

Effectiveness Gamal Leaf Flour (*Gliricidia siphium*) on the Growth of Red Tilapia (*Oreochromis sp.*)

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Abstract. Artificial feed is a feed that is formulated from plant and animal materials with nutritional content that is in accordance with the feed formulation. One of the potential ingredients used in artificial feed is gamal leaves. This study aims to determine the effectiveness of gamal leaves processed into flour and fermented on fish growth, and what is the right dose of gamal leaves in increasing the growth and survival of fish. This study was conducted for 42 days using a Completely Randomized Design (CRD) with 4 treatments and 3 replications. The treatments used include A (feed dose 2%), B (feed dose 3%), C (feed dose 4%), and D (feed dose 5%). The parameters observed include growth, absolute length, absolute weight, survival, feed conversion ratio (FCR), feed utilization efficiency, and water quality. The results of the study showed that fermented gamal leaf flour was able to increase the growth of red tilapia fry. This was indicated by an increase in fish weight, and the results of the study showed that the best dose was treatment D (feed dose 5%), which was assessed by an increase in fish weight in treatment D, which was more significant than the others, and a survival rate of 100%.

Keywords: Gamal leaf flour, fermentation, growth, survival.

INTRODUCTION

Red tilapia (*Oreochromis sp.*) is favored by many people due to its delicious, thick flesh, similar to red snapper. One crucial issue in developing red tilapia cultivation is feed. Juvenile fish require a high nutritional value. Feed availability and quality indicators are crucial factors, including protein, carbohydrates, vitamins, minerals, and fat (Renaldi, 2024). In the cultivation process, especially during grow-out, feed accounts for 60-70% of total production costs. The high cost of feed is due to the high cost of feed ingredients. Since 80% of raw materials are imported, alternative natural ingredients are needed, taking into account their nutritional content. One such ingredient is Gamal leaves (*Gliricidia siphium*).

According to (Apriani et al., 2019), Gamal leaves contain 27.44% protein and 14.64% crude fiber. Gamal leaves are also a plant with significant potential. Gamal leaves have not been widely used as a raw material for fish feed, so information on their use in fish feed is limited. Commercial pellet feed formulated with moringa leaves, gamal leaves, and gotu kola leaves significantly improves fish growth, making them suitable for use as a raw material for fish feed.

METHODS

This study used a Completely Randomized Design (CRD) with four treatments and three replications, resulting in 12 experimental units. The containers were randomly placed using a lottery method, as shown in Figure 1 below:

Figure 1. Research Container Layout

Treatment A: Dose 2%

Treatment B: Dose 3%

Treatment C: Dose 4%

Treatment D: Dose 5%

Tools and Materials

The tools and materials used in this study included 12 aquariums, one pellet press, one grinder, one sieve, one mixing container, one plastic jar, one digital scale, one analytical balance, one ruler, one aerator, one oven, one spoon, one thermometer, one pH meter, one DO

meter. Meanwhile, the materials used consist of tilapia fish seeds (3-5 cm long), gamal leaf flour (grams), coconut meal (grams), shrimp heads (grams), wheat flour (grams), corn flour (grams), premix (grams), water (liters), EM4 (ml), molasses (grams), and sticker paper.

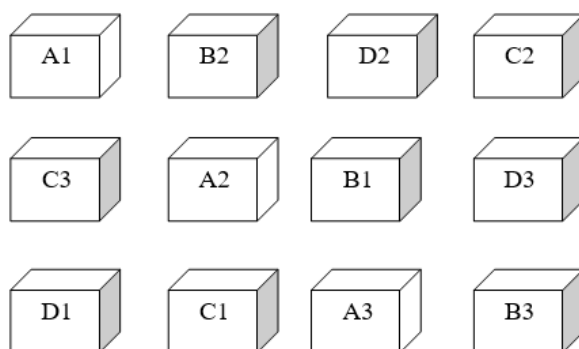


Figure 1. Research Container Layout

Research Procedure

This research procedure involved several stages, beginning with the fermentation process of gamal leaf flour using the probiotic EM4 and molasses. The solution was prepared by mixing 10 ml of EM4 with 1 liter of air, followed by 500 g of molasses. The gamal leaf flour was placed in a container, and 300 ml of the probiotic solution was placed in a perforated jar to create aerobic conditions. The fermentation process lasted for 14 days. The tank preparation consisted of 12 aquariums measuring 30 x 30 x 25 cm. They were cleaned with water and methylene blue, dried for one day, and then watered and aerated to stabilize oxygen levels before the fish were introduced. The test fish were prepared by acclimating red tilapia (*Oreochromis* sp.) fry to the container for 24 hours before being weighed and placed in the aquarium. (Sina et al. 2024 in Haetami et al., 2025) stated that the protein requirement for Red Tilapia for optimal growth is around 28-35%.

