturated Fatty Acids            | Requirement* | Sample A | Sample B | Sample C | Sample D |
|----------------------------------|--------------|----------|----------|----------|----------|
| Methyl Butyrate                  | <0.1         | 0.73±0.09| 0.33±0.06| 0.88±0.03| 1.95±0.09|
| Methyl Hexanoate                 | <0.1         | 1.64±0.03| 1.63±0.02| 2.09±0.04| 2.75±0.03|
| Methyl Undecanoate               | <0.1         | 1.23±0.02| 1.85±0.09| 2.74±0.06| 3.09±0.02|
| Methyl Laurate                   | 0.23         | 1.44±0.02| 1.90±0.08| 2.16±0.02| 2.83±0.02|
| Methyl Tridecanoate              | 0.89         | 2.78±0.06| 2.95±0.08| 3.82±0.05| 4.19±0.06|
| Methyl Pentadecanoate            | 2.27         | 3.13±0.08| 3.75±0.09| 3.86±0.07| 4.95±0.08|
| Methyl Palmitate                | 0.73         | 5.65±0.02| 5.83±0.06| 6.15±0.02| 7.95±0.02|
| Methyl Heptadecanoate            | 0.97         | 1.88±0.07| 2.19±0.09| 2.28±0.07| 3.19±0.07|
| Methyl Arachidate                | 4.75         | 3.65±0.07| 4.15±0.03| 5.37±0.03| 6.64±0.07|
| Methyl Tricosanoate              | 1.26         | 1.66±0.02| 1.93±0.06| 1.85±0.02| 2.55±0.02|

| Unsaturated Fatty Acids          | Requirement* | Sample A | Sample B | Sample C | Sample D |
|----------------------------------|--------------|----------|----------|----------|----------|
| Linolenic                        | <0.1         | 2.35±0.02| 2.97±0.06| 3.75±0.07| 4.85±0.04|
| Linoleic                         | <0.1         | 2.52±0.05| 3.08±0.09| 4.56±0.05| 5.90±0.06|
| Erucate                          | 2.93         | 1.32±0.02| 2.62±0.05| 3.05±0.02| 3.95±0.01|
| Eicosapentaenoate                | 0.93         | 1.23±0.04| 2.07±0.03| 2.75±0.03| 3.17±0.01|
| Docosahexaenoate                 | <0.1         | 1.23±0.02| 1.15±0.06| 1.89±0.08| 2.59±0.07|

Based on amino acid and fatty acid profiles, the test feed has met the requirements of amino acids and fatty acids of a carp. The highest amino acid profile is 8.17% in leucine and the highest essential fatty acid is 5.90% in linoleic at the substitution of fish meal with maggot meal which cultivated using 50 g/L of chicken manure + 100 g/L of tofu waste (D).

3.5. Total Feed Consumption
The results showed that the total feed consumption of carp feed substituted by maggot meal with 150 g/L of tofu waste (A) of 19.85 ± 0.64 g and the lowest value is at fish meal substitution with maggot meal cultivated in 50 g/L of chicken manure + 100 g/L of tofu waste (D) of 17.55 ± 2.63 g. Variance analysis showed that the substitution of fish meal with maggot meal in carp did not have a significant effect (P> 0.05) on the TFC. This is because the tested fish are in the same stadia and the tested feed has the same physical properties. This is emphasized by Hanief et al. [27] that consumption of fish meal is influenced by a number of factors including body size, stadia, availability of feed, gastric emptying rate, water temperature, activity and health of fish body. Selection of feed for freshwater fish does not only involve criteria for nutritional value and cost efficiency, but also must consider other criteria such as digestibility, toxicity and availability.

The highest total feed consumption results were fish meal substitution with maggot meal cultivated in with 150 g/L of tofu waste (A) of 19.48 ± 0.64 g. Mudlofar et al [28] stated that feed with different protein content with an E/P value of 8.5 kcal/g in carp produced the highest TFC of 19.73 g in 30% protein treatment. It showed that fish meal substitution with maggot meal can be consumed by carp.

3.6. Survival Rate
The treatment of fish meal substitution with maggot meal with different culture media did not give a significant effect on survival rate, with the highest value in carp fed by fish meal substituted with
maggot meal which is cultivated in culture media of 50 g/L of chicken manure + 100 g/L of tofu waste (D) that is 91.89%. According to Ogunji et al. [29] substitution of fish meal with maggot meal in tilapia produces 100% survival rate in each treatment.

Fish death occurs at the time of changing water after cleaning the maintenance container by removing few water along the waste of the fish. New water changes causes fish to experience adaptation to new water condition. The weak adaptability of fish will lead to its death. This is reinforced by Siregar and Adelina [30], survival rate can be influenced by biotic and abiotic factors. Biotic factors consist of age and fish's ability to adapt to the environment. Abiotic factors are food availability and quality of living media.

