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Utilization of Fish Waste Flour as a Substitute for Fish Meal on the Growth Rate and Survival of Catfish (*Clarias* sp.)

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Abstract

Catfish (*Clarias sp.*) is a type of fish that is relatively easy to cultivate and has relatively fast growth. The quality and quantity of raw materials used to make feed must be considered to enhance the development of catfish. One of the nutrients in the feed needed by catfish is protein. Catfish utilize protein for the growth process. One alternative protein source to fish meal is fish waste meal. Fish waste meal contains a protein content of 46.02% and has a lysine amino acid profile content of 3.68%. This research aims to determine the effect of substituting fish waste flour for fish flour in feed on the growth performance of catfish. This study employed an experimental method with a completely randomized design (CRD) consisting of 5 treatments and 3 replications. The treatments tested were treatment A (40% fish waste flour), B (30% fish waste flour), C (20% fish waste flour), D (10% fish waste flour), and E (0% fish waste flour). The test fish used were Sangkuriang catfish weighing 2.85-3.15 grams and stocking density of 10 per container. The catfish was reared in an aquarium with a water volume of 35 litres. Maintenance was carried out for 42 days with feeding three times a day at 08:00, 12:00, and 16:00. The research results indicate that substituting fish meal with fish waste flour significantly affects ($P<0.05$) TFC, FUE, FCR, SGR, and absolute weight. The best dose of fish meal substitution with fish waste flour is treatment B (30% substitution of fish waste flour), which can produce TPW of 191,61±1,910 grams; FUE of 61,74±0,441 % FCR of 1,62±0,012; SGR of 3,87±0,043% per day; and absolute weight of 11,98±0,193 grams.

Keywords: Catfish; Fish Waste Flour; Feed; Growth

1. Introduction

Catfish (*Clarias* sp.) is one of the freshwater fish commodities that is highly favored by the public. Catfish is widely cultivated because it is a type of fish that is relatively easy to farm and has a fast growth rate. This aligns with the statement of Anis and Diah (2019), who stated that catfish have advantages compared to other fish species, including fast growth, tolerance to poor water quality, and resistance to disease. Catfish can also be raised in almost any type of cultivation container (Abror *et al.*, 2021). Catfish is a freshwater species that has the advantage of being able to survive in poor water conditions. It is popular among the public due to its high protein content, delicious meat, and ease of cultivation. Therefore, catfish is a freshwater species whose productivity is continuously being increased due to market demand both domestically and internationally. The production output of catfish ranks at the top in fishery production. According to the Ministry of Marine Affairs and Fisheries (KKP), catfish production in Indonesia reached 1.06 million tons with a value of IDR 18.93 trillion in 2021.

One of the important factors in the effort to increase catfish production is feed. Feed is a crucial element in the cultivation process, from the seeding stage to the growing phase until the fish are ready to be harvested. Feed is a key component that can support the growth and survival of catfish. According to Anis and Dyah (2019), high-quality feed can enhance the growth and survival rate of fish during cultivation, leading to better production. Currently, fish farmers tend to use more commercially produced feed from factories. Over time, commercial feed from factories has become a problem for farmers due to the rising cost of commercial feed. This is in line with the statement by Muntafiah (2020), which states that the high price of commercial feed can account for up to 75% of the total costs required for freshwater fish farming. The high feed cost is due to the expensive raw materials used to make commercial feed, specifically fish meals. There is a need for alternative raw materials that are more economical to replace fish meal as the main ingredient in commercial fish feed. One alternative raw material that can be used is fish waste meal. Fish waste meal is a potential raw material because, in Indonesia, it has not been well utilized and is often simply discarded. According to Aryanti *et al.* (2020), fish waste can be effectively processed into meals to be used as a component in fish feed production. Yanuartono *et al.* (2020) state that fish waste meal contains 45-55% protein. In addition to being a source of protein and minerals, fish waste meal also has a high lysine amino acid content.

