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Substitution of fish meal with maggot meal (*Hermetia Illucens*) on the survival and growth performance of snakehead (*Channa Striata*)

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Abstract. The high protein content and complete nutrition are the main reasons for maggots as a source of animal protein for fish feed. This research aims to substitute fish meal (FM) in feed with maggots meal (MM) in snake head fish formulation feed. The study used a completely randomized design with 4 treatments and 3 replications A(100%FM), BFM75%; MM25%), C (FM50%;MM50%), D(25FM;75%MM). Feeding was carried out 4 times a day for 60 days with a density of 1 fish/l. The results of the ANOVA statistical test on survival and relative weight showed that there were no significant differences between all treatments. The survival value of treatments A, B, C and D was >90%, the highest relative weight gain was on the 30th day of treatment C (23.52 ± 2.37), on the 60th day the relative weight value for all treatments was between 39, 86±4.68 to 42.76±3.90. Treatment C showed the best feed responsibility and feed storage for up to ± 2.5 months. Fat analysis will be higher by increasing the percentage of maggot meal in the feed. It was concluded that the use of fish meal substitution with maggot meal up to 75% in feed can still be used for rearing snakehead fish

1 Introduction

Snakehead fish (*Channa striata* Blkr) is a marshy water fish with great economic worth and the potential to be developed. Snakehead fish is a "culture" for the Banjar tribe because it is used in various regional delicacies. [1] As a result, the demand for snakehead fish increases. Domestication efforts must be made because the ontology is so strong, in addition to its role as one of the most effective interior wound treatments because of its high albumin content. [2]. So far, all marketed snakehead fish come from nature, and the population is starting to decline. Snakehead fish farming is cannibalistic nature and the hatchery response to feed is still low, resulting in substantial mortality. [3],[4]. Snakehead fish are carnivorous fish that require higher animal protein feed than herbivorous and omnivorous fish. The fulfillment of amino acids needed by fish for growth and reproduction, where the addition

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of casein in snakehead fish feed at 450 g/kg resulted in the best performance on growth parameters, larval length, fecundity, hatchability, and egg diameter. To handle snakehead fish seeds in aquaculture containers, the quality of feed that is by the nutritional needs of the developmental stage, eating habits, and nutritional content can be an effort to solve the problem.

The snakehead fish feed formula relies on the fish meal as the main protein source due to its high protein content and complete essential amino acid content. Today, one of the challenges in making artificial feed a source of animal protein is the imported raw material commodity for fish meal. Indonesia imported 221,564 tons of fish feed raw materials in 2016. [5] Availability of fish meal in the market the quality is very fluctuating and the price is also very varied. Therefore, an alternative source of animal protein feed is needed to replace fish meal. [6-8]. The inclusion of maggot as an animal protein component in the formulated feed is an attempt to lower the amount of fish meal used in the feed while preserving its nutritional quality. However, few experiments have been carried out to develop carnivorous fish feed, particularly snakeheads, from locally available raw materials. The purpose of this study is to determine the amount and impact of the substitution of fish meal with maggot meal (*Hermetia illucens*) in snakehead fish diet on growth performance.

2 Material and methode

2.1. Time and location

This research took 8 months to complete the tools and the preparation of the report. For maintenance and feed formulation, it is located at Argo Wisata Kampung Iwak, Mentaos district, Banjarbaru City, South Kalimantan Province, and the Nutrition Laboratory of the Faculty of Fisheries and Marine Affairs, Lambung Mangkurat University, Banjarbaru.

2.2 Research procedures

The test fish weighed 18.17 0.76 grams and measured 13.42 0.75 cm in length. The fish were then separated into 20 units of 1 x 1 m biofloc pond containers. Preparation of feed raw materials. The first step in making test feed is to prepare feed ingredients. Fish meal and maggot meal are used as a source of animal protein, soybean meal is used as a source of vegetable protein, bran meal is used as a carbohydrate source, fish oil is used as a source of fat, sago meal is used as an adhesive, a mineral mixture is used as a mineral source, and a vitamin mixture is used. as a source of vitamins. Using a grinder, all raw components are ground into fine meal. (composition of ingredients mentioned in Table 1) All ingredients are mixed and then molded using a meat grinder and then dried using direct sunlight or using an oven at 50 C for approximately 48 hours. The maggot drying process is carried out by utilizing an oven with a temperature of 50 C for 7 hours or fresh maggot is completely dry. The maggot refining process is carried out by utilizing maggot that has been dried, then ground until the maggot is smooth and turns into meal. After 60 days of therapy, the survival rates, relative length growth, and relative weight of snakehead fish were all measured. Feeding took place four times a day at a rate of 5% of the snakehead fish's body weight. Sampling was done on the 15th, 30th, 45th, and 60th days, which included counting the number of fish and measuring their length and biomass.

