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The Effect of Maggot Meal as Fish Meal Substitute on Milkfish (*Chanos chanos* Forsskal) Growth and Survival Rate

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Abstract. As one of the ten leading aquaculture commodities in Indonesia. The high demand for milkfish (Chanos chanos Forsskal) certainly requires a new alternative to fulfill feed ingredients in milkfish cultivation. Currently, the fish meal comes from imports and is quite expensive, despite being the main source of protein for farmed fish. Therefore, an alternative to the fish meal is needed to reduce production costs. One of them is maggot meal which has high availability and high protein. This study aims to examine maggot meal as fish meal substitutes effects on milkfish's (Chanos chanos Forsskal) growth and survival. This study utilized the experimental method, using a Completely Randomized Design (CRD), and analyzed with ANOVA. The difference in treatment lies in the difference in the percentage of fish and maggot meal as the substitutes, divided into five treatments of 0%, 25%, 50%, 75%, and 100%. The parameters being observed include absolute weight gain, survival rate, and specific weight growth rate. The results illustrate highest average absolute weight growth was recorded in 0% maggot meal substitution, and the highest daily specific weight growth rate was in the treatment of substitution with 0% maggot meal. The greatest survival rate, there is a substitution of 25% maggot meal. ANOVA results illustrated no significant effect ($P<0.05$) on the growth of total weight, the growth rate of specific weight, and the milkfish (Chanos chanos Forsskal) survival rate from the maggot meal substitutes.

Keywords: Growth, Maggot Meal, Milkfish (Chanos chanos Forsskal), Substitution, Survival Rate

1 Introduction

Milkfish (*Chanos chanos* Forsskal) is one of the ten leading aquaculture commodities in Indonesia. In 2020, based on statistics from the Indonesian Ministry of Maritime Affairs and Fisheries, milkfish production reached 811.883 tons. Milkfish is also a major commodity in several provinces in Indonesia such as West, Central, and East Java and South and Southeast Sulawesi. Statistics from the aforementioned ministry showed that in 2020, South Sulawesi is the largest milkfish cultivating area, which will be able to produce 193.765,78 tons of milkfish with a value of up to 3.708.895.406,00 IDR [1].

The milkfish's high demand for general consumption, the skipjack tuna industry's bait flesh, as well as for the export market, certainly requires a new alternative to fulfill feed ingredients in milkfish aquaculture. This is because feed is important in aquaculture to increase fish growth. Fish meal, despite its importance as the main protein source for farmed fish, comes from imports [2][3][4] and is quite expensive, so an alternative to a fish meal is needed to reduce production costs. In intensive aquaculture activities, the feed has an important role in increasing production, where the cost of purchasing feed contributes around 70% of the total production costs [5]. The feed raw material's price will have a consequence on the feed price, which later will affect production costs.

Local fishmeal production can only meet 60–70% of the demand with actively fluctuating quality and quantity [6][7]. Therefore, an in-depth research is needed on various alternative raw materials to replace fish meals such as maggot meals. Several alternatives to replace fish meal in fish feed other than maggot meal that has been researched include spirulina meal [8], earthworm meal [9], seaweed meal [10], tofu dregs [11], Moringa leaves [12], *Pomacea canaliculate* L. [13], sago larvae [14], and soybean meals [15]. For the maggot itself, the current development of maggot cultivation in Indonesia is very rapid. This is because maggot cultivation does not require water, electricity, simple infrastructure, and chemicals. And for nutritional content, maggot has been proven to be high [16]. These characteristics are by following the requirements for raw materials that can be used as feed

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ingredients, which have high nutritional value, are available in abundant and sustainable quantities, do not compete with human needs, and are economically quite cheap [5].

Maggot meal utilization as fish meal's protein source substitute has been studied by several researchers on aquaculture commodities, especially in freshwater aquaculture such as freshwater pomfret [17], bauble fish [18], Nirwana tilapia [19], and catfish [20]. Based on the results of these studies it appears that maggot meal is possible to be utilized as a substitute for fish meal, especially in freshwater fish farming. Research by [21], took light on maggot flour usage in milkfish farming but focuses on nutrient retention, body composition, and milkfish feed efficiency. Therefore, it is important to study maggot flour usage effects on milkfish growth and survival aspects.

2 Research Method

The main text should be written using Times New Roman, 10pt, fully justified, first line in each paragraph should be 0.75 cm from left margin. Italics can be used for emphasis and bold typeset should be avoided.