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Research using fish waste flour has previously been conducted on several marine and freshwater fish types. According to Manullang *et al.* (2019), a study on catfish (*Clarias* sp.) with formulation substituting 70% fishmeal protein with fish waste flour resulted in a daily growth performance of 0,32 gram/day and absolute weight growth of 18,9 gram. In Sopha *et al.*'s 2015) study optimal results were shown in the long-term feeding of common catfish (*Clarias* sp.) with 8% fish waste flour with a absolute weight growth of 12,04 grams and food conversion ratio of 1,42. Meanwhile, a study by Kader *et al.* (2011), a study on catfish (*Clarias* sp.) with formulating substituting 67% fish waste meal of SGR 4,1%, FCR 1,5, and PER 2,3.

2. Material and Methods

This research was conducted in March - April 2024 at Balai Benih Ikan Mijen, Semarang, Central Java. The nutritional content of the artificial feed can be seen in Table 1.

Table 1. Proximate Analysis of Test Feed

Treatment	Ash (%)	Lipid (%)	Fiber (%)	Protein (%)
A	8.25	7.28	3.19	39.56
B	9.54	8.08	3.40	39.80
C	9.16	6.98	3.69	38.06
D	9.26	6.19	3.19	36.83
E	8.25	7.28	2.99	39.43

Source: Animal and Agriculture Sciences Laboratory, Diponegoro University

2.1. Preaparation

Prepare research facilities, such as 10 fish per container in aquariums. Test animals were maintained for 28 days using a stagnant water system with added aeration

2.2. Commercial Feed Preparation

The feed production process begins with a proximate analysis of the flour ingredients needed. These ingredients include fish waste meal, fish meal, cornmeal, soybean meal, rice bran flour, and wheat flour. The results of the proximate analysis are then used in the formulation process in Table 2.

Table 2. Feed Formulation

	Feed Composition (g/100 g feed)				
	A (40%)	B (30%)	C (20%)	D (10%)	E (0%)
Soybean Meal Flour	9.30	8.30	7.40	6.30	5.40
Corn flour	2.00	2.00	3.30	4.20	6.00
Bran flour	3.80	4.60	5.20	5.00	5.20
Wheat flour	33.90	34.10	33.10	33.50	32.40
Fish meal	25.20	29.40	33.60	37.80	42.00
Fish waste meal	16.80	12.60	8.40	4.20	0.00
CMC	2.00	2.00	2.00	2.00	2.00
Fish oil	2.00	2.00	2.00	2.00	2.00
Corn oil	2.00	2.00	2.00	2.00	2.00
Vit-Min mix	3.00	3.00	3.00	3.00	3.00
TOTAL (%)	100.00	100.00	100.00	100.00	100.00
Protein (%)	32.27	32.26	32.26	32.25	32.26
NNFE (%)	31.67	31.53	31.51	32.16	32.51
Lipid (%)	11.11	11.08	10.96	10.94	10.82
En. (kkal/g)*	283.27	282.57	281.59	282.99	282.91
Ratio E/P**	8.78	8.76	8.73	8.78	8.77

Table 3**.** Proximate Analysis of Material Feed

	Component (%)				
	Protein	NNFE	Lipid	Fiber	Ash
Fish meal*	54.75	0.58	7.79	2.10	25.25
Fish waste meal**	46.02	12.17	28.39	4.88	4.38
Soybean meal flour***	44.51	31.66	2.42	4.41	7.55
Bran flour***	4.84	44.46	1.38	21.93	18.23
Wheat flour***	9.81	67.90	7.45	1.80	0.59
Corn flour***	7.38	75.36	1.50	0.50	0.59

The fish used in this research are Catfish (*Clarias* sp.) weighing 2,85 – 3,15 grams, with a stocking density of 10 fish per container in aquariums. Maintenance was carried out for 42 days, with feeding three times a day as a satiation method. Fish growth was sampled every seven days to determine growth.

