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Effectiveness of Fish Meal Substitution Using Maggot Meal in Floating Pellets on The Growth and Life Survival of Tilapia Fish *(Oreochromis niloticus)*

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Abstract

The purpose of this study was to determine the effectiveness of fish meal substitution using maggot flour in floating pellets on growth, life expectancy of tilapia and FCR (Food Conversion Ratio). Tilapia is widely cultivated by the community so that it has economic value with high market demand. The high price of feed causes many farmers to suffer losses. To overcome the problem of losses, cultivators use maggot as a substitute for fish meal to be used as a local raw material which has the advantage of being relatively cheap, high protein and increasing the digestibility of fish. The research method used experimental methods with the treatment of artificial feeding with fish meal protein sources and maggot flour protein sources and analyzed using the T test. The results of absolute growth research on fish meal pellets were 3.5 and maggot flour pellets 3.6. This shows that maggot flour can be used as a local raw material in the manufacture of fish feed. The results of the survival rate of tilapia by giving fish meal pellets were 60% and giving maggot flour pellets was 55%. Fish meal pellets and giving maggot flour pellets show that they can support the basic needs of fish and can support fish life. The results of the study showed that the FCR value for fish meal pellets was 1.36 and for maggot flour pellets was 1.36.

Keywords: *Effectiveness; Substitution; Maggot; Floting Pellets; Tilapia*

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INTRODUCTION

Tilapia is one of the freshwater fish that many people cultivate, because it is easy to breed with relatively fast growth and adapts to less favorable environments. The advantages of tilapia are that it has a specific taste, dense flesh and does not have many spines. Tilapia fish meat contains 17.5% protein, 4.7% fat and 74.8% water (Yustiati et al., 2019). This is the factor that causes tilapia to have high economic value with high market demand.

Feed is one of the important factors in cultivation activities to increase the growth rate of fish and the survival rate of tilapia (*Oreocromis niloticus*). Artificial feed containing high nutrients will encourage faster growth of tilapia (Arifin et al., 2020). As is known, feed is the largest component of production costs in fisheries activities, reaching 60-70% of total production (Salamah & Zulpikar, 2020). Currently, the price of commercial feed still requires imports to meet the needs of the livestock and fisheries industry. This situation causes production costs to be high and it is not uncommon for cultivators to experience losses. To anticipate these problems, we are looking for alternative sources of local raw materials that have nutritional qualities that are not inferior to fish meal, which can be used as a source of animal protein for making feed. One of the substitute feeds recommended by the is maggot (Prajayati et al., 2018).

Maggot can be used as a substitute for fish meal to increase digestibility in meeting protein needs in feed. Maggot is used as an alternative fish feed because it has a high protein content. Food ingredients that contain more than 19% crude protein are classified as good sources of protein (Rachmawati, 2013). Natural food is food in the form of plant or animal organisms that can be obtained naturally from nature. However, along with the development of cultivation science, natural food can now be cultivated. Maggots or larvae of the *black soldier fly* (*Hermetia ilucens*) are an alternative natural food source that can be cultivated to the desired size and quantity. Apart from that, maggots can also reduce organic waste using the bioconversion method by recycling organic waste into kasgot (*used maggots*) which can be used as an alternative organic fertilizer. Increasing tilapia seed production must be supported by good feed. Feed that meets fish nutrition can increase the growth of tilapia (Karimah, 2018).

The advantage of maggots being used as feed ingredients is their high protein and fat content. Wardhana (2017), stated that protein components have an important role in animal feed formulation because they are involved in the formation of body tissue and are actively involved in vital metabolism such as enzymes, hormones, antibodies and so on. *Black Soldier Fly* (BSF), the black soldier fly (*Hermetia illucens*, Diptera: Stratiomyidae) is one of the insects whose characteristics and nutrient content are beginning to be widely studied. This fly originates from America and then spread to subtropical and tropical regions of the world (Ali et al., 2022). Based on the above, it is necessary to conduct research on the effectiveness of fish meal substitution using maggot meal on floating plates on the growth and survival of tilapia. And as a reference for making fish food at a relatively cheap price and can use organic waste as raw material for making fish food.