Water quality is very influential on survival rate. Based on observations of the water quality of carp cultivation media, it is known that the temperature in the cultivation media has fluctuated with a temperature range of 23 – 29°C. Unstable temperatures can cause stress and lead to death. This is highlighted by Madeira et al. [31] that oxidative stress can occur due to an increase in temperature and there is a relationship between thermal stress response and oxidative stress response.

3.7. Water quality

The measurement results on the water quality parameters of carp (C. carpio) maintenance media during the study is presented in the Table 5.

Table 5. The measurement results on the water quality parameters of carp (C. carpio) maintenance media during the study

| Treatment | Range of Water Quality Parameter Value |
|-----------|---------------------------------------|
|           | Temperature (°C) | pH          | DO (mg/L) | NH₃ (mg/L) |
| A         | 23 - 29          | 7.3-7.8     | 3.4 – 4.8 | 0.02-0.19  |
| B         | 23 - 29          | 7.3-7.9     | 3.4 – 4.8 | 0.02-0.19  |
| C         | 23 - 29          | 7.4-7.8     | 3.4 – 4.8 | 0.02-0.19  |
| D         | 23 - 29          | 7.3-7.8     | 3.4 – 4.8 | 0.02-0.19  |

Reference (Appropriateness)

23-30°  6.5-9.0°  > 3°  < 0.2°

Notes: (a) FAO [32] (b) Zonneveld et al. [22]

Water quality during the study is in the optimal range for carp growth.

Based on study that has been carried out, the temperature in the cultivation media ranged from 23°C to 29°C. The temperature is still in the normal range for carp cultivation. This is encouraged by FAO [32] that the best growth occurs when the temperature is in the range of 23-30°C. Fish can survive in cold temperatures. Hermanto [33] stated that temperature changes that are too high will affect the physiological and chemical processes in fish's body. These changes will affect feed intake, care needs, metabolic rate, enzymatic process, and speed of protein synthesis. The relationship between temperature and growth is the interaction of feed consumption and metabolism.

Dissolved Oxygen in the cultivation media are in the range of 3.4 – 4.4 ppm. This value exceeds the limit of dissolved oxygen standard for carp cultivation, which is 3 mg/L. Oxygen is needed for the combustion process to produce energy which is used for activities such as swimming, growth, and reproduction. This is supported by Zonneveld [22] that in the cultivation of carp and salmon the oxygen concentration should not be less than 3 mg/L. The need for oxygen for fish has two aspects, they are the environmental needs for certain species and the consumptive needs based on fish metabolism. Fish needs oxygen to burn their feed components to produce energy to do activities such as swimming, growth, reproduction, and others. Therefore, the oxygen availability determines the life cycle of fish. Conversion of feed, as well as growth rate, are depend on oxygen provided as long as other conditions are optimum.
The observation of pH in carp cultivation media during the study showed that pH of water in the range of 7.3 – 7.8. The pH value is still in the normal range for carp cultivation. According to Flajšhans and Hulata [34], the optimal pH for carp cultivation is in the range of 6.5 – 9.0. The pH value will affect the amount of ammonia content in the water. The higher the pH value, the higher the ammonia level in the water. This is strengthened by Silaban et al. [35] which stated that the pH value which has increased greatly affects the concentration of ammonia in the water. Ammonia content is directly proportional to the pH value. The percentage of ammonia in the water will increase as the pH of the water increases. When the pH is high, the ammonia is not ionized therefore it is toxic to fish.

Ammonia content in carp cultivation media during the study was 0.0 – 0.19. Ammonia levels are still within the normal limits for carp cultivation. According to Zonneveld et al. [22], the range of ammonia content for aquaculture varies according to the type of fish, fish can tolerate the toxicity of ammonia between 0.2 mg/L to 2.0 mg/L. Ammonia accumulation in cultivation media can cause damage to fish organs. This is emphasized by Sutomo [36] that some study results showed that ammonia accumulation in aquaculture water causes various kinds of damage to organisms, especially damage to the function and structure of organs. At very low levels it is less dangerous, but with increasing levels of ammonia, it quickly becomes dangerous to aquatic animals.

4. Conclusion
The conclusion in this study is, carp by feeding substitute fish meal with maggot meal which are cultivated in different culture media have a significant effect (P<0.05) towards the rate of Feed Utilization Efficiency, protein efficiency ratio, and specific growth rate, but no significant effect (P>0.05) towards total feed consumption and survival rate of carp (C. carpio). The best treatment in this study was carp by feeding substitution of fish meal with maggot meal which is cultivated in 50gr/l chicken manure + 100gr/l tofu waste (D) culture media and 63.5% fish meal, provide Feed Utilization Efficiency by 74.93±0.91, protein efficiency ratio by 2.24 ±0.085, specific growth rate by 2.81 ± 0.07, and survival rate by 91.89% ±3.85.

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