Article must follow IMRAD Structure, and what content should put in each section see information below:

Example article titled "Exploring the Impact of Social Media on Modern Society," was published in SAGA Journal and follows the IMRAD structure, consisting of an Introduction, Methodology, Results and Discussion, Acknowledgements, and Conflict of Interest.

In the Introduction, the authors provide background on the topic of social media and its increasing prevalence in modern society. They outline the research question and objectives of their study and describe the significance of their work.

The Methodology section details the research design, sample size and selection, data collection methods, and analysis techniques used in the study. The Results and Discussion section presents the findings of the study and discusses their implications in the context of previous research on the topic.

The Acknowledgements section acknowledges the contributions of any individuals or organizations that assisted in the research and publication of the article. The Conflict of Interest section declares any potential conflicts of interest that the authors may have had in conducting and publishing the research.

2.1 Research Material

The material of this research is milkfish that initially weights around 0.84-0.87 g/fish. The selected fish were then distributed into 15 aquariums with the size 50 x 40 x 35 cm and designed with a recirculation system. The density of each aquarium was 15 individuals/45 liters of water with a salinity of 4-5 ppt.

2.2 Research Design

This research utilized the experimental method, using a Completely Randomized Design (CRD), divided into 5 treatments, with each treatment subjected to 3 replications. The treatment that was tried was the rate of fish meal substitutes with maggot flour are as follows: Treatment A with 0%, Treatment B with 25%, Treatment C with 50%, Treatment D with 75%, and Treatment E with 100%. The observed parameters were absolute weight growth, specific growth rate (SGR), and survival rate (SR).

2.3 Work Procedure

The initial stage is the preparation of the test feed which begins with preparing raw materials consisting of imported fish meal, soy flour, and maggot flour as a protein source, wheat flour, and refined bran as a carbohydrate source, fish oil as a fat source, vitamin mix as vitamins source, and minerals mix as a mineral source. Furthermore, the dry feed ingredients are sifted first so that very fine feed ingredients are obtained. Then weigh all the ingredients needed according to Table 1 and place them in a plastic bag and mix thoroughly. Then add oil, vitamins, and minerals to the dry ingredient mixture, then add warm water to the mixture. Stir the feed mixture until it doesn't stick to your hands. The dough is put into the feed printer and printed to become pellets. Pellet-shaped feed is spread regularly on trays. Then drying the feed to dry. Dry feed is stored in plastic bags that have been labeled and stored in a dry place.

Before the feed is given continuously, the fish is first adapted to the test feed consisting of 100% fish meal for seven days with a thrice-a-day feeding frequency. This adaptation aims to prevent the test animals from getting stressed when given new food and to accustom the test animals to the new artificial feed so that later the test animals will be in normal conditions when the research takes place. After the adaptation stage, the test animals fasted for 1 day to avoid the effects of feeding 100% fish meal during the adaptation process, and the test animals were weighed to determine test animals' initial weight.

A sampling of test animals is done every ten days by sampling all the test fish in each treatment. In this process, the weight and survival of the test animals were measured. Water quality parameters, namely temperature, and salinity were measured every day. Then the parameters of dissolved oxygen, pH, and ammonia, measurements were carried out at the beginning of the study, then once every ten days before changing the water. Every ten days at the time of sampling, 80% of the water was changed.

Absolute weight growth was measured based on the test animals' weight, both at the beginning and the end of the study, which was formulated as follows [22]:

$$W\ (g) = W_t - W_0 \qquad (1)$$

Where:
W = Growth in absolute weight (g)
W_t = Weight at study's end (g)
W_o = Weight at study's beginning (g)

This study will also be taking the study from [22] on the formula to determine specific weight growth rates.

$$SGR = \frac{L_n\, W_t - L_n\, W_o}{t} \times 100 \qquad (2)$$

Where:
SGR = daily specific weight growth (g/day)
W_t = individual weight at study's end (g)
W_o = individual weight at the study's beginning (g)
t = length of maintenance (days)

Test animals' survival rate was measured based on the population of test animals at the beginning and the end of the study, which was formulated as follows [22]:

$$SR = \frac{N_t}{N_o} x100 \qquad (3)$$

Where:
SR = Survival rate (%)
N_t = Number of milkfish that lived at the study's end (fish)
N_o = Number of milkfish at the study's beginning (fish)

2.4 Analysis Data

The effect of maggot flour as fish meal substitute in the milkfish was determined by Analysis of Variance (ANOVA) through the SPSS program. The significance of the analysis of variance was carried out by comparing the F count and F table at the 5% level test. If the results of the ANOVA test have a significant effect ($p < 0.05$), the effect of this significant difference in treatment need to be analyzed further through post hoc tests.