2.3 Experimental design

This study used a completely randomized design (CRD) with 4 treatments and 3 replications. The treatments were the substitution of fish meal with different doses of maggot meal, namely Treatment A (100% fish meal), B (75% fish meal + 25% maggot meal), C (50% fish meal + 50% maggot meal), D (25% Fish Meal + 75% Maggot Meal). The test feed formulations can be seen in Table 1. Tes feed is formulated using computerized calculations so that isoenergy and isoprote

Table 1. Test feed formulation with around 40% protein content.

Raw material type	Ingredients composition (% Per Kg)			
	A (0%)	B (25%)	C (50%)	D (75%)
Fish meal	54	36	27	18
Maggot Meal	-	18	27	36
Soybean Meal	20	20	20	20
Bran Meal	14	14	14	14
Sago meal	10	10	10	10
Fish oil	1	1	1	1
Vitamin Mineral Mix	1	1	1	1

3 Result

3.1 Survival rate

The survival rate of the snake fish over 60 days of maintenance is shown in Table 2 below.

Table 2. Average percentage of survival value of snakehead fish

Treatment	Snakehead fish survival average			
	A	B	C	D
Day 15	96.67 ± 2.89^a	93.33 ± 2.89^a	$100,00 \pm 0.00^a$	98.33 ± 2.89^a
Day 30	93.33 ± 2.89^a	93.33 ± 2.89^a	$95,00 \pm 0.00^a$	$95,00 \pm 0.00^a$
Day 45	$90,00 \pm 5.00^a$	$90,00 \pm 0.00^a$	$95,00 \pm 0.00^a$	$95,00 \pm 0.00^a$
Day 60	86.67 ± 2.89^a	88.75 ± 2.89^a	91.67 ± 2.89^a	$90,00 \pm 0.00^a$

Anova survival results show no differences between treatment values in response to differences in feed composition given.

3.2 Relative Weight

The increase in length, weight, or volume through time is referred to as growth. Real signs of growth include changes in the number or size of cells that build up body tissues over time. Energy growth is measured by changes in the total energy level of the body over time. The use of maggot meal as a partial replacement for fish meal animal protein should not influence the relative weight growth of snakehead fish. (Table 3).

Table 3. Average relative weight of snakehead fish.

Treatment	Average relative length of snakehead fish			
	A	B	C	D
Day 15	9.76±0.71[a]	10.88±1.93 [a]	9.76±2.90[a]	10.79±1.90[a]
Day 30	20.02±1.54[a]	20.24±2.14 [a]	23.85±9.63[a]	20.90±1.67[a]
Day 45	31.54±2.10[a]	32.83±3.79 [a]	30.16±4.14 [a]	31.73±1.34[a]
Day 60	42.05±0.49[a]	42.76±3.97 [a]	39.86±4.68 [a]	42.29±1.87[a]

3.3 Relative length

The ANOVA test of relative length revealed that replacing up to 75% of fish meal with maggot meal had no statistically significant difference when compared to using 100% fish meal. (Table 4).

Table 4. Average relative length treatment of snakehead fish

Treatment	**Average relative length of snakehead fish**			
	A	**B**	**C**	**D**
Day 15	9.76±0.71[a]	10.88±1.93 [a]	9.76±2.90 [a]	10.79±1.90 [a]
Day 30	20.02±1.54 [a]	20.24±2.14 [a]	23.85±9.63 [a]	20.90±1.67 [a]
Day 45	31.54±2.10 [a]	32.83±3.79 [a]	30.16±4.14 [a]	31.73±1.34 [a]
Day 60	42.05±0.49 [a]	42.76±3.97 [a]	39.86±4.68 [a]	42.29±1.87 [a]

3.4 Feed physical test

The results of the physical test observations of feed include breaking speed, homogeneity level, sinking speed, allure and shelf life (Table 5).