METHOD

This research was carried out using an experimental method with artificial feeding treatment with fish meal as a protein source and artificial feeding with maggot meal as a protein source and analyzed using the T test.

Sample or Participant

The maintenance period in this study was 28 days. The sample used in this research was 80 tilapia fish. The sampling method is by means of a simple random sample (Simple Random Sampling). Artificial feed formulated with protein with a

value of 28%. Every 7 days sampling is carried out by taking a sample of the population.

Data collection

Observations and data measurements carried out in this research are by recording important data related to the research, which will then be used in preparing the research. The data that has been collected is then presented for discussion. Data taken includes:

Absolute Weight Growth

Absolute weight growth is the average weight growth rate of tilapia fry during rearing. Sampling for absolute weight measurements is carried out every 7 days. The calculation uses the (Mulqan et al., 2017), namely:

$$W = Wt - Wo$$

Information:
W = Absolute weight growth (g)
Wt = Average weight of fish at the end of rearing (g)
Wo = Average weight of fish at the start of rearing (g)

Absolute Length Growth

Absolute length growth is the average length growth rate of tilapia fry during rearing. Sampling for absolute weight measurements is carried out every 7 days. The calculation uses the Mulqan et al., (2017), namely:

$$L = Lt - Lo$$

Information:
L = Absolute length growth (cm)
Lt = Average length of fish at the end of rearing (cm)
Lo = average length of fish at the beginning of rearing (cm)

Survival rate

Survival rate is obtained by counting the number of fish at the beginning of rearing and comparing it with the number of fish at the end of rearing. The calculation of the survival rate percentage is carried out using the formula (Mulqan et al., 2017), namely:

$$SR = \frac{Nt}{No} x\ 100\ \%$$

Information:
SR = Survival Rate (%)
Nt = Number of fish at the end of rearing
No =Number of fish at the start of rearing

Feed Conversion Ratio (FCR)

FCR can be calculated using the following formula (Mulqan et al., 2017):

$$FCR = \frac{F}{(Wt + D) - Wo}$$

Information :
FCR = Feed Conversion Ratio

F = Amount of feed consumed during the rearing period (g)
Wt = Final biomass (g)
Wo = Initial biomass (g)
D = weight of dead fish during rearing (g)

Procedure
Making Feed For Treatment
Feed with a protein source of fish meal

Making feed using fish meal by (1) collecting the raw materials for making feed, namely: (Fish meal, soybean meal, bran, corn, wheat flour (2) sifting all the raw materials. (3) calculating the feed formulation. (4) weighing all raw materials for making feed, namely: Fish meal = 1.19 kg, soybean meal = 1.19 kg, bran = 0.87 kg, corn = 0.87 kg, wheat flour = 0.87 kg (5). dough (6) printing feed (7) drying.

Feed with a protein source of maggot flour

Making feed using maggot flour by (1) collecting the raw materials for making feed, namely: (maggot flour, soybean meal, bran, corn, wheat flour. (2) sifting all the raw materials. (3) calculating the feed formulation. (4) weighing all the raw materials for making feed Maggot flour = 1.19 kg, soybean meal = 1.19 kg, bran = 0.87 kg, corn = 0.87 kg, wheat flour = 0.87 kg (5) make dough . (6) printing feed (7) drying.

Calculation of Feed Formulation

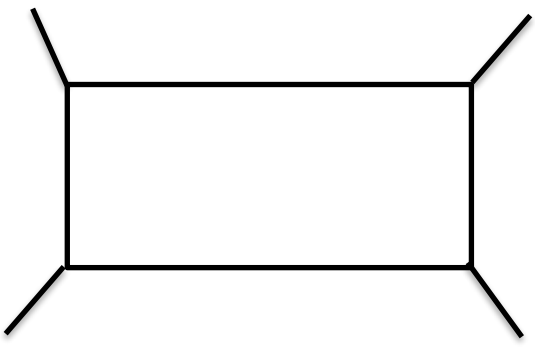
Make 5 kg of 28% protein fish feed. If using more than two raw materials, first group the bassal raw materials (protein content < 20%) and the protein raw materials (protein content > 20%) and average them first, then each group is put into the square method.

