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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 liters. 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 is in line with the statement of Anis and Dyah (2019), who stated that catfish have several advantages compared to other fish species, including rapid 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 continues to increase due to strong market demand, both domestically and internationally. The production output of catfish ranks among the highest in fisheries 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 increasing catfish production is feed. Feed is a crucial element in the cultivation process, starting from the seeding stage through the grow-out phase until the fish are ready for harvest. It is a key component that supports the growth and survival of catfish. According to Anis and Dyah (2019), high-quality feed can enhance fish growth and survival rates during cultivation, thereby improving production outcomes. Currently, fish farmers tend to rely more on commercially produced feed from factories. However, over time, commercial feed has become a challenge for farmers due to its rising cost. This is in line with the statement by Muntafiah (2020), who noted that feed cost can account for up to 75% of the total expenses in freshwater fish farming. The high cost of feed is mainly due to the expensive raw materials, particularly fish meals. Therefore, there is a need for alternative raw materials that are more economical to replace fish meal as the primary ingredient in commercial fish feed. One potential alternative is fish waste meal. Fish waste meal is a promising raw material because, in Indonesia, it is not yet well utilized and is often 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), stated that fish waste meal contains 45-55% protein. In addition

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to being a good source of protein and minerals, fish waste meal also has a high lysine content.

Research on the use of fish waste flour has previously been conducted on several marine and freshwater fish species. According to Manullang et al. (2019), a study on catfish (*Clarias* sp.) using formulation that substituted 70% of fishmeal protein with fish waste flour resulted in a daily growth rate of 0.32 gram/day and an absolute weight gain of 18,9 gram. In a study by Sopha et al. (2015), optimal results were observed in long-term feeding of catfish (*Clarias* sp.) with 8% fish waste flour, resulting in an absolute weight gain of 12.04 gram and a feed conversion ratio (FCR) of 1.42. Meanwhile, Kader et al. (2011), reported that substituting 67% of fishmeal with fish waste meal in catfish (*Clarias* sp.) feed resulted in a specific growth rate (SGR) of 4.1%, an FCR of 1.5, and a protein efficiency ratio (PER) of 2.3.

2. Material and Methods

This research was conducted from March - April 2025 at Balai Benih Ikan Mijen, Semarang, Central Java.

2.1. Preparation

The research facilities were prepared by stocking 10 fish per container in aquariums and rearing them for 42 days using a stagnant water system with added aeration. Proximate Analysis of Test 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 for 42 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-based ingredients used. 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 feed formulation process.

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 study were catfish (*Clarias* sp.) with an initial weight of 2.85–3.15 g, stocked at a density of 10 fish per aquarium. The rearing period lasted for 42 days, during which the fish were fed three times daily to apparent satiation. Growth measurements were taken every seven days to evaluate fish growth.

2.3. Maintenance of Test Animals

Test animals were maintained for 43 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 methods used in this research were descriptive and experimental, employing a Completely Randomized Design (CRD). This study consisted of five treatments with three replicates each. The treatment ratios were as follows:

Treatment A: 40% fish waste meal and 60% fish meal
Treatment B: 30% fish waste meal and 70% fish meal
Treatment C: 20% fish waste meal and 80% fish meal
Treatment D: 10% fish waste meal and 90% fish meal
Treatment E: 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 the data obtained during the study was carried out using SPSS 23 and Microsoft Excel 2016. The data were subjected to normality and homogeneity tests. If the data were normally distributed and homogeneous, an analysis of variance (ANOVA) was conducted. ANOVA was used to determine whether the applied treatments had a significant effect. The analysis was performed at a 95% confidence level. If the ANOVA results showed significant differences, Duncan's multiple range test was conducted as a post hoc test. Water quality data 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 total feed consumption of catfish.

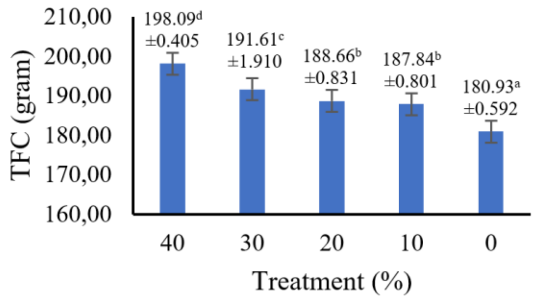

Figure 1. Total Feed Consumption

Note:
Different superscript letters (a, b, c, d) indicate significant differences among treatments ($P < 0.05$), whereas the same letters indicate no significant difference among treatments.