2.3. Maintenance of Test Animals

Test animals were maintained for 28 days using a stagnant water system with added aeration. Water quality measured during the research included temperature, pH, and dissolved oxygen (DO). Water quality measurements were taken before feeding fish. The water quality measurement process was carried out twice in the morning and evening during research.

2.4. Experimental Design

The method used in this research was descriptive and experimental, using the Complete Randomized

Design (CRD). This study used a completely randomized design (CRD) with 5 treatments and 3 replicates with the ratio used in the treatment as follows:

Treatment A : Substitution of 40% fish waste meal and 60% fish meal
Treatment B : Substitution of 30% fish waste meal and 70% fish meal
Treatment C : Substitution of 20% fish waste meal and 80% fish meal
Treatment D : Substitution of 10% fish waste meal and 90% fish meal
Treatment E : Substitution of 0% fish waste meal and 100% fish meal

2.5. Research Parameter

Growth parameters, including absolute weight (AW), specific growth rate (SGR), total feed consumption (TFC), feed conversion ratio (FCR), and feed utilization efficiency (FUE), were calculated as follows (Tacon (1987); Effendie (1997); Weatherley (1972) and Zonneveld *et al.*, (1991).

TFC (g) = Initial Feed – Final Feed
FUE (%) = (Final Weight – Initial Weight) Total Feed^{-1} x 100
FCR = Total Feed (Final Weight – Initial Weight) $^{-1}$
AW (g) = Final Weight – Initial Weight
SGR (%/day) = (Ln Final Weight – Ln Initial Weight) maintenance time^{-1} x 100

2.6. Data Analysis

The statistical analysis of data obtained during the study was carried out using SPSS 23 and Microsoft Excel 2016. The data obtained were subjected to normality test and homogeneity test. If the data is normally distributed and homogeneous, then analysis of variance (ANOVA) is continued. Analysis of variance (ANOVA) was conducted to determine whether the treatment applied had an effect. Data were analyzed for variance (test) at the 95% confidence level. If the analysis of variance obtained significantly different results, then Duncan's multiple area test was conducted. Water quality data obtained were analyzed descriptively.

3. Results and Discussion

3.1. Results

3.1.1. Total Feed Consumption

The results of observations made during rearing showed that the highest total feed consumption was in treatment A and B (40% and 30% fish waste meal), and the lowest total feed consumption was in treatment E (0% fish waste meal). Based on the results of the analysis of variance (Anova), it shows that natural food treatments A (40% fish waste meal), B (30% fish waste meal), C (20% fish waste meal). D (10% fish waste meal), E (0% fish waste meal) have a significant effect ($P < 0.05$) on toral feed consumption of catfish.

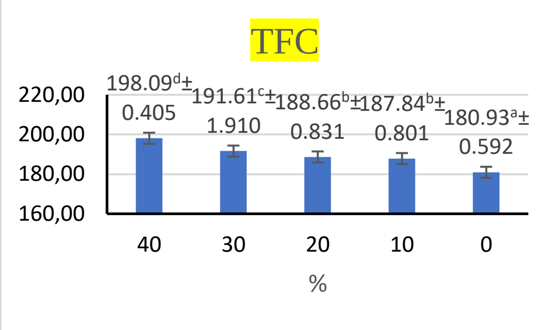

Figure 1. Feed Consumption

3.1.2. Feed Utilization Efficiency

The observations made during rearing showed that the highest feed utilization efficiency was in treatment A and B (40% and 30% fish waste meal), and the lowest was in treatment D (10% fish waste meal). Based on the results of the analysis of variance (Anova), it shows that natural food treatments A (40% fish waste meal), B (30% fish waste meal), C (20% fish waste meal). D (10% fish waste meal) and E (0% fish waste meal) have a significant effect ($P < 0.05$) on the feed utilization efficiency of catfish.