$$\frac{\text{maggot meal protein} + \text{soybean meal protein}}{2} = \frac{45\% + 50\%}{2} = 47{,}50\%$$

$$\frac{\text{bran protein} + \text{corn protein} + \text{wheat protein}}{3} = \frac{11\,\% + 10\% + 10\%}{3} = 10.33\%$$

Entered into the square method

soybean meal + maggot flour (protein raw materials) 47.50% 28-10.33 = 17.67



Bran + corn + wheat (bassal raw material) 10.33 47.5 – 28 = 19.50

37.17

So that :

Protein raw materials $= \frac{17,67}{37,17}\ x\ 100\% \ = 47,53\%$

Bassal raw material $= \frac{19,50}{37,17}\ x\ 100\% \ = 52,46\%$

To make 5 kg of fish food, you can mix the following:

Maggot flour $= \frac{47,53}{100}\ x\ \frac{5\ kg}{2} \ = 1,19\ kg$

Soybean meal $= \frac{47,53}{100}\ x\ \frac{5\ kg}{2} \ = 1,19\ kg$

Bran $= \frac{52,46}{100}\ x\ \frac{5\ kg}{3} \ = 0,87\ kg$

Corn Flour $= \frac{52,46}{100}\ x\ \frac{5\ kg}{3} \ = 0,87\ kg$

Wheat flour $= \frac{52,46}{100}\ x\ \frac{5\ kg}{3} \ = 0,87 kg$

Make 5 kg of 28% protein fish feed. If using more than two raw materials, first group the bassal raw materials (protein content < 20%) and the protein raw materials (protein content > 20%) and average them first, then each group is put into the square method.

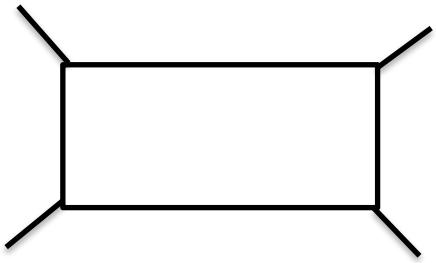
Protein raw materials

$$\frac{\text{fish meal protein } + \text{ soybean meal protein}}{2} = \frac{45\% + 50\%}{2} = 47,50\%$$

$$\frac{\text{bran protein } + \text{ corn protein } + \text{ wheat protein}}{3} = \frac{11\ \% + 10\% + 10\%}{3} = \ 10.33\%$$

Entered into the square method

soybean meal + fish meal (protein raw materials) 47.50% 28-10.33 = 17.67



Bran + corn + wheat (bassal raw material) 10.33 47.5 – 28 = 19.50 / 37.17

So that :

$$\text{Protein raw materials} = \frac{17,67}{37,17}\ x\ 100\% = 47,53\%$$

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$$\text{Bran} = \frac{52,46}{100}\ x\ \frac{5\ kg}{3} = 0,87\ kg$$

$$\text{Corn Flour} = \frac{52,46}{100}\ x\ \frac{5\ kg}{3} = 0,87\ kg$$

$$\text{Wheat flour} = \frac{52,46}{100}\ x\ \frac{5\ kg}{3} = 0,87kg$$

Preparation of Maintenance and Acclimatization Containers

Preparation of containers

Preparations that will be made during the research are preparing containers measuring 56 cm x 40 cm x 40 cm in a total of 8 aquariums. Then cleaned and washed with running water, then dried. Next, the container is filled with clean water to a height of approximately 30 cm, then the water is left for 24 hours or one day so that the water temperature is stable, dirt and dissolved particles are not carried away.

Acclimatization Procedure

Tilapia samples were obtained from fish seed sellers. The sample fish used were 80 fish. Each container will be filled with 10 tilapia fish. Before being used in research, the fish are first acclimatized. The way to carry out acclimatization is by placing the fish in plastic packaging on top of a container filled with water. Next, wait for 15 minutes and see that there are water bubbles inside the plastic packaging. Then the plastic is opened and the water in the pond is slowly poured into the plastic and the fish are allowed to come out on their own. The purpose of acclimatization is for the fish to quickly adapt to the new environment.