RESULTS AND DISCUSSION

Absolute Weight Growth

Absolute weight was observed to determine the effect of gamal leaf meal on the growth of red tilapia (*Oreochromis* sp.) fry. The highest average absolute weight growth rate at the end of the study was in treatment D at 0.54 g, followed by treatment C at 0.48 g, treatment B at 0.20 g, and treatment A at 0.14 g (Figure 2).

The best weight growth rate occurred in treatment D at a 5% dose, followed by treatment C at a 4% dose, then treatment B at a 3% dose, while treatment A at a 2% dose showed the lowest growth. This is because the higher the dose given to red tilapia fry, the greater their appetite. This indicates that this fermentation process is necessary because fish are unable to digest cellulose, pectin, beta-glucans, pentoses, and xylans because they cannot be hydrolyzed by endogenous enzymes (Dinsa, 2017). According to (Nazlia & Nurhayati, 2019), excessively high fiber content in feed can suppress fish growth. The fermentation process of gamal leaves in this study was able to meet the nutritional needs of tilapia, resulting in increased body weight, which impacts growth rate.

Research (Herawati and Royani, 2017, cited in Sirait et al., 2019) also indicates that gamal leaves contain 25.7% protein, meaning they can support the protein needs of tilapia fry. Proximity test results indicated that gamal leaf meal feed contained 22.74% crude protein, 10.03% crude fat, 4.91% crude fiber, 8.91% ash, and 15.33% water. Gamal leaves are also known to contain secondary metabolites that function as a defense against bacteria or toxins that enter and attack the body (Akharaiyi et al., 2012).

The results of the analysis of variance (ANOVA) (Table 1) show that the provision of gamal leaf flour (*Gliricidia Sipiium*) has a significant effect on the absolute weight growth of Red Tilapia (*Oreochromis niloticus*) fry ($p > 0.05$). Sina et al. 2024 in Haetami et al., 2025 stated that the protein requirement for red tilapia for optimal growth ranges from 28-35%. Based on this, the test feed used in this study was a self-formulated feed.

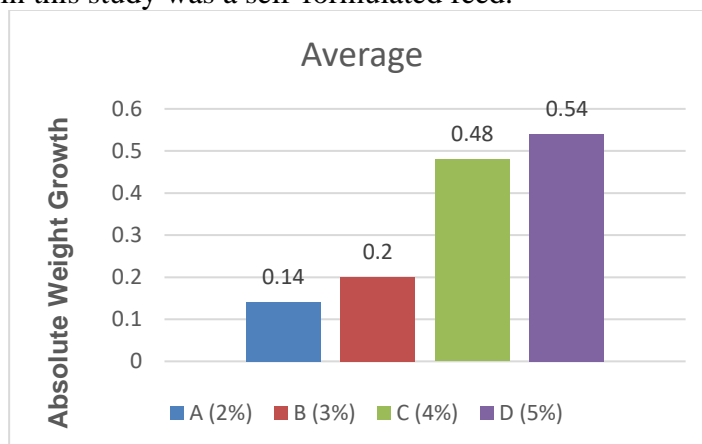


Figure 2. Absolute Weight Growth

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Table 1. Results of the Absolute Weight Growth (ANOVA) test

Heavy	Sum of Squares	Degress Of Freedom	Square	F Count	Significant
Sum of Squares Between groups	.327	3	.109	7.270	.011
Sum of Squares in Withing Group	.120	8	.015		
Total	.444	11			

Internal and external environmental factors influence fish growth. Therefore, when raising fish, a balance and adjustment to the tolerance level between these two factors are essential. One such internal factor is feed nutrition. Feeding must also be well-regulated; inefficient feeding can lead to material losses and reduced water quality during cultivation. Overfeeding can lead to poor water quality due to pollution (Walujan et al., 2025).