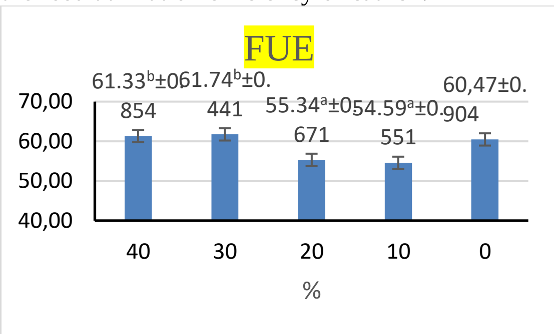

Figure 2. Feed Utilization Efficiency

3.1.3. Food Conversion Ratio

The results of observations made during rearing showed that the highest food conversion ratio was in treatment A and B (40% and 30% fish waste meal), and the lowest total food conversion ratio was in treatment D (10% fish waste meal). Based on the results of the analysis of variance (Anova), it shows that natural food treatments A (40% fish waste meal), B (30% fish waste meal), C (20% fish waste meal). D (10% fish waste meal), E (0% fish waste meal) have a significant effect ($P < 0.05$) on food conversion ratio of catfish.

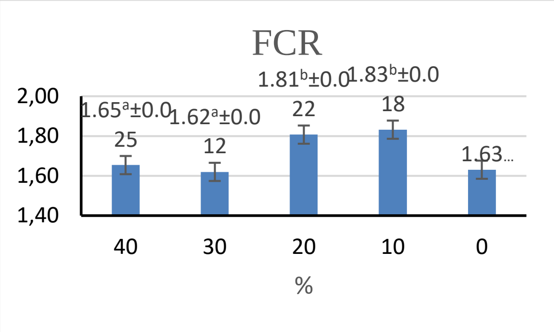

Figure 3. Food Conversion Ratio

3.1.4. Absolute Weight

The observations made during rearing showed that the highest absolute weight was in treatment A and B (40% and 30% fish waste meal), and the lowest total weight was in treatment D (10% fish waste meal). Based on the results of the analysis of variance (ANOVA), it shows that natural food treatments A (40% fish waste meal), B (30% fish waste meal), and C (20% fish waste meal). D (10% fish waste meal), E (0% fish waste meal) have a significant effect ($P < 0.05$) on absolute weight of catfish.

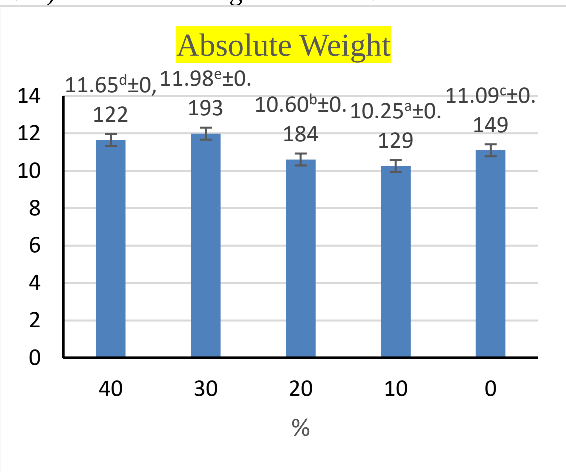

Figure 4. Absolute Weight

3.1.5. Spesific Growth Rate

The observations made during rearing showed that the highest specific growth rate was in treatment A and B (40% and 30% fish waste meal), and the lowest specific growth rate was in treatment D (10% fish waste meal). Based on the results of the analysis of variance (ANOVA), it shows that natural food treatments A (40% fish waste meal), B (30% fish waste meal), and C (20% fish waste meal). D (10% fish waste meal), E (0% fish waste meal) have a significant effect ($P < 0.05$) on specific growth rate of catfish.