3 Result and Discussion

3.1 Milkfish Growth

Measurement of the weight growth of the test animals was carried out every ten days with a study time of two months. Based on Table 2, the average individual absolute weight growth value and the highest daily specific weight growth rate were in the treatment at the fish meat substitution level of 0% maggot, although when compared with other treatments the difference in value was not too great.

The ANOVA results showed no significant effect ($p > 0.05$) both on the absolute growth and the growth rate of the daily specific weight of milkfish from the level of substitution of fish meal and maggot. This illustrates that the substitution of fish meal and maggot produces the same growth without substituting the meal with maggot flour. The possible cause is the given maggot feed's nutritional content in the form of carbohydrates, protein, and fat according to the milkfish's needs. This study's results are similar to the ones conducted by [20] who tested the addition of maggot flour to catfish feed on the growth in weight of catfish with insignificantly different results between treatments. Unlike the research by [23], where the results of maggot flour substitution showed a significant effect on the growth of both absolute length and weight in sangkuriang catfish (*Clarias* sp.). [6] also conducted a similar study that tested the Balashark fish (*Balanthiocheilus melanopterus* Bleeker) which showed a significant effect of maggot flour substitute of maggot flour on the Balashark fish weight growth. The difference in the results of the effect of magot flour substitution is probably caused by differences in the nutritional needs

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needed by catfish, Balashark, and milkfish. In addition, the composition of the feed ingredients used is also different so the nutritional content of the feed used is also different.

Table 1. Milkfish's (*C. chanos* Forsskal) absolute individual growth and average daily specific weight growth rate during the study.

Fish Meal and Maggot Substitution Rate (%)	Average individual absolute weight growth (g)	Daily Specific Weight Growth Rate (%/day)
0	1,71 ± 0,56[a]	2,72 ± 0,55 [a]
25	1,44 ± 0,35[a]	2,45 ± 0,36 [a]
50	1,58 ± 0,42[a]	2,56 ± 0,45 [a]
75	1,40 ± 0,47[a]	2,38 ± 0,55 [a]
100	1,61 ± 0,34[a]	2,65 ± 0,34 [a]

Note: [a]=no significant effect at the 5% level ($p>0.05$)

[24] stated that apart from fat and carbohydrates, a significant energy source for fish is feed's protein content. According to Boonyaratpalin (1997), the ideal feed fish must have complete nutrition including 25-35% protein, 8.5% fat, 7-10% carbohydrates, and 25% vitamins, and based on [21], the need for protein in feed for the growth of milkfish ranges from 30-40%. Following this opinion, the feed's protein content in this study was by the requirements, which ranged from 31.20 to 35.21%. Fat is usually added to artificial feed, the addition of this fat in addition to adding nutritional value can also function as a source of energy for the feed and prevent the feed from breaking [25]. According to [26], fish need around 4-16% fat in their feed. Table 4 shows feed's fat content is still within the range of fish needs, i.e 5.28-11.42% where the highest fat content is found in the 100% substitution level. The crude fiber of each level of substitution is relatively the same. The substitution level 0%, 25%, 50%, 75%, and 100% respectively contain 5.47%, 5.83%, 5.58%, 5.96%, and 6.62% of crude fiber. The ideal crude fiber content in the feed according to [27], is no more than 21% because if it is too high, it can interfere with digestion and absorption in the fish digestive system. The content of BETN in the substitution level 0%, 25%, 50%, 75%, and 100% was 41.52%, 42.74%, 42.74%, 43.75%, and 44.11%. This value fulfills the need for carbohydrates for milkfish where [28] states that herbivorous fish require up to 50% carbohydrates in their feed. Herbivorous fish are capable of producing the enzyme amylase (breaking down carbohydrates) throughout their digestive tract. Therefore, herbivorous fish are more capable and more efficient at utilizing carbohydrates [28].