Absolute Length Growth

Observations on the growth of red tilapia fry showed an increase throughout the study. The results showed that the average change in body length during each treatment increased during the observation period. Treatment D (5% dose) had an average tilapia of 4.68 cm,

followed by treatment C (4% dose) with an average total tilapia of 4.57 cm, treatment B (3% dose) with an average total value of 4.51 cm, and the lowest was in treatment A (2% dose) with an average value of 4.38 cm.

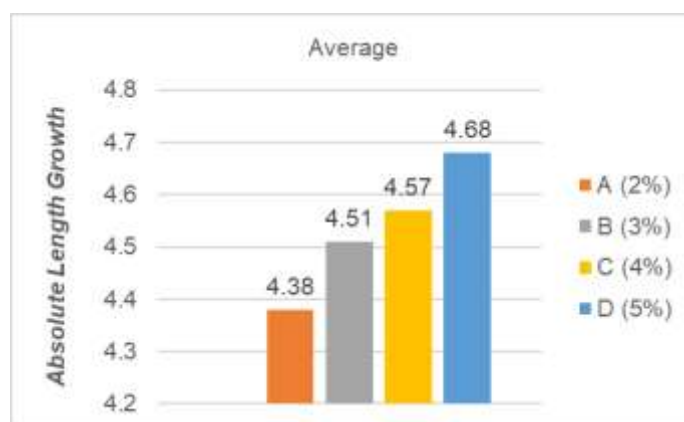


Figure 3. Absolute length growth

The best absolute length growth increase occurred in treatment D (5% dose) followed by treatment C (4% dose) and Treatment B (3% dose), while the lowest growth was in treatment A (2% dose). The results of the study explain that the provision of fermented gamal leaf flour with a dose of 5% can increase the length growth of Red Tilapia seeds. This increase is thought to be because the feed combination contains an optimal nutritional composition, especially protein and essential amino acids which are very much needed in the growth process. According to (Anwar et al., 2025) adequate nutrition in feed not only acts as a source of energy for the metabolic process of tilapia, but also supports its optimal growth process. (Rozi et al., 2018) stated that good fish growth can affect its life because it is able to use the feed eaten optimally. According to (Mardhiana et al., 2017 cite in Gonsaga et al., 2023) fermented feed ingredients, in addition to acting as the main source of energy for fish, are also able to increase digestibility values so that feed utilization is more efficient. This is in line with the view of (Wardika et al. 2014 cite in Rubai et al., 2024), which emphasizes that good quality feed can increase fish digestibility, provide sufficient energy, and support optimal growth.

Table 2. Results of the Absolute Length Growth (ANOVA) Test

Long	Sum of Squares	Degress Of Freedom	Square Mean	F Count	Significant
Sum of Squares Between groups	.278	3	.093	1.248	.355
Sum of Squares in Withing Group	.593	8	.074		
Total	.871	11			

The results of the analysis of variance (ANOVA) indicate that the substitution of gamal leaf flour in feed formulation did not significantly affect the growth of red tilapia fry ($p > 0.05$). This indicates that the use of gamal leaf flour did not significantly affect the growth of red tilapia fry.

According to Effendie (1997), growth in length is influenced by internal and external factors. Internal factors depend in part on the condition of the fish, such as its ability to utilize remaining energy and protein after metabolism for growth. External factors, such as

environmental factors including water quality, temperature, pH, dissolved oxygen, and the feed provided, significantly influence the growth of tilapia fry. Feed with good quality and the right quantity will support the growth of the organism. Both factors will balance the fish's body condition during the maintenance medium and support the growth of red tilapia (*Oreochromis* sp).

Survival Rate

The survival rate of fish is a measure of the percentage of survivors at the end of the study compared to the number of survivors at the beginning of the study. Figure 4 shows that in treatment A (2% dose), the percentage of survivors was 93%. In treatment B (3% dose), the number of survivors was 93%. In treatment C (4% dose), the number of survivors was 100%, and in treatment D (5% dose), the number of survivors was 100%.