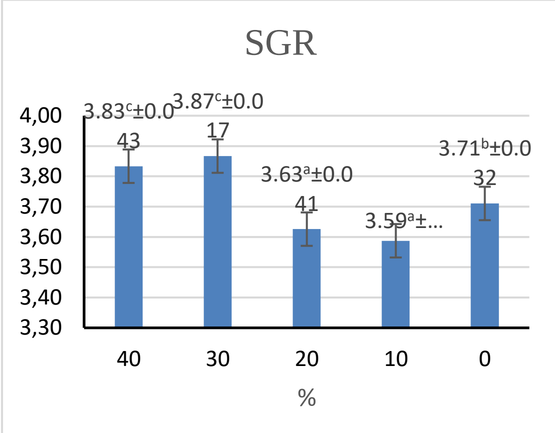

Figure 5. Spesific Growth Rate

3.1.6. Water Quality

Water quality parameters include temperature, pH and dissolved oxygen (DO). The results of water quality parameters in the maintenance of tilapia fish can be seen in the Table 3.

Table 3. Water Quality Values

Parameters	Result	Optimal Value*
Temperatur (oC)	28-29	25-30*
pH	7-8,1	6,5-8*
DO (mg/l)	4,8-5,5	>3*

*SNI (2014)

The results of water quality variables during research showed that values still in good condition for catfish. This is based on literature regarding due to optimal condition of water quality for catfish.

3.2.Discussion

3.2.1. Growth Performance

Based on the analysis of variance, the substitution of fishmeal with fish waste meal had a significant effect on total feed Consumption (TFC), feed utilization efficiency (FUE), feed conversion ratio (FCR), absolute weight gain, and specific growth rate (SGR). The highest results were obtained in the treatment with 30% fish waste meal (B), with values for total feed Consumption (TFC), feed utilization efficiency (FUE), feed conversion ratio (FCR), absolute weight gain, and specific growth rate (SGR) of 188.86±0.831 grams, 61.74±0.441%, 1.62±0.012, 11.98±0.193, and 3.87±0.043% per day, respectively. Growth is defined as the increase in weight, length, and size of catfish fingerlings. Wijaya *et al.* (2018) stated that feed is an essential factor in supporting fish growth performance, and insufficient feed can disrupt fish growth. Based on the results of this study, the best treatment was found to be the 30% fish waste meal (B) treatment due to its high TFC and FUE values and low FCR value. The 30% fish waste meal (B) treatment achieved the highest values because it had a feed palatability preferred by the fish. The feed in the 30% fish waste meal (B) treatment had an aroma, taste, and texture that was liked by the fish. The feed in the 30%

(B) treatment had a more pleasant aroma and remained floating longer, making it more effective for fish consumption. The nutritional content of the 30% fish waste meal (B) substitution feed, which contains 39.80% protein, also supported the utilization of this feed.

Total feed consumption is usually directly proportional to the increase in fish length. Fish can respond well to feed due to its palatability, which includes aroma, taste, and texture preferred by the fish. The highest total feed consumption was observed in the treatment with 40% fish waste meal (A), with a total feed consumption of 198.09 grams. This is because the aroma produced by the 40% fish waste meal (A) treatment is more stimulating to the fish, making them more inclined to eat it than other feeds. The feed resulting from the 40% fish waste meal (A) treatment has a more appealing and distinctive taste and aroma than other treatments, making it more favored by the fish. This is supported by Islama *et al.* (2020), who stated that feed with a distinctive and fish-preferred aroma is considered high-quality feed. This is further reinforced by Manganang and Numisye (2019), who noted that high feed consumption is usually accompanied by texture and aroma that attract fish to eat. The strategy or method of feeding can influence total feed consumption. The at-satiation method was used to minimize wasted feed during the research. Good fish growth is significantly influenced by how well the fish can maximize the feed for their development. According to Subandiyono *et al.* (2018), the energy needs for physiological activities in fish must be met by carbohydrates and fats to efficiently utilise protein for growth.

