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Efficiency Of Feed Cost And Business Feasibility In Catfish Cultivation Using Black Soldier Larvae As Additional Feed

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ABSTRACT— The price of commercial feed, which is becoming more expensive, has caused the need for alternative fish feed with the same quality but at a lower price. The feed costs are the most significant component in catfish farming. The larvae of Black Soldier Fly or maggots can be used as an additional alternative feed. This study aimed to determine the efficiency of feed costs by providing additional maggot feed-in Sangkuriang catfish cultivation. Furthermore, the effect of giving maggots was also analyzed in the feasibility business of catfish farming. The results showed that the most efficient feed cost was a combination of 50% commercial feed in the form of pellets and 50% maggots. This combination of feed reduced costs by IDR 675 / kilogram of feed. The business feasibility indicator of this combination of feed showed better results than the use of pellets only. NPV increased to IDR 1,831,038, IRR of 64.41%, Net B / C with a value of 2.36, and the Pay Back Period improved at 15 months. Thus, the best recommendation for Sangkuriang catfish cultivation is a combination of 50% commercial feed and 50% maggots.

KEYWORDS: Maggots, Sangkuriang Catfish, Feed Cost Efficiency, Feasibility Study

1. INTRODUCTION

Catfish (Clarias sp) is a type of fish favored by Indonesian people and cultivated because it can adapt to extreme environments, such as low oxygen conditions and thus have high-density spread and high productivity, and high productivity [1]. Based on data obtained from the Ministry of Marine Affairs and Fisheries in 2015, catfish production in 2014 reached 679,379 tons with an average increase of 29.48 percent. West Java is the largest catfish producer in Indonesia, with production reaching 197,783 tons in 2013. Feed is an essential element in intensive catfish farming. It is necessary to have sufficient quantity and quality of feed available at all times to obtain good yields in catfish farming. Farmers generally use commercial feed, which is widely available in the market, to meet their livestock feed needs, significantly affecting the overall production costs. According to [2], the feed cost is the largest component in breeders' total costs reaching up to 70% of the total costs [3]. A good livestock feed formula must contain sufficient protein components because protein has an essential function in forming body tissues and is actively involved in body metabolism [4]. Fish flour is the source of protein commonly used in the fish feed industry. However, the availability of fish flour is still not sufficient for feed production. [5] stated that Indonesia still has to import fish flour to meet domestic- produced feed production needs. The commercial feed industry's imported raw materials cause the feed price to be high and increase every year. Therefore, it is necessary to find alternative protein sources of local raw materials to reduce commercial fish feed dependence. The available insects in large quantities can be used as alternative animal feed. Besides, insects are not used by humans for consumption. There are several types of insects that have the potential to be utilized to produce useful biomass. Insects that have been studied widely are the larvae of the Black Soldier Fly (BSF), whose Latin name is Hermetia illucens and is better known as maggots, the House Fly larvae (Musca domestica), and Tenebrio molitor [6]. BSF larvae or maggots, which have high growth and feed conversion rates, can make fair use of various types of materials

as food sources, including organic materials [7]. Maggots can be used directly or mixed with other ingredients such as bran to make pellets. Of course, using maggots will make it easier for breeders to produce their feed because maggots can be mixed with commercial feed. In this manner, it will automatically decrease production costs without reducing livestock growth quality [8]. Maggots also can also be used as a protein source in aquaculture [9]. With the great potential of maggots to reduce feed costs in catfish farming, this study on the effect of utilizing maggots as additional feed on the feed costs in Sangkuriang catfish cultivation in Bogor was carried out. After determining the composition of feed producing the most efficient feed cost, further analysis was carried out to determine the effect of additional feed on Sangkuriang catfish cultivation's feasibility. In this way, the analysis results can be used as a reference for Sangkuriang catfish farmers who use maggots as additional feed.

2. Material and Method

This experimental research was conducted using a completely randomized design (CRD) with five treatment levels and three repetitions for each treatment. Each treatment used a circular pond with a diameter of two meters filled with 200 catfish fingerlings with a size of 10-11 cm. The feed used in this study is a floating pellet, Hi-Pro-Vite 781, produced by PT Central Proteina Prima, the most widely used by Sangkuriang catfish farmers in Bogor Regency. The additional feed used is 14 day- old maggots. Maggots have supple skin at that age, and catfish prefer them to compared to maggots in the prepupa phase, whose skin has started to turn brown and harden. The total feed given per day is 4% of daily body weight. Feeding time is twice a day, 50% at 09.00 am and the same amount at 06.00 pm.