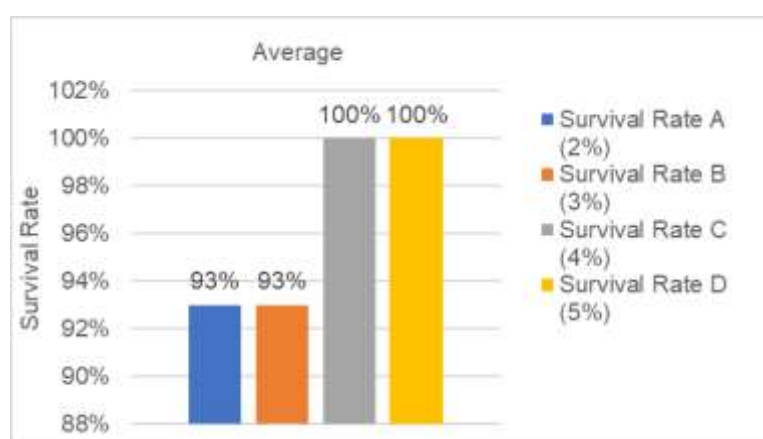


Figure 4. Survival Rate Graph

The results of this study indicate a survival rate above 95% across all treatments. The survival rate in this study is approximately the same as that stated by Hyline et al., 2025. According to Hyline et al., a fish farming business can be considered successful if the survival rate reaches above 84%. One factor influencing fish survival is the nutritional quality of the feed provided, and the addition of fermented gamal leaf meal also plays a role in supporting survival. As stated by Densities & Time (2023), high-quality feed plays a significant role in maintaining the survival of fish fed with leaves.

Other factors such as stable water quality, good maintenance management, and sufficient feed availability likely contribute to high survival. Furthermore, an optimal rearing environment, including adequate dissolved oxygen levels, appropriate temperature, and moderate fish density, can also support maximum survival.

Feed Conversion

Feed conversion (FCR) and feed efficiency are indicators for determining feed effectiveness. Feed conversion is defined as the ability of a cultivar (fish) to convert feed into meat, while feed efficiency is defined as the fresh weight of fish meat obtained for each unit of dry weight of feed fed to the fish, in this case tilapia. The results of the study showed the average feed efficiency value over 42 days, as shown in 5.

Figure 4 shows that the FCR value obtained for feed treatment A (2% dose) was 6.84. For feed treatment B (3% dose), the FCR value obtained was 8.24. For feed treatment C (4% dose), the FCR value obtained was 5.32. For feed treatment D (5% dose), the FCR value obtained was 6.21.

Based on the FCR data above, the feed conversion ratio values obtained for each

treatment varied, ranging from a low of 5.32 for feed treatment C to a high of 8.24 for feed treatment B. Feed conversion is the ratio between the amount of feed given and the total weight of fish produced. A lower feed conversion rate indicates a more efficient feed utilization rate. Conversely, a higher feed conversion rate indicates a less efficient feed utilization rate.

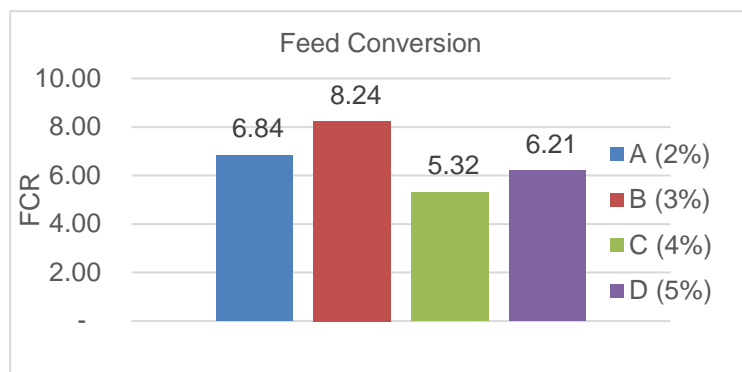


Figure 4. Feed Conversion Graph

According to (Saputra et al., 2024), the conversion rate is also influenced by various factors, including environmental conditions. A favorable environment for fish habitats will influence the metabolic process in utilizing available energy for optimal growth. Furthermore, the feed provided must be of good quality in terms of feed ingredients. The feed content includes protein, fat, carbohydrates, ash, and water, appropriate for the needs of Red Tilapia. It is important to note that each fish has different protein requirements depending on the species. The texture and size of the feed must also be considered. A good texture and size appropriate to the fish's mouth opening will make it easier for the fish to digest the feed.

Feed Utilization Efficiency

Feed efficiency is a parameter used to assess the extent to which fish utilize feed efficiently. Feed efficiency is calculated by comparing the difference in body weight between the start and end of maintenance and the amount of feed consumed (Iskandar et al., 2023). Fish feed efficiency is strongly influenced by the protein content of the feed. The results of the study, which obtained the average feed efficiency value over 30 days, are shown in Figure 5.