Data analysis

The data obtained in this study were analyzed using the T test. The requirements for this type of t test are:

a. Data is normally distributed.
b. The two groups of data are independent (connected/paired).

c. The types of data used are numeric and categorical (two groups).

$S_a^2 = \sum \frac{(x-x)n}{n_a-1}$ $S_b^2 = \sum \frac{(x-x)n}{n_b-1}$

$Df_a = n_a - 1$ dan $df_b = n_b - 1$

If the p value > a, then the variances are the same, but if the p value ≤ a, it means the variances are different, if the variances are not the same, then the Kerja et al., (2018) 't' test is used as follows:

$$t = \frac{Xa-Xb}{Sp\sqrt{\left(\frac{1}{n_a}\right)+\left(\frac{1}{n_b}\right)}}$$

where Sp:

$$S_P^2 = \frac{(n_a-1)S_a^2 - (n_b-1)S_b^2}{n_a + nb - 2}$$

Information :
Xa = Average on the increase in weight and length of fish given fish meal pellets
Xb = Average on the increase in weight and length of fish given maggot flour pellets
Sp = Combined standard deviation
Sa = Standard deviation of fish fed with soybean meal
Sb = Standard deviation of fish given maggot flour pellets
na = Number of fish data given fish meal pellets
nb = Number of data on fish given maggot meal pellets and fish meal pellets
df = na + nb-2

RESULT AND DISCUSSION

Heavy Growth

From the results of research carried out on the weight growth of tilapia fry using fish meal pellets in artificial feed and maggot meal pellets, the results were obtained for 4 measurements during 28 days of rearing. Based on these data, the absolute average weight growth for giving fish meal pellets was 3.5 grams/head and for maggot meal pellets the results were 3.6 grams/head.

Table 1. Average Absolute Weight

Week	Fish Meal Pellets (gram)	Maggot Flour Pellets (gram)
0	2,5	2,6
1	3,0	3,1
2	3,5	3,6
3	4,0	4,1
4	4,5	4,6
Absolute Weight	3,5	3.6

According to Pangestu (2020), the maintenance time for tilapia fry from 3-5 cm in size for 21-28 days with artificial feeding can result in an average weight growth of 2-4 grams. With the increase in weight from both treatments, the treatment with fish meal pellets showed good growth and the treatment with maggot meal pellets showed

good growth. This shows that fish meal can be substituted for maggot flour, because maggot flour can be used as a local raw material which has a high protein content and provides rapid growth in cultivation activities. By using SPSS Version 22 software, absolute weight variations were obtained in the fish meal feeding treatment and the maggot meal substitution feeding treatment. Based on the T test at a significance level of 0.05, it can be stated that the absolute weight gain between feeding fish meal is significantly different from feeding maggots.

Table 2. T test for Tilapia Fish Weight Data

Absolute weight gain of tilapia fish	N	df	T	Sig.(2-tailed)
Fish meal pellets	5	14	2.400	0,31
Maggot flour pellets	5	14	2.345	0,34