3.2 Survival rate

The average survival rate for milkfish (*C. chanos* Forskal) juveniles fed fish meal and maggot substitutes is presented in Table 2., which showed that 25% substitution of maggot flour showed the highest survival rate, i.e 97.78 %, and the lowest at 0% maggot flour substitution, i.e 73.33 %. The average survival rate for milkfish juveniles at the end of the study ranged from 73.33–97.78%. This result shows a high percentage of milkfish juvenile survival in all treatments during the study. These results are also consistent with [29] statement that the good category of survival rate (SR) is when the SR value is more than 70%. This value is almost the same as the research of [10] who obtained a milkfish survival rate of 78-83%. The high survival rate of milkfish juveniles produced in this study probably comes from the feed's nutritional contents, which are protein, carbohydrates, and energy needed by milkfish. Therefore, the juvenile's need for energy can be fulfilled and increasing survival possibilities. In addition, milkfish can be cultivated at high densities and responsive to artificial feed. Another reason for the high survival rate of milkfish juveniles is the sufficient dose of feed so that the fish's need for feed (energy) is met. With the availability of energy, fish continue to exist to maintain their survival.

Table 2. The survival rate of milkfish (*C. chanos* Forsskal)

Treatment (%)	Survival (%)
0	73,33 ± 6,66[a]
25	97,78 ± 3,85[a]
50	91,11 ± 15,39[a]
75	95,56 ± 7,70[a]
100	93,33 ± 11,55[a]

Note: [a]= no significant effect at the 5% level ($p>0.05$)

The ANOVA statistical analysis showed an insignificant effect on milkfish survival from the level of substitution of fish meal and maggot ($p>0.05$). This result reflects the study of [30][20] who conducted a similar study on catfish feed, which showed no significant effect. [10] who conducted a study on adding seaweed flour to milkfish feed also showed no significant effect on milkfish survival. [31] also conducted the same research as this study but with different sizes of milkfish and showed results that had no significant effect. This result shows that the substitution or addition of alternative flour to replace fish meal in cultivated fish does not affect the survival rate of these fish so it can be concluded that the feed given is feed that has good nutrition for milkfish. [32] state that good feed for fish has good nutrition that plays an essential role in maintaining the survival rate. The dead fish were probably caused by a lack of adaptation and stress during the study.

3.3 Water Quality

Optimal environmental conditions are necessary for the maximum survival and growth of milkfish. Several water quality parameters that influence include pH, dissolved oxygen, temperature, and ammonia. This is following the statement of [33] that the survival and growth level of cultivated aquatic organisms is also influenced by water quality.

Table 3. Water quality in research media

Parameter	Treatment				
	A	B	C	D	E
Suhu (˚C)	25-27	25-27	25-27	25-27	25-27
pH	6,62-8,42	6,69-8,42	6,73-8,42	6,76-8,42	6,80-8,42
DO (ppm)	4,2-5,0	4,8-5,0	3,5-5,0	4,5-5,0	3,8-5,0
NH_3 (ppm)	0,002-0,02	0,003-0,02	0,004-0,02	0,014-0,02	0,007-0,02

As one of the water quality parameters, water temperature is one of the important aspects in the survival of aquatic organisms. [34] supported the statement that reproduction, growth and development, and survival of milkfish (*C. chanos*) are affected by water temperature. Table 3 shows the temperature of the media obtained during the study ranging from 25-27 ˚C. This range is feasible for the maintenance and growth of milkfish and following [35] who stated that the optimum temperature for milkfish rearing ranges from 22-35˚C.

The next parameter is pH, where this parameter influences and determines the speed of metabolic reactions in consuming feed [36]. The level of acidity (pH) obtained during the study ranged from 6.62 to 8.42 and this range is feasible for milkfish. According to [37] [38] aquatic biota prefer a pH ranging from 7 to 8.5. The pH value also affects pond water's ammonia concentration. [39] stated that a lower pH value causes an increase in ammonia concentration and toxicity. As seen in Table 3, the ammonia content obtained during the study ranged from 0.002 to 0.020 ppm. This range is still feasible for the maintenance of milkfish and under the opinion of [35], in raising milkfish the ammonia content should not be more than 0.1 ppm. Otherwise, if the ammonia level is too high, it will damage the gill tissue.

The dissolved oxygen content obtained in this study ranged from 3.5 to 5.0 ppm. The low oxygen value is because the recirculation system has a weakness, namely organic matter originating from leftover feed, and feces is not removed from the system. But this problem can be solved with regular water changes and siphoning. However, according to [40], the dissolved oxygen content in the water for milkfish cultivation should not be less than 3 mg/l.

4 Conclusion

The research concludes that the utilization of maggot flour as a fish meal substitute did not have a significant effect on the growth rate of individual absolute weight and the growth rate of specific individual weight (SGR). Likewise, the survival (SR) of milkfish (*Chanos chanos* Forsskal) showed no real effect from the fish meal replacement.

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