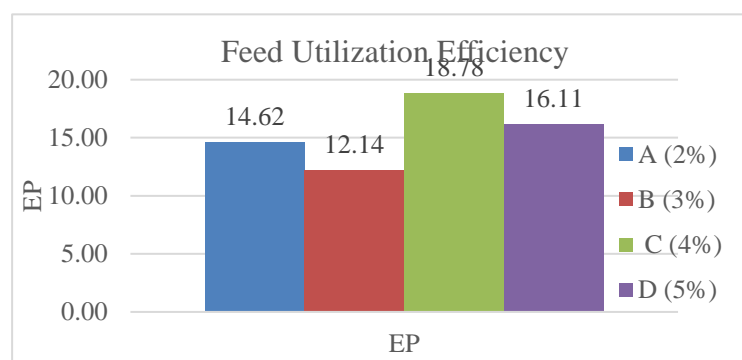


Figure 5. Feed Utilization Efficiency Graph

From the data in graph 7, it can be seen that treatment A (2% dose) the feed efficiency value obtained is 14.62. In treatment B (3% dose), the feed efficiency value obtained was 12.14. In feed treatment C (4% dose), the efficiency value obtained was 18.78. In feed treatment D (5% dose), the feed efficiency value obtained was 16.11.

Feed efficiency is inversely proportional to feed conversion. According to (Norry et al., 2025), feed efficiency is the ratio between the amount of feed given and the growth of fish

weight. This means that the absorption of feed energy by fish in each kilogram of feed given. The higher the feed efficiency value, the better the absorption of feed energy for fish growth. Feed utilization by fish is determined by the quantity of feed given and the quality of the feed itself. Many factors influence feed efficiency, including environmental conditions, water quality, age of feed, and feed ingredients used. The proximate content of the feed. The factors mentioned above will affect the use of fish feed, so that the feed used can be reduced to be more efficient and fish growth will be more optimal.

The results obtained in this study are in accordance with the research of Syahputra et al. (2018) which stated that the provision of 10% gamal leaf flour in artificial feed has a lower feed conversion ratio value for gourami fish compared to concentrations of 5% and 15%. This means that the treatment of adding 10% gamal leaf flour has a higher feed efficiency value than the other two treatments because the lower the feed conversion ratio value, the higher the efficiency value. This result is also almost similar to the research of Restiningtyas et al. (2012) who added lamtoro leaves to commercial feed, where the addition of 10% lamtoro leaf flour to commercial feed was able to produce the highest feed efficiency of 60.87%.

Water Physics and Chemistry

Water quality is a key aspect in red tilapia cultivation because it is the primary medium in which the fish live and grow. Water quality measurements in this study included temperature, pH, and DO, and were conducted weekly in the morning at 9:00 a.m. WITA. This was done to maintain stable water quality in the rearing tank and prevent the growth and survival of the fry. The results of water quality measurements during the rearing of saline tilapia (*Oreochromis niloticus*) fry are shown in Figure 6.

Figure 6 shows a temperature range of 26°C. This is considered good because it is still suitable for fish survival. This is in accordance with the Indonesian National Standard (SNI, 2009), which states that the optimal temperature for tilapia growth is 28.2°C-29.2°C. This is in line with the statement (Fadila et al., 2023) that the optimal temperature for rearing tilapia fry is between 25-32°C. Temperature significantly influences the life activities of cultured organisms, such as appetite and metabolic rate (Lamangkaraka et al., 2024).

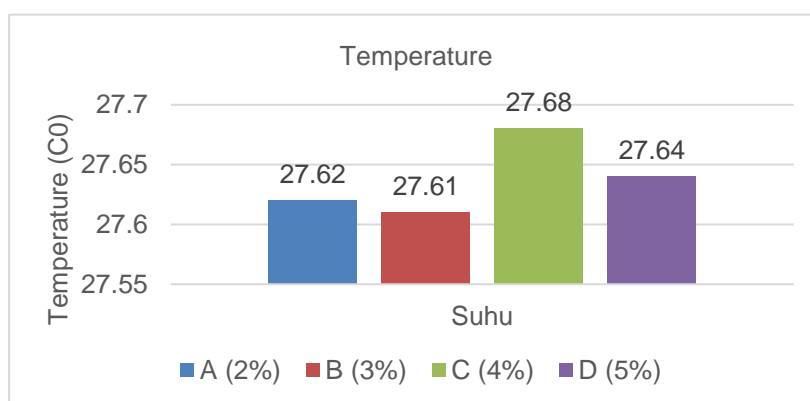


Figure 6. Temperature Measurement

Sugihartini et al., 2025, state that the optimal temperature range for fish survival is between 25 and 30°C. However, if the water temperature falls below 14°C, fish will die. If the water temperature drops below 20°C, fish's digestibility of the food they consume decreases. Conversely, if the temperature rises to 30°C, fish will become stressed due to their increased oxygen requirements. This is also confirmed by Koniyo (2020), who states that the normal water temperature for fish cultivation ranges from 25 to 30°