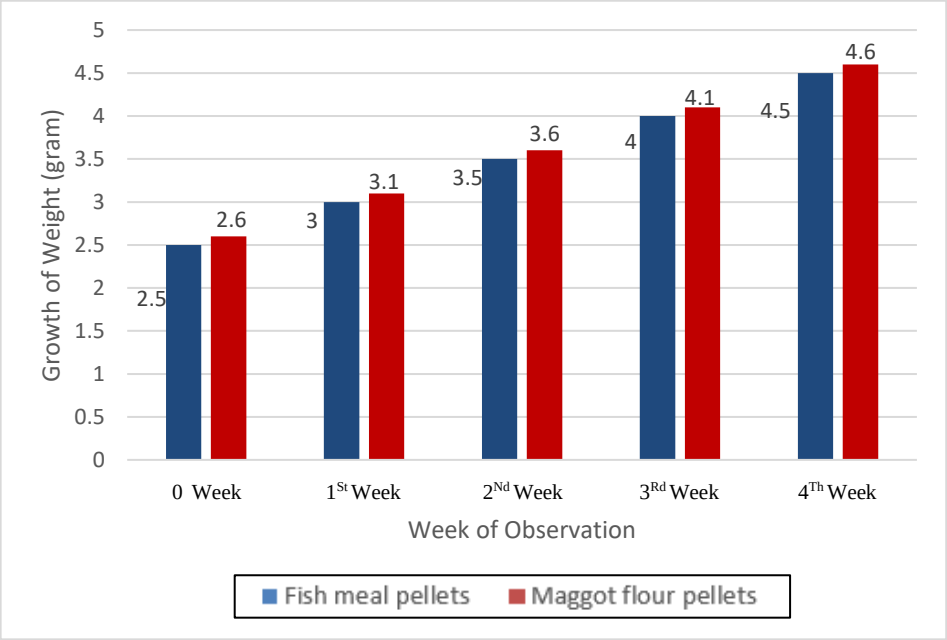

Figure 1. The Graph of Total Weight Growth

Based on the fish weight growth rate graph above, it can be seen that tilapia fry treated with fish meal pellets and maggot meal pellets have different absolute weight growth rates. Overall, the weight gain of tilapia fish increased in all feeding treatments. According to (Putri et al., 2019) the increase in weight is because every feed given can be responded to by the fish and used for metabolic and growth processes. Growth is influenced by the balance of nutrients contained in the feed. Prajayati et al., (2020),This is in accordance with that fish will consume feed to meet their energy needs, most of the feed is used for metabolic processes and the rest is used for other activities such as growth.

Long Growth

From the results of research carried out on the growth in length of tilapia fry using the treatment of giving fishmeal pellets to artificial feed and the treatment of giving maggot flour pellets, the results were obtained for 4 measurements during 28

days of rearing. Based on these data, the absolute average length growth for giving fish meal pellets was 5.7 cm/fish and for standard feed the results were 5.8 cm/fish.

Table 3. Average Absolute Length

Minggu	Fish meal pellets (cm)	Maggot flour pellets (cm)
0	4,7	4,8
1	5,0	5,2
2	5,5	5,7
3	6,2	6,4
4	6,9	7,1
Absolute length	5,7	5,8

According to Kurniawati (2017), the maintenance time for tilapia fry from 3-5 cm in size for 21-28 days with artificial feeding can result in an average weight growth of 2-4 grams. The growth in length of tilapia fry for each treatment showed striking differences because tilapia fry were still in the process of adapting to the environment. According to Mulqan et al., (2017), growth in the early phases of fish life is initially slow for a while but then growth progresses quickly and is followed by slow growth again in old age. By using SPSS Version 22 software, absolute weight variations were obtained in the fish meal feeding treatment and the maggot meal substitution feeding treatment by measuring 4 times in 28 days of rearing. Based on the T test at a significance level of 0.05, it can be stated that the absolute weight gain between feeding fish meal is significantly different from feeding maggots.

Table 4. T-test for Tilapia Length Data

Absolute increase in length of tilapia fish	**N**	**df**	**T**	**Sig.(2-tailed)**
Fish meal pellets	5	14	2.400	0,31
Maggot flour pellets	5	14	2.345	0,34

Based on the graph of the rate of growth in length of fish with the provision of fish meal pellets and maggot meal pellets, the last observation showed an increase in length growth. The effect of giving fish meal pellets and maggot meal pellets has begun to appear. If the observation time is increased, the effect of giving fish meal pellets and maggot meal pellets will be clearer. The graph above shows that at the end of the study, giving fish meal pellets, there was an average absolute length growth of 5.7 cm and maggot flour pellets, an average absolute length growth of 5.8 cm. Mulqan et al., (2017), said that growth occurs when there is excess energy resulting from metabolism after being used for body maintenance and activities. By using SPSS Version 22 software, absolute length variations were obtained in the fishmeal feeding treatment and the maggot meal substitution feeding treatment by measuring 4 times in 28 days of rearing. Based on the T test at a significance level of 0.05, it can be stated that the absolute increase in length between feeding fish meal is significantly different from feeding maggots.