3.1.2. Feed Utilization Efficiency

Observations during the rearing period showed that the highest feed utilization efficiency was recorded in treatments A and B (40% and 30% fish waste meal, respectively), while the lowest was observed in treatment D (10% fish waste meal). Based on the results of the analysis of variance (ANOVA), 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) had a significant effect ($P < 0.05$) on the feed utilization efficiency of catfish.

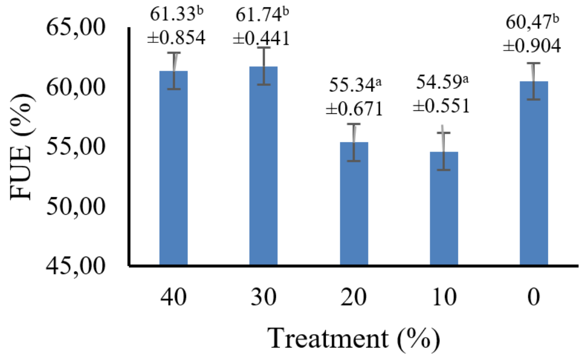

Figure 2. Feed Utilization Efficiency

Note:
Different superscript letters (a, b) indicate significant differences among treatments ($P < 0.05$), whereas the same letters indicate no significant difference among treatments.

3.1.3. Food Conversion Ratio

The results of observations during the rearing period showed that the highest feed conversion ratio (FCR) was recorded in treatments A and B (40% and 30% fish waste meal, respectively), while the lowest FCR was observed in treatment D (10% fish waste meal). Based on the results of the analysis of variance

(ANOVA), 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) had a significant effect (P < 0.05) on the feed conversion ratio of catfish.

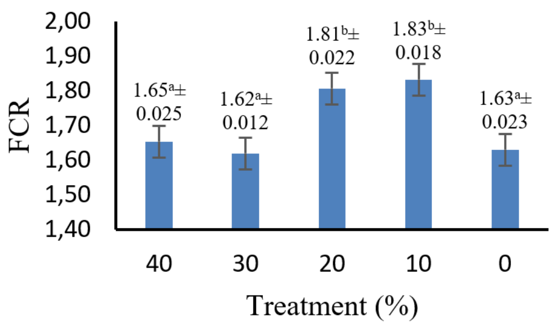

Figure **3**. Food Conversion Ratio

Note:
Different superscript letters (a, b) indicate significant differences among treatments (P < 0.05), whereas the same letters indicate no significant difference among treatments.

3.1.4. Absolute Weight

Observations during the rearing period showed that the highest absolute weight was recorded in treatments A and B (40% and 30% fish waste meal, respectively), while the lowest absolute weight was observed in treatment D (10% fish waste meal). Based on the results of the analysis of variance (ANOVA), 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) had a significant effect (P < 0.05) on the absolute weight of catfish.

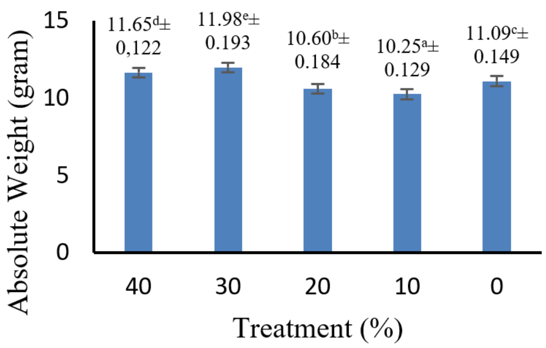

Figure 4. Absolute Weight

Note:
Different superscript letters (a, b, c, d) indicate significant differences among treatments (P < 0.05), whereas the same letters indicate no significant difference among treatments.

3.1.5. Spesific Growth Rate

Observations during the rearing period showed that the highest specific growth rate (SGR) was recorded in treatments A and B (40% and 30% fish waste meal, respectively), while the lowest SGR was observed in treatment D (10% fish waste meal). Based on the results of the analysis of variance (ANOVA), 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) had a significant effect (P < 0.05) on the specific growth rate of catfish.

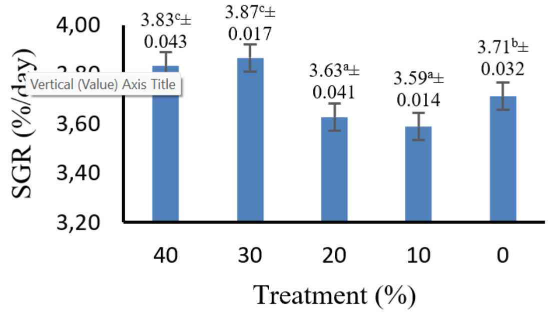

Figure 5. Spesific Growth Rate

Note:
Different superscript letters (a, b, c) indicate significant differences among treatments (P < 0.05), whereas the same letters indicate no significant difference among treatments.