The average weight of catfish used in this study was 10 grams/fingerling, and the level of treatment carried out in this study was as follows:

a) Treatment A: 100% commercial pellet feed
b) Treatment B: 75% commercial pellet feed + 25% Fresh Maggots
c) Treatment C: 50% commercial pellet feed + 50% Fresh Maggots
d) Treatment D: 25% commercial pellet feed + 75% Fresh Maggots
e) Treatment E: 100% fresh maggot feed

This study's business feasibility calculation scale is per circular pool unit with a diameter and height of one meter and filled with 1200 fingerlings, with a fish mortality rate of 3%. The cultivated fish seeds were 10- 11 cm in size with an average weight of 10 grams/fish. Within two months, the catfish reached the market size (> 100 grams/fish) and could be harvested, so that in one year, the farmers could carry out six cycles of Sangkuriang catfish farming activities. To analyze the financial aspects, quantitative data were processed using Microsoft Excel. The following is a further explanation of quantitative data and the processing methods used.

2.1 Weight Growth

The formula used to calculate weight growth according to [10] is:

$$W = Wt - Wo$$

Where:
W = Absolute Weight Growth (g)
Wt = Final Weight of Fish (g)
Wo = Initial Weight of Fish (g)

2.2 Feed Efficiency

The formula used to determine feed efficiency according to [11] is:

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

Where:
EP = Feed efficiency (%)
Wt = final Weight of fish (g)
Wo = initial weight of fish (g)
D = Weight of dead fish (g)
F = Amount of feed consumed (g)

2.3 NPV (Net Present Value)

The business is declared to be feasible if all the benefits received are greater than the costs required to run the business. The difference between the benefits and costs is called the net benefits [12]. The formula used is:

$$NPV = \sum_{t=1}^{n} \frac{\mathrm{Bt} - \mathrm{Ct}}{(1 + \mathrm{i})^{\mathrm{t}}}$$

where
Bt = Benefits of business activities in year t
Ct = Costs incurred in year t
t = Year of business activity, the initial year is year 1
I = Discount Rate (DR)

Indicators
- NPV> 0, means that the catfish farming business is feasible and can provide benefits.
- NPV = 0, means that the catfish farming business is neither profitable nor does it cause loss. The business can return the exactly amount of capital, the social opportunities cost of normal production factors.
- NPV <0, means that catfish farming is not feasible because it will not generate profits or benefits.

2.4 IRR (Internal Rate of Return)

The amount of return on investment is one factor that needs to be assessed in determining business feasibility. The IRR value is usually obtained based on the interpolation between a lower Discount Rate (DR) level (resulting in a positive NPV) and a higher DR rate (resulting in a negative NPV). The business is said to be feasible if the IRR is greater than the DR [13]. The formula used is:

$$\mathrm{IRR} = \mathrm{i}_1 + \frac{\mathrm{NPV}_1}{\mathrm{NPV}_1 - \mathrm{NPV}_2} \times (\mathrm{i}_2 - \mathrm{i}_1)$$

where:
i_1 = DR which produces positive NPV
i_2 = DR which produces negative NPV
NPV_1 = Positive NPV
NPV_2 = Negative NPV

2.5 Net B / C Ratio (Net Benefit Cost Ratio)

Net B / C is the ratio between net benefits that are positive and negative benefits. A net benefit to the business is generated against every one-unit loss of the business.

$$\textbf{Net B/C} = \frac{\sum_{t=1}^{n} \frac{Bt - Ct}{(1+i)^t}}{\sum_{t=1}^{n} \frac{Bt - Ct}{(1+i)^t}}$$

where
Bt = Benefits in year t
Ct = Cost in year t
i = Discount rate
t = Period

Indicator

- Net B / C> 1, means that catfish farming is feasible and profitable
- Net B / C = 1, means that the catfish farming business is neither profitable nor loss (break-even)
- Net B / C <1, means that catfish farming is detrimental or not feasible to implement