A high feed utilization efficiency (FUE) value indicates that the fish can maximally utilize the feed provided for their growth. Conversely, a low feed efficiency value suggests that the fish cannot optimally use the feed provided to support their growth. The fish's ability to digest the feed, along with the nutritional quality of the feed, greatly determines the feed efficiency value. The highest FUE value was found in the treatment with 30% fish waste meal (B) at 61.74%, while the lowest FUE value was in the treatment with 10% fish waste meal (D) at 55.34%. The best growth was observed in the treatment with 30% fish waste meal (B). The feed utilization efficiency can be considered good if the value is above 50% (Craig *et al.*, 2017). This is likely because the feed provided met the nutritional needs of catfish, allowing it to be well utilized by the fish. According to Sebayang *et al.* (2020), the protein requirement for catfish is 30-36%. In addition to its palatability, fish waste meal also has a high pepsin digestibility value. According to Tatuhe *et al.* (2022), fish waste meal has a high pepsin digestibility value of 85%. This high digestibility helps fish maximize feed utilization. Feed efficiency can also be used as a benchmark for feed quality. If the feed efficiency value is high, the feed quality is good. Conversely, if the feed efficiency value is low, the feed quality is likely poor. According to Fahrudin *et al.* (2020), a low EPP value indicates that the fish require more feed to increase their weight, thus increasing the overall feed requirement. This aligns with the statement by Murtini *et al.* (2022). High-quality fish feed can efficiently promote fish growth with minimal waste. According to Herawati *et al.* (2020), the factors of absorption and digestion of feed by fish efficiently depend on the quality of the nutrient sources in the feed. The feed utilization efficiency value is always inversely proportional to the feed conversion ratio (FCR) value. According to Abdel-Warith *et al.* (2020), FCR can be reduced with feed containing high protein and adding amino acid supplements. The higher the EPP value, the lower the feed conversion ratio.

The feed conversion ratio (FCR) is an index of the total feed utilization required to produce 1 gram of wet weight. A low FCR value indicates that the quality of the feed provided is good, while a high FCR value indicates that the quality of the feed is poor. This aligns with the statement by Silaban (2021), which asserts that fish will effectively utilize high-quality feed for growth. In this study, the highest FCR was found in the treatment with 30% fish waste meal (B) with an FCR of 1.62, and the lowest FCR was found in the treatment with 10% fish waste meal (D) with an FCR of 1.83. A good FCR indicates that the provided feed is being maximized for fish growth. Fish growth is influenced by internal factors such as genetic traits, physiological conditions, and external factors such as feed and environment. According to Maranga *et al.* (2022), factors that can affect variations in FCR include feed material variation, species type, cultivation system, and stocking density. The ability of fish to convert feed into biomass also determines the FCR value (Mengistu *et al.*, 2020). The treatment with 30% fish waste meal (B) used 11.9% fish waste meal and 12.69% soybean meal. The high amino acid content in fish waste meal is believed to help improve the FCR value. This is supported by proximate analysis results showing that the treatment with 30% fish waste meal (B) had the highest protein value, at 39.80%. Khairunnisa *et al.* (2023) stated that the high levels of leucine and valine in fish waste meal are 3.3% and 2.51%, respectively. Layman (2006) stated that leucine maintains blood glucose levels, growth hormone concentration, energy metabolism, and stimulates protein synthesis. Bae *et al.* (2012) stated that valine also plays an important role for fish, such as aiding in protein synthesis and energy production.