Table 5. Average physical test value of feed treatment

Treatment	**CF***	**A**	**B**	**C**	**D**
Breaking Speed (Hours)	>24	>24	>24	>24	>24
Homogeneity Level (gr)	4	4	4	4	4
Sink Speed (seconds)	36 hours	4.02	25.25	12.01	4.47
Allure (seconds)	>4	>4	>4	4	>4
Storability (Months)	>6	±1.5	±1.5	±2.5	±2.5

CF*= Commercial Feed

3.5 Feed chemistry test

The results of the observation of feed chemistry tests/proximate analysis are shown in Table 6 below

Table 6. Chemical test of feed treatment

Analysis parameters	**A**	**B**	**C**	**D**
Water content (%)	12.45 ± 0.01	12.54 ± 0.03	12.46 ± 0.02	13.82 ± 0.03
BK Level (%)	87.55 ± 0.01	87.46 ± 0.01	87.54 ± 0.02	86.18 ± 0.03
Ash Content (%)	17.11 ± 0.02	16.99 ± 0.03	14.51 ± 0.02	13.82 ± 0.02
Protein Content (%)	30.36 ± 0.01	29.55 ± 0.03	29.16 ± 0.03	29.15 ± 0.01
Fat level (%)	7.82 ± 0.02	9.57 ± 0.01	12.14 ± 0.01	12.18 ± 0.03
Crude fiber content (%)	6.25 ± 0.02	7.40 ± 0.02	8.34 ± 0.02	8.37 ± 0.01

3.6. Water quality

The temperature in all treatments ranged from 26-28°C. The temperature range can be stated as good to support the growth of snakehead fish were kept, which was at 25.5-30°C [18].

Table 7. Data on water quality measurement results

No.	Parameter	Average Initial	Average value during experiment	Comparative literature
1.	Temperature(°C)	26.7 ± 0.01	28.6 ± 0.01	25.5-30.7
2.	DO mg/l	3.53 ± 0.01	3.06 ± 0.01	2-3,7 mg/L
3.	pH	6.90 ± 0.02	8.58 ± 0.02	4 - 9
4.	NH3 (mg/l)	0.30 ± 0.02	1.58 ± 0.02	< 1 mg/L

4 Disscusion

Snakehead fish fed maggot (treatment B; C and D) had a better survival rate than those not (treatment A). Although the ANOVA statistical test showed no significant difference between the treatments. The superior survival rates in treatments B, C and D with the addition of maggot indicated that maggot flour increased the nutritional content of the treated feed and made it more adaptable to the environment. Fish development is influenced by internal characteristics such as sex, genetics, age, reproduction, and disease resistance, and external characteristics such as water quality, stocking density, and the number and composition of complete amino acids in the feed.

The results showed that replacing maggot flour with fish meal had a significant effect (Figure 1). The ANOVA statistical test showed no significant difference between any treatments, but it did indicate that maggot flour could be utilized up to 75 percent of replacing fish meal in feed. The addition of maggot flour to fish feed changes the amino acid composition and increases energy supplies due to the high essential fat contained in maggot. So that the growth rate can be accelerated because protein is used for growth while energy is supported by fat in the feed.

The increase in body length is related to bone growth, which is related to the availability of minerals (calcium and phosphorus) and amino acids. Minerals in feed can be found in large amounts in the raw materials used to make feed, such as mineral mixtures, maggot meal, and fish meal. The use of two protein sources will improve the quality of nutrition and growth because the amino acid content complements each other. However, it should be noted that combining both protein sources will alter the content and balance of amino acids, which can damage fish growth if used in excess.

Based on the results of the breakdown speed test in all treatments, it was known that the feed could survive in the water for more than 24 hours. The rate of break down speed is a major consideration in fish feed formulations. Artificial feed with a low break down speed causes the feed to be easily crushed and scattered so that it cannot be eaten by fish. Thus the feed has a very high stability compared to the general needs of fish feed. In general, the stability or break down speed ranges from 3 to 5 hours [11]. Several factors affect the stability of feed in the water, such as the tenderness of feed raw materials and the process of mixing ingredients in the feed production process, where the finer the feed ingredients, the better the feed produced. The feed ingredients are mixed evenly to produce a product that is more compact and stable in water [12]. Artificial feed that has good quality cannot be separated from the process of mixing feed ingredients. To obtain homogeneous raw materials in the feed, the mixing stage must be carried out as well as possible. Simply mixing can be done by hand, while in large quantities can use a mixer that uses electrical energy.

The allure of snakehead fish to the highest test feed was shown in treatment C (50% Fish Meal + 50% Maggot Flour), the feed given was directly approached and eaten in seconds (±4 seconds), these was caused by testing the feed containing these ingredients. Ingredients that provide strong succulent strength and the right combination of fishmeal and maggot aromas. Fish meal and maggot flour used as raw materials in the test feed had good quality so that they emitted a sharp aroma and were liked by fish, while other treatments showed a longer response to fish approaching the treatment feed. The shelf life of feed in each treatment has a different length of time, where treatment C substitution of maggot flour to fish meal by 50% can increase a longer shelf life compared to substitution of maggot flour to fish meal <50% feed (Table 5).