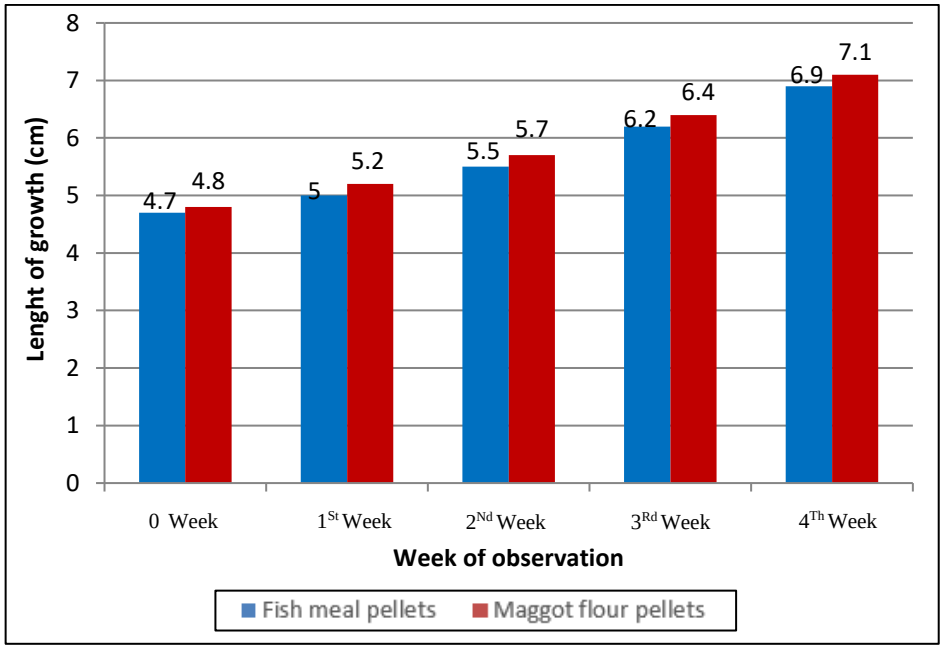

Figure 2. Total Length Growth Graph

Survival Rate (SR)

The results of the survival rate of tilapia fry during the research were 60% for feeding fish meal pellets and 55 % for feeding maggot meal pellets which can be seen in table 5. Based on the results of this research, it was found that the survival rate for tilapia fish when fed fish meal pellets was 60 % and when fed maggot meal pellets was 55%. The survival rate of tilapia fry during the study showed a good level according to Wardhana (2017) which stated that a survival rate (SR) ≥ 50 % was classified as good, survival rate of 30 - 50 was moderate and less than 30 % was classified as not good.

Table 5. Survival Rate Calculation Results

Feed	Number of initial stockings (tails)	Final stocking number (tails)	SR (%)
Fish meal pellets	40	24	60
Maggot flour pellets	40	22	55

In this study, fish deaths occurred during the environmental adaptation process because fish mortality was obtained at the beginning of rearing and fish adaptation to the feed provided was relatively slow. After fasting, the fish were still maximally able to consume the treated fish given, so that some of the sample fish were unable to survive and eventually died. However, the survival rate value in this study is still in the good category. As stated Indra et al., (2021) the sufficient quantity and type of feed is sufficient to support the basic needs of fish and can support the life of fish. Therefore, in future research it is very important to pay attention to the adaptability of fish, so that deaths are not caused as above.

Food Corversion Rate (FCR)

The FCR calculation obtained during the research for feeding fish meal pellets and feeding maggot meal pellets can be seen in table 6. Based on the results of this research, it was found that the FCR value of fish meal pellets to get 1 kilogram (kg) of tilapia fish meat requires 1.36 kilograms (kg) of feed and for maggot flour pellets to get 1 kilogram (kg) of tilapia fish meat requires 1.36 kilograms (kg) feed. This FCR value concludes that the feed provided is consumed and digested well. According to Handajani (2006) that the higher the FCR, the food given is not liked by the fish and is not digested by the fish.