2.6 Payback Period (PP)

The payback period is used to measure the speed of return of the investment made in the business. The faster the rate of return of a business, the more likely it is that the business will be selected. The Sangkuriang catfish cultivation business can be said to be feasible, if the value of the payback analysis period is shorter than the project life [14].

$$Payback\ period = \frac{\mathrm{I}}{\mathrm{Ab}}$$

Where
I = the amount of investment costs required
Ab = net benefits that can be obtained each year

2.7 BEP (Break Even Point)

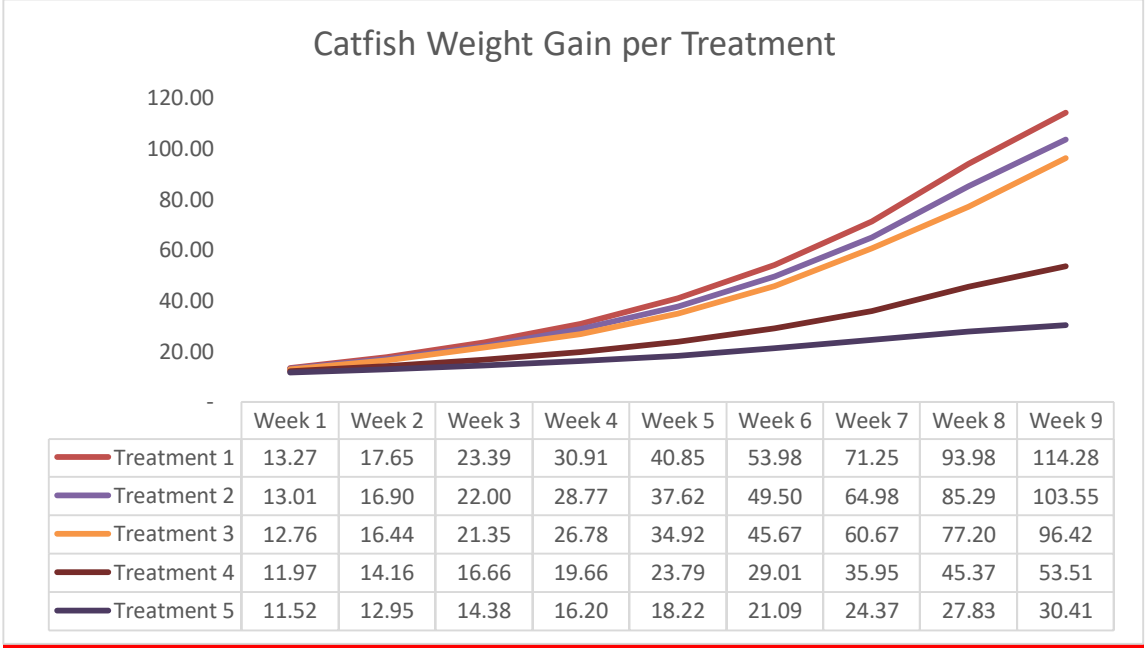
BEP is a tool used to analyze or determine the relationship between several variables in a business, such as the area of production, the level of production carried out by a business, the costs incurred in the business, and the revenue / income received from the business activities [15]. The following is the formula for calculating the BEP:

$$\mathrm{BEP} = \frac{\mathrm{FC} + \mathrm{Investment\ Cost}}{\mathrm{P} - \mathrm{VC}}$$

Where
FC = Fixed Cost
P = Price
VC = Variable Cost

4. Result

The weight gains of the catfish observed is based on feed treatment. Growth observations were carried out every week by measuring the average fish weight for each treatment. Figure 1 shows that the highest weight growth was obtained in the treatment using 100% commercial pellet feed. The average weight gains of the Sangkuriang catfish achieved in week 9 was 104.27 grams. The higher the proportion of maggots used in the feed, the less the weight growth. Giving 100% maggot feed to Sangkuriang catfish resulted in a weight growth of only 20.40 grams.