Fish growth depends on the amount of feed consumed and how effectively it can utilize that feed for its growth process. The highest absolute weight growth was observed in the treatment with 30% fish waste meal (B), with an average absolute weight growth of 11.98 grams, while the lowest absolute weight growth was in the treatment with 10% fish waste meal (D), with an average absolute weight of 10.25 grams. The highest absolute weight growth was found in the treatment with the highest dose of fish waste meal, which was 40%. The significant absolute weight growth of the fish is likely due to the good digestion of the feed by the catfish, and the fish waste meal contains a fairly complete range of amino acids. In addition to being a source of protein and minerals, fish waste meal also contains a high level of the amino acid lysine. Lysine is a feed additive that can accelerate growth. According to Tandi *et al.* (2022), lysine is one of the high amino acid contents in fish waste meal. This amino acid component stimulates growth and enhances digestibility, leading to a faster growth rate in fish. According to Pertiwi *et al.* (2021), good fish growth is also due to the fish's ability to digest the feed maximally. The growth of catfish is directly proportional to the specific growth rate.

The specific growth rate (SGR) is the weight gain over a particular period, calculated as a numerical value. One of the important factors that determine the specific growth rate is the quality of the feed used. The quality of the feed is assessed based on its aroma and taste (palatability), nutritional content, and digestibility. Good feed should have balanced nutritional content to maximize fish growth (Chilmawati *et al.*, 2020). In this study, the highest specific growth rate was found in the treatment with 40% fish waste meal (A), with an average SGR of 3.87%/day, and the lowest SGR was in the treatment with 20% fish waste meal (C), with an average of 3.59%/day. Similarly, the highest SGR value was obtained in the treatment with 40% fish waste meal (A), which involved the highest dose of fish waste meal substitution. This is because fish waste meal contains essential amino acids, including leucine, isoleucine, and valine. These amino acid components stimulate growth (Tandi *et al.*, 2022). Additionally, according to Tatuhe (2022), fish waste meal contains 28.39% fat. The energy stored from the fat and protein content in the feed can be used for activities and metabolism, activity, and growth (Riyanti *et al.*, 2020).

3.2.2. Survival Rate

Survival rate is the percentage of cultivated organisms that are able to survive from the beginning of cultivation until the end of the study. The survival rates for the treatments with 40% fish waste meal (A), 30% fish waste meal (B), 20% fish waste meal (C), 10% fish waste meal (D), and 100% fish meal (E) were all 100%. Survival rates can be influenced by many factors, such as environmental conditions, the physiological state of the fish, and water quality. This is supported by Mutia *et al.* (2020), who stated that factors affecting fish survival include the physiological state of the fish, environmental conditions, stress levels, and disease agents. Additionally, the provision of feed also affects the survival rate of fish, meaning that the feed given must be of good quality and not excessive. Overfeeding can cause the water in the cultivation medium to become cloudy and increase ammonia levels. According to Suarjuniarta *et al.* (2021), increased ammonia levels can cause catfish (*Clarias* sp.) to become stressed and hang near the water surface. This is consistent with the statement by Dhiba *et al.* (2020), who mentioned that factors contributing to increased ammonia levels include metabolic waste and excess feed.

3.2.3. Water Quality

Water quality is a crucial supporting factor in aquaculture activities. As aquatic organisms, fish rely heavily on water quality for their survival. During the 42-day study, water quality measurements were taken, including parameters such as temperature, pH, and dissolved oxygen (DO). Temperature is a very important parameter in aquaculture. According to Pertiwi *et al.* (2021), if the temperature is too low, fish may experience a shortage of dissolved oxygen, which can cause stress and a loss of appetite, leading to wasted feed and stunted growth. During the study, the temperature range was 28-29°C, pH was 7-8, and DO was 4.8-5.5 mg/l. Temperature, pH, and DO levels fall within the optimal range. According to Suarjuniarta *et al.* (2021), the optimal values for temperature, pH, and DO are 20-30°C, pH 6-8, and DO >3 mg/l.

4. Conclusion

Based on the results of research that has been carried out, it can be concluded a substitution of fish waste meal in artificial feed for catfish (Clarias sp.) has a significant effect on growth performance but has no significant effect on survival. Based on the research, the percentage of fish waste meal substitution of 30% (b) had better performance, not significantly different with fish waste meal substitution 40% (A), but significantly different with fish waste meal substitution 20% (C), 10% (D), 0% (E).

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