Table 6. FCR calculation results

Feed	Final total weight (kg)	Total feed given during rearing (kg)	FCR
Fish meal pellets	40	24	1,36
Maggot flour pellets	40	22	1,36

Water Quality Data

Based on the water quality measurements carried out, temperature and pH can be seen in table 7. Observation of water quality, temperature and pH, where the average temperature during maintenance ranges from 27-30 C. Meanwhile, the results of pH observations during the research had values ranging from 6.9 to 8.0. This average value is still considered good, where this value is still in accordance with SNI (01-6141-2009). In maintaining water quality, it is very important to pay attention and control. Because fish are still easily stressed if drastic changes occur in water quality. Of course, this will inhibit fish growth. Another effort to maintain water quality is to throw away food scraps in the rearing container, and separate sick fish. This is done to spread disease to other fish. If treatment is slow, the chances of survival will be low.

Table 7. Water Quality Measured During The Research

Observation	Temperature (°C)	pH
Fishmeal pellet container	27-30	7.0-8.0
Maggot flour pellet container	28-30	6.9-7.0

Proximate Analysis of Fish Meal Pellets

Results of proximate analysis of fish meal pellets carried out in the laboratory of PT. Leong Hup Jayaindo. According to Manik (2022), the optimum protein content for fish is 25-50%, when compared with the results of protein analysis in the fish meal pellet test feed which obtained a protein content of 32.41% and protein analysis in the maggot meal pellet test feed obtained The protein level is 28.06, which means it still meets the optimum protein level for fish. Iskandar & Fitriadi (2017) declared that fat is an organic compound that is insoluble in water, but is soluble in organic solvents as the most important energy source for fish growth and survival. Feed generally contains 4-18% fat. Meanwhile, according to Fitriani et al., (2023), the optimal fat content to support fish growth is 2.57%. The fat content of the fishmeal pellet test feed was 3.07 and the fat content of the maggot pellet test feed was 3.89, so the fat content of the feed could be said to be in the good category.

Table 9. Results of Proximate Test Analysis

Product	Analysis Result				
	Protein	**Fat**	**Fiber**	**Water**	**Abu**
Fish Meal Pellets	32.41	3.07	2.55	14.03	22.48
Maggot Meal Pellets	28.06	3.89	4.08	16.11	15.23

Crude fiber is part of carbohydrates that cannot be digested and is not an important nutrient for fish. Crude fiber will cause dirt in the container, but is needed to facilitate decreased digestibility, decreased absorption, increased metabolic waste, decreased water quality (Iskandar & Fitriadi, 2017). According to Amarwati (2015) in tilapia the optimal crude fiber content to support fish growth is 4-8%. The results of the crude fiber analysis of the fish meal pellet test feed were 2.55% and the crude fiber analysis of the maggot meal pellet test feed was 4.08%. When compared with the literature, the test feed has crude fiber levels that do not match the needs of the fish.

The water content contained in the fish meal test feed was 14.03 and the water content contained in the maggot meal test feed was 16.11. The water content in the test feed meets the criteria according to SNI 01-7242-2006, namely 12%. The high water content in the test feed is thought to be due to the drying process at a low temperature and a short time. This is in accordance with income Lisa et al., (2015), the higher the drying temperature and the longer the drying time. Causing the water evaporation process that occurs in the material to become lower.

Total ash is defined as the residue produced during the combustion process of organic material. In the form of inorganic compounds in the form of oxides, salts and minerals. The total ash contained in a product is limited in quantity. The ash content in feed meets the criteria according to SNI 01-3148-2:2017, namely 12%. The ash content in fish meal pellets is 22.48% and the ash content in maggot meal pellets is 15.23%. This shows a very high ash content, not suitable for fish needs because it has excessive mineral content. The higher the ash content, the less effective it is for fish food. Because ash content can reduce the quality of cultivation water.

CONCLUSION

The absolute growth in weight and length in fish meal pellets is 3.5 grams/head and 5.7 cm in length. The absolute weight and length growth in maggot flour pellets was 3.6 grams/head and 58 cm in length. This shows that maggot flour can be used as a local raw material for making fish feed. The survival rate for tilapia fish when given fish meal pellets is 60% and when given maggot meal pellets is 55%. Fish meal pellets and giving maggot meal pellets show that they can support the basic needs of fish and can support fish life. The research results show that the FCR value for fish meal pellets is 1.36 and for maggot meal pellets is 1.36.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions

All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submited by [Florentina Pauli Sirait]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.