	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
Treatment 1	13.27	17.65	23.39	30.91	40.85	53.98	71.25	93.98	114.28
Treatment 2	13.01	16.90	22.00	28.77	37.62	49.50	64.98	85.29	103.55
Treatment 3	12.76	16.44	21.35	26.78	34.92	45.67	60.67	77.20	96.42
Treatment 4	11.97	14.16	16.66	19.66	23.79	29.01	35.95	45.37	53.51
Treatment 5	11.52	12.95	14.38	16.20	18.22	21.09	24.37	27.83	30.41

Figure 1. Weight Gain of Catfish Based on Different Feed Treatments

The feed efficiency was analyzed by comparing the additional weight of the Sangkuriang catfish and the amount of feed given during the observation period. Thus, the value of feed efficiency was directly proportional to the growth in fish weight. The feed efficiency of each treatment can be seen in Figure 2. Feeding 100% pellets (Treatment 1) resulted in the highest feed efficiency. The resulting feed efficiency value is 105%, meaning that giving 1 kg of feed resulted in an additional weight of catfish of 1.05 kg. The greater the feed efficiency value indicates the better feed quality in meeting the nutritional needs for fish growth. Treatment 2 (75% pellets and 25% maggots) resulted in feed efficiency of 94%, meaning that by giving 1 kg of mixed feed in treatment 2, the additional weight obtained was 0.94 kg.

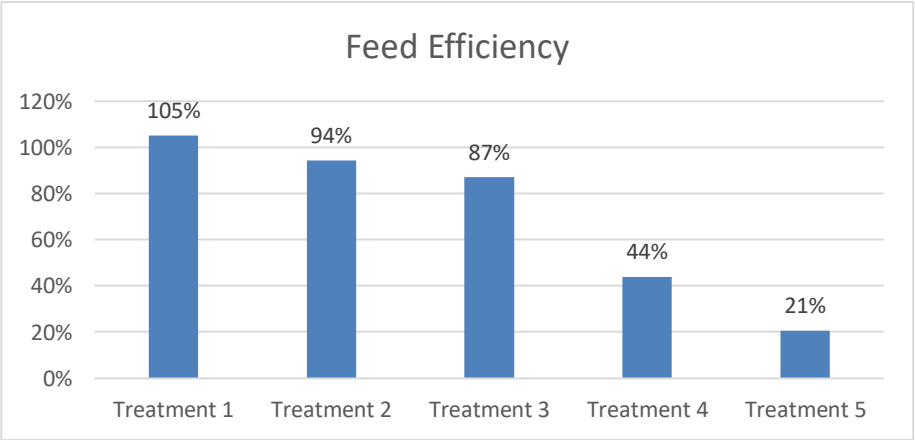


Figure 2. Average Feed Efficiency of Each Treatment

Treatment 1 used 100% of commercial pellets; therefore, the price of feed used per kilogram was the same as the price per kilogram of Hi-Pro-Vite 781, IDR 11,000. Treatment 2 used 75% pellets and 25% maggots. This composition reduced the pellet feed component's price to IDR 8,250 and the maggot feed component to IDR 1,500. So that the price of feed per kilogram in Treatment 2 was IDR 9,750. In treatment 3, the feed's composition was 50% pellet feed and 50% maggot feed. The price of the pellet feed component used in treatment 3 was Rp. 5,500, and the maggot component was Rp. 3,000; thus, the price of feed per kilogram in treatment 3 was Rp. 8,500. For Treatment 4, the feed component was 25% pellets and 75% maggots; thus, the pellet feed component's price in Treatment 4 was IDR 2,750, and the maggot component was IDR 4,500; the total cost of feed in treatment 4 was IDR 7,250. Treatment 5 used 100% maggots as Sangkuriang catfish feed, so the feed cost per kilogram was IDR 6,000.

Table 1. Price per Kilogram of Feed in every treatment.

Treatment	Pellet feed	Maggot	Price of Feed/Kg
Treatment 1	11000	0	11000
Treatment 2	8250	1500	9750
Treatment 3	5500	3000	8500
Treatment 4	2750	4500	7250
Treatment 5	0	6000	6000

The volume of feed required to produce an additional 1 kg of fish weight was obtained by dividing the value of 1 kg by the average feed efficiency. Thus, in treatment 1, it is worth 0.95. This value indicates that to obtain an additional 1 kg of weight in the Sangkuriang catfish, it takes 0.95 kg of feed. Treatment 5 produces the most excellent value, in which 4.89 kg of feed was needed to produce an increase of 1 kg of Sangkuriang catfish weight. Table 2 shows the feed volume needed to produce 1 kg of additional catfish weight for each treatment.