3.1.6. Water Quality

Water quality parameters measured included temperature, pH, and dissolved oxygen (DO). The results of the water quality measurements during the maintenance of tilapia can be seen in 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 the water quality parameters during the study indicated that the values remained within suitable conditions for catfish. This is consistent with literature reporting the optimal water quality conditions 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 values were obtained in treatment B, which included 30% fish waste meal, with TFC, FUE, FCR, absolute weight gain, and SGR values of 188.86 ± 0.831 g, 61.74 ± 0.441%, 1.62 ± 0.012, 11.98 ± 0.193 g, 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 hinder growth. Based on the results of this study, the best treatment was found to be treatment B (30% fish waste meal) due to its high TFC and FUE values and low FCR. The superior performance of treatment B was attributed to the feed's palatability, which was preferred by the fish. The feed in this treatment had an aroma, taste, and texture that were attractive to the catfish. Additionally, it had a more pleasant aroma and remained floating longer, making it more accessible for consumption. The nutritional content of the 30% fish waste meal feed, which contains 39.80% protein, further supported its effective utilization.

Total feed consumption is usually directly proportional to the increase in fish length. Fish respond well to feed when it has high palatability, which includes aroma, taste, and texture preferred by the fish. The highest total feed consumption was observed in treatment A (40% fish waste meal), with a total feed consumption of 198.09 g. This is because the aroma produced by the 40% fish waste meal feed was more stimulating to the fish, encouraging higher intake compared to other treatments. The feed in this treatment also had a more appealing and distinctive taste and aroma, making it more favored by the fish. This finding is supported by Islama et al. (2020), who stated that feed with a distinctive and fish-preferred aroma is considered high-quality feed. It is further reinforced by Manganang and Numisye (2019), who noted that high feed consumption is usually associated with texture and aroma that attract fish to feed. Feeding strategy can also influence total feed consumption. In this study, the at-satiation method was used to minimize feed wastage. Good fish growth is significantly influenced by how efficiently fish can utilize feed for development. According to Subandiyono et al. (2018), the energy required for physiological activities in fish must be met by carbohydrates and fats to efficiently utilize protein for growth.

A high feed utilization efficiency (FUE) value indicates that fish can maximally utilize the feed provided for growth, whereas a low FUE value suggests that the fish cannot optimally use the feed to support their development. Feed efficiency is largely determined by the fish's ability to digest the feed and the nutritional quality of the feed. In this study, the highest FUE value was observed in treatment B (30% fish waste meal) at 61.74%, while the lowest FUE was in treatment D (10% fish waste meal) at 55.34%. The best growth was also observed in treatment B. Feed utilization efficiency is generally considered good if the value exceeds 50% (Craig et al., 2017), likely because the feed provided met the nutritional requirements of the catfish, allowing it to be effectively utilized. According to Sebayang et al. (2020), the protein requirement for catfish is 30–36%. In addition to its palatability, fish waste meal has a high pepsin digestibility, with a reported value of 85% (Tatuhe et al., 2022), which helps fish maximize feed utilization. Feed efficiency is often used as a benchmark for feed quality: high FUE values indicate good feed quality, while low values suggest poor-quality feed. Fahrudin et al. (2020) noted that low feed efficiency requires fish to consume more feed to achieve weight gain, increasing overall feed demand. This aligns with Murtini et al. (2022), who emphasized that high-quality fish feed can promote efficient growth with minimal waste. Herawati et al. (2020) further stated that the efficiency of feed absorption and digestion depends on the quality of nutrient sources in the feed. Feed utilization efficiency is inversely proportional to the feed conversion ratio (FCR). Abdel-Warith et al. (2020) reported that FCR can be reduced with high-protein feed and the addition of amino acid supplements. Thus, the higher the FUE value, the lower the FCR, reflecting more efficient feed utilization.