Protein plays an important role in fish growth because fish growth depends on protein quality. In addition, protein is also the main source of energy in fish. If protein requirements are not met in the diet, there will be a drastic reduction or cessation of growth or weight loss because the fish will pull back protein from some tissues to maintain more vital tissue functions. Based on the literature, it was found that the optimum protein content for fish is 25-50% when compared with the results of protein analysis in the test feed, the protein content ranges from 29.15% - 30.36%, which means that it has the optimum protein content for fish, which is 25-50. %. 50% (Table 6).

Fat is the main source of energy in feed so that protein can be optimally used for fish growth and survival. A good feed generally contains 4 – 18% fat. The optimal fat content in supporting, fish growth is 2.57%. The fat content in the test feed ranged from 7.82% - 12.18%, so the fat content in the feed could be said to be in the good category. Total ash is defined as the residue produced in the combustion process of organic matter, in the form of inorganic compounds in the form of oxides, salts, and minerals. The total ash contained in a product is limited in number. The ash content in the feed represents the mineral content of the feed, the appropriate level is 3-7% [15]. The ash content in the test feed ranged from 13.82% - 17.11%. This indicates a very high ash content, not suitable for fish needs because it has excessive mineral content. Crude fiber is part of carbohydrates that cannot be digested and is not an important nutrient for marine fish. Crude fiber will cause impurities in the culture container, but it is still needed to facilitate expulsion of feces. Too much crude fiber (> 10%) will result in decreased digestibility, decreased absorption, increased metabolic waste, and decreased culture water quality. In tilapia, the optimal crude fiber content to support fish growth is 4-8%. When compared with the literature, the test feed has a crude fiber content that is in accordance with the needs of fish. Fish feed that is good for fish is feed that contains nutrients (protein, fat, ash, water, and crude fiber) that are balanced and in accordance with the needs of the fish.

Dissolved oxygen (DO) is one of the limiting factors. If its availability in water is not sufficient for the needs of cultivated biota, all biota activities will be hampered [19]. The results of DO measurements in each treatment were still at the value required by snakehead fish fry of around 3 mg/L (Table 7). The dissolved oxygen content for the treatment of snakehead fish ranges from 2.0 to 3.7 mg/L [20]. Dissolved oxygen is good for the cultivation of snakehead fish which is in the range of 3–6 mg, fish with additional breathing apparatus can live in water with a low dissolved oxygen content of up to 2 mg/L [19]. Snakehead fish have additional breathing apparatus (diverticula) so they snakehead fish can take oxygen directly from the air. Degree of Acidity (pH) stands for negative Puissance of de H is a theory used to explain the properties of compounds in water. The pH range during the study ranged from 6-to 8. Snakehead fish will experience optimal growth at pH values between 4-9 [21]. So it can be concluded that the pH contained in the rearing container is still normal for water (Table 7). A good pH range for the growth of snakehead fish is 4–9 [19]. Furthermore, water that has a pH below 4 and above 11 it can cause death for fish [22]. So it can be concluded that the pH contained in the rearing container is still normal for water (Table 7). Ammonia (NH3) in water comes from aquaculture waste resulting from the activities of micro-organisms in the decay of organic matter or feed that is rich in nitrogen (protein). An increase in ammonia in the water will reduce the excretion of ammonia by fish so that ammonia in the blood and tissues increases. Ammonia also causes the rate of oxygen consumption by tissues to increase, gill damage occurs, reduces the ability of blood to bind oxygen, and death for fish [23]. Ammonia content during the study ranged from 0.3 to 1.88 mg/L. Ammonia levels that are still below 1 mg/L can be tolerated by fish [24]. At the beginning of treatment, the ammonia content was normal and increased in the middle of the until the end of the study (Table 7). The increase in ammonia levels is closely related to the entry of organic matter (protein) which is easily decomposed in the water. Sources of ammonia in water can come from organic materials (protein and urea), feces, and the excretion of aquatic biota as waste from metabolic activities [25]. Refers to government regulation about water quality standards. No. 82 of 2001 (Class II) that the maximum limit of ammonia for fishery activities is less than 0.02 mg/l.

5 Conclusion

Based on the results of the study, it was concluded that the substitution of maggot flour on the growth of snakehead fish was able to maintain survival up to >90%, and increase absolute and relative weight, as well as length growth. The percentage of 75 percent substitution of fish meal with maggot flour can be used for the maintenance of snakehead fish fry, with recommendations on treatment C (50% fish meal + 50% maggot flour) which can increase the attractiveness of fish to feed, shelf life of up to ±2.5 months.

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