Table 2. Feed Cost for Each Treatment

Treatment	Price Feed/Kg	Feed Volume to Produce 1 Kg Fish Weight	Feed Costs to Produce 1 Kg Fish Weight
Treatment 1	11.000	0,95	10.450
Treatment 2	9.750	1,06	10.335
Treatment 3	8.500	1,15	9.775
Treatment 4	7.250	2,29	16.598
Treatment 5	6.000	4,89	29.323

The cost of feed incurred to produce 1 kg of Sangkuriang catfish was obtained by multiplying the feed/kg price for each treatment with the volume of feed required to produce an additional fish weight of 1 kg. The data in Table 5 shows that Treatment 2 and Treatment 3 produce lower feed costs to produce 1 kg of Sangkuriang catfish compared to 100% pellet feed. The cost incurred to produce 1 kg of catfish in Treatment 2 was IDR 10,335, and in Treatment 3, IDR9,775. The Analysis of the business feasibility in this research was conducted based on financial indicators. Based on the calculation of feed costs incurred, Treatment 3 was the most efficient composition for Sangkuriang catfish cultivation. This result was obtained from comparing the feasibility of catfish farming in Treatment 1 and Treatment 3. The total costs incurred in Sangkuriang catfish farming activities consist of investment costs, fixed costs, and variable costs. Investment costs are costs

incurred when starting the business. The investment cost incurred for the cultivation of Sangkuriang catfish in this study was the construction of a circular tarpaulin pond with a diameter of 2 meter and a pool frame made of wire mesh with a wire diameter of 0.7 mm. The tarp used was the Orchid type. Between the tarpaulin and the wire mesh frame, a 1-meter gutter carpet was inserted to prevent friction between the tarpaulin and the wire mesh so that the tarpaulin could last for a more extended period. The total cost of making a circular pool was IDR 1,000,000. Another investment cost incurred was the purchase of a water pump, costing IDR 350,000. The total investment cost incurred was IDR 1,350,000. Fixed costs define costs that have a fixed value and do not depend on the number of products produced. Fixed costs incurred in catfish culture business activities consist of workers' salaries. Each worker in catfish farming can handle 20 circular ponds per day, with a salary IDR 2,500,000/month. One catfish rearing business cycle takes two months. Thus, the worker/pool salary in one cycle was obtained the total salary for two months divided by the number of pools handled. Thus, the labor cost incurred for each pool was IDR 250,000. Another fixed cost is the cost of depreciating equipment, such as buckets, filters, and scales. The calculation shows that the depreciation cost per cultivation cycle was Rp. 25,000. The total fixed costs incurred during one production cycle was IDR 275,000. The variable costs incurred in catfish farming in a circular pond with a 2-meter diameter consisted of buying 1,200 catfish fingerlings 10-11 cm in length. With the price of IDR. 400 per fingerling, the total cost of purchasing fingerlings was IDR 480,000. To produce 120 kg of fish, based on feed efficiency data in this study, 114 kg of Hi-Pro-Vite 781 floating pellets were needed at IDR 1,254,000/kg. During the cultivation process, the medications used consisted of krosok salt, EM4, and antibiotics amounting to IDR 20,000 and an electricity fee of IDR 25,000. Therefore, the total variable costs incurred in 1 production cycle was IDR 2,054,000. The revenue obtained in the Sangkuriang catfish farming business was calculated by multiplying the price of catfish with the quantity of the harvest. The price of Sangkuriang catfish at the collector level was IDR 18,000 per kilogram. The yield quantity per pond with a diameter of 2 meters in 1 cycle was120 kg. Thus, the revenue obtained for each pool in 1 cycle was IDR 2,160,000.

Table 3. Business Feasibility Indicator Values of Financial Aspects

	100 % Pellets Feed	**Mixed feed (50% Maggots dan 50% Pellet Feed)**
NPV	453.155	1.831.038
IRR	19,51%	64,41%
Net B/C	1,34	2,36
PP	26 months	15 months
BEP	1.840	422