The feed conversion ratio (FCR) is an index of the total feed required to produce 1 gram of wet weight. A low FCR value indicates that the feed provided is of high quality, whereas a high FCR value suggests poor feed quality. This aligns with the statement by Silaban (2021), who asserted that fish effectively utilize high-quality feed for growth. In this study, the lowest FCR was observed in treatment B (30% fish waste meal) with a value of 1.62, while the highest FCR was found in treatment D (10% fish waste meal) at 1.83. A good FCR indicates that the feed is being efficiently converted into fish growth. Fish growth is influenced by internal factors, such as genetic traits and physiological conditions, as well as external factors, such as feed and environmental conditions. According to Maranga et al. (2022), variations in FCR can be affected by feed composition, 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). Treatment B (30% fish waste meal) contained 11.9% fish waste meal and 12.69% soybean meal. The high amino acid content in fish waste meal is believed to improve FCR. This is supported by proximate analysis results, which showed that treatment B had the highest protein content at 39.80%. Khairunnisa et al. (2023) reported that fish waste meal contains high levels of leucine and valine, at 3.3% and 2.51%, respectively. According to Layman (2006), leucine plays a role in maintaining blood glucose levels, growth hormone concentration, energy metabolism, and stimulating protein synthesis. Bae et al. (2012) stated that valine also plays an important role in protein synthesis and energy production in fish.

Fish growth depends on the amount of feed consumed and how effectively the fish can utilize that feed for its growth. The highest absolute weight gain was observed in treatment B (30% fish waste meal), with an average gain of 11.98 g, while the lowest was in treatment D (10% fish waste meal), with an average gain of 10.25 g. Although treatment A (40% fish waste meal) had the highest dose of fish waste meal, the optimal absolute weight gain was achieved in treatment B. The significant weight gain in the fish is likely due to the good digestibility of the feed and the relatively complete amino acid profile of fish waste meal. In addition to being a source of protein and minerals, fish waste meal contains high levels of lysine, an amino acid that can accelerate growth. According to Tandi et al. (2022), lysine is one of the amino acids present in high concentrations in fish waste meal. This amino acid stimulates growth and enhances feed digestibility, leading to faster growth rates in fish. Pertiwi et al. (2021) also noted that good fish growth is associated with the fish's ability to digest feed efficiently. The growth of catfish is directly proportional to the specific growth rate (SGR).

The specific growth rate (SGR) represents the weight gain over a particular period, expressed as a numerical value. One of the key factors influencing SGR is the quality of the feed. Feed quality is assessed based on palatability (aroma and taste), nutritional content, and digestibility. Good feed should provide balanced nutrition to maximize fish growth (Chilmawati et al., 2020). In this study, the highest SGR was observed in treatment A (40% fish waste meal), with an average of 3.87% per day, while the lowest SGR was found in treatment C (20% fish waste meal), with an average of 3.59% per day. The highest SGR corresponded to the treatment with the highest substitution of fish waste meal. This is likely because fish waste meal contains essential amino acids, including leucine, isoleucine, and valine, which stimulate growth (Tandi et al., 2022). Additionally, according to Tatuhe (2022), fish waste meal contains 28.39% fat. The energy stored in the fat and protein of the feed supports metabolic activities, daily activity, and growth (Riyanti et al., 2020).

3.2.2. Survival Rate

Survival rate is the percentage of cultivated organisms that survive from the beginning of cultivation until the end of the study. In this study, the survival rates for all treatments—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 several factors, including 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 condition of the fish, environmental conditions, stress levels, and disease agents. Feed provision also affects survival; the feed must be of good quality and given in appropriate amounts. Overfeeding can lead to water cloudiness and increased ammonia levels. According to Suarjuniarta et al. (2021), elevated ammonia levels can cause catfish (*Clarias* sp.) to become stressed and congregate near the water surface. This aligns with Dhiba et al. (2020), who noted that factors contributing to increased ammonia levels include metabolic waste and excess feed.

3.2.3. Water Quality

Water quality is a crucial factor in aquaculture activities, as fish, being aquatic organisms, rely heavily on water quality for survival. During the 42-day study, water quality measurements were taken, including parameters such as temperature, pH, and dissolved oxygen (DO). Temperature is particularly important in aquaculture. According to Pertiwi et al. (2021), if the temperature is too low, fish may experience reduced dissolved oxygen availability, leading to stress, decreased appetite, wasted feed, and stunted growth. During this study, the observed water quality parameters were as follows: temperature ranged from 28–29°C, pH from 7–8, and DO from 4.8–5.5 mg/L. These values fall within the optimal ranges for catfish. According to Suarjuniarta et al. (2021), the optimal values for temperature, pH, and DO are 20–30°C, 6–8, and >3 mg/L, respectively.

4. Conclusion

Based on the results of this study, it can be concluded that the substitution of fish waste meal in artificial feed for catfish (*Clarias* sp.) has a significant effect on growth performance but does not significantly affect survival. Among the treatments, the 30% fish waste meal substitution (B) showed the best performance. Its growth performance was not significantly different from the 40% substitution (A) but was significantly higher than the 20% (C), 10% (D), and 0% (E) substitutions.

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