5. Discussion

Maggots have a fat content of 30% and a protein content of 30-40%. Thus, maggots can be used as additional feed because the nutritional content can meet the nutritional needs of Sangkuriang catfish's growth [5]. The results showed that commercial pellet feed is the best feed for fish growth because it contains all the nutrients needed to grow the Sangkuriang catfish. Giving only maggot feed to the Sangkuriang catfish cannot produce consumer size catfish because the nutrient content of maggots is incomplete, and it is not enough to meet the fish growth needs. However, giving a certain additional amount of maggots can reduce the cost of feed incurred by the Sangkuriang catfish farmers as the price of 1 kg of maggots is much cheaper than that of commercial pellet feed. The average feed efficiency obtained from this study shows that the higher the

maggots' composition as additional feed, the lower the average feed efficiency value. Treatment 4 and treatment 5 produced the smallest average feed efficiency values, namely 44% and 21%. The recommended additional feed composition provides a mixture of equal amounts of pellets and maggots because this mixture results in a reasonably high feed efficiency of 87%, which produces profitable catfish growth. The combination of 50% pellet feed and 50% maggot feed produced the lowest feed cost for Sangkuriang catfish cultivation based on the research data. This result is in line with the research results conducted by [16], which stated that 50% of maggot feed provides the highest Total Feed Consumption for milkfish. [17] asserted that providing 40% adding maggots to feed the rainbow trout provides the best growth. Thus, fish cultivators can use maggots as additional feed to reduce feed costs in the fish cultivation process, especially for Sangkuriang catfish. Based on table 2, treatment 3 is the best composition to produce 1 kg of Sangkuriang catfish in terms of feed costs and feed composition. The cost of feed incurred in treatment 3 is the lowest, i.e., IDR 9,775. Thus, fish feed with a combination of 50% pellets and 50% maggots is recommended as the best feed to be used by Sangkuriang catfish farmers. In Treatment 3, farmers can save Rp. 675 / kg in feed costs compared to using 100% commercial pellet feed. Considering the ever-increasing commercial feed prices, in the future, the use of a combination of factory feed and maggots will further save on feed costs incurred by farmers. If fish farmers can also cultivate maggots, then the costs incurred to get maggots will be cheaper. state that the production cost of 1 kilogram of maggots is IDR 2,477, which is much cheaper than the price the catfish farmers pay when buying maggots from maggot cultivators. However, to produce maggots, catfish cultivators need to know the best techniques for cultivating maggots. They also need to have additional space for cultivating maggots and the initial capital required for building cages and purchasing maggot cultivation equipment. Table 3 shows that the business feasibility indicator value of the financial aspects of using pellet feed only and feeding 50% pellets and 50% maggots shows promising results and is feasible to implement. However, feeding 50% maggots and 50% pellet feed gives better results than using only factory pellet feed. The Net Present value obtained by using pellet feed only was IDR 453,155. Meanwhile, the NPV value in the use of additional feed resulted in a better NPV value, namely IDR 1,831,038. A more considerable NPV value indicates better results because the cultivators will get more significant benefits using additional maggot feed.

The IRR value obtained from the 100% pellet feeding method was 19.51, and the IRR value obtained by using additional feeding was 64.41%. The greater the IRR value, the better the business performance. So, the use of additional feed in the form of maggots is recommended. The Net B / C using only pellets yielded a value of 1.34, and the Net B / C value when using the combination feeding method was 2.36. A business is feasible if the Net B / C value is more significant than 1 so that the combination feeding method produce a good performance. However, a higher Net B / C value indicates better performance, so that combination feeding will result in better business performance than full pellet feeding. The value of the Pay Back Period of the full factory feed is 26 months, while with combination feeding, the PP's value is 15 months. The smaller the PP value, the better the results because the business actors will get a faster return on their capital. The smaller PP value in combination feeding indicates that this feeding method is better than full pelleted feeding. The Break-Even Point (BEP) that occurred with full pelleting is 1,840 kg, while the BEP that occurred with additional feeding is 422 kg. BEP is a break-even point, where the business actor does not receive a profit but does not suffer any loss. A smaller BEP value indicates better results because the business actors gain profits faster than methods that produce a considerable BEP value. Thus, all financial aspects' business analysis indicators indicate that the additional feeding method will give better results than full commercial pellet feeding. Based on the calculation of the financial aspect of business feasibility analysis, adding maggots in the feed is recommended because it will provide additional income for the Sangkuriang catfish cultivation business. Maggots have high protein content, so they can be used as a protein source in making fish feed. Further research recommendation is to investigate the production of maggot-based pellets as a protein source so that the resulting feed costs will be even lower.

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