The research results showed that the measured pH range was around 8.57 – 8.63. This

value is still within the optimal range for the development and survival of tilapia. The pH value is defined as the negative logarithm of the hydrogen ion concentration, and the acid value is indicated by a value of 1 - 7 and base 7 - 14. Most public waters have a pH value between 6-9. Acidic waters are smaller and can decrease to 2. The tolerance limit of aquatic organisms to pH varies and is influenced by, among other things, temperature, dissolved oxygen, alkalinity, cation and anion content, as well as the type and habitat of the organism.

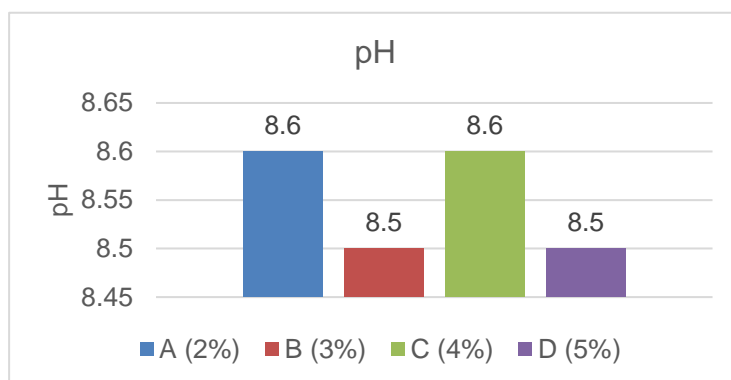


Figure 7. pH measurement

Based on SNI 7550:2009, the optimal water pH for tilapia cultivation is 6.5–8.5. According to Fadillah et al., 2022, the optimal pH range for optimal tilapia growth is 6.5–8.

The degree of acidity is also known as pH. The normal pH value for tilapia is 6–9 (Mudjiman and Suyanto, 2003). A pH above 10 can kill the fish, while a pH below 5 can stunt their growth. This was confirmed by Amri and Khairuman (2013), who stated that the optimal pH for fish growth is 6–8. Water pH measurements at the research site ranged from 8.1–8.5. This indicates that the water pH was stable throughout the study and suitable for red tilapia cultivation.

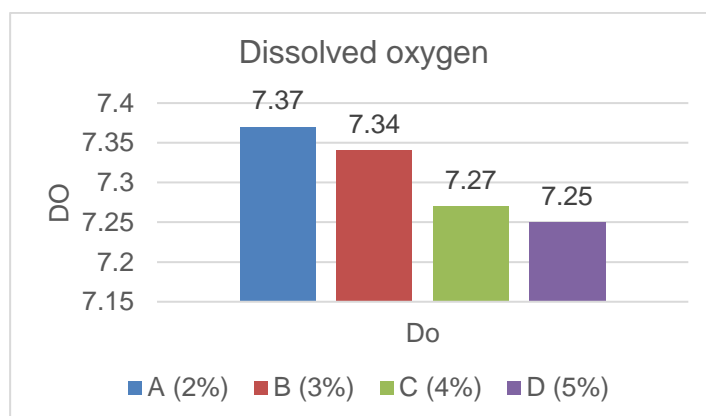


Figure 8. DO measurement

The DO measurement results were around 7.25–7.37 mg/L. This value is within the acceptable range for red tilapia cultivation. Ningtias & Suwartiningsi (2012) stated that maximum tilapia growth occurs at dissolved oxygen levels between 4 and 7 mg/L. Optimal DO levels support fish metabolism, thus contributing to better growth. Low dissolved oxygen levels can stress fish, reduce appetite, and even cause death (Riyadi et al., 2025).

According to Indonesian National Standard 7550: 2009 (March 21, 2013), the optimum dissolved oxygen level for tilapia is 7 ppm. Effendi (2003) stated that waters designated for

fisheries should have a dissolved oxygen content of at least 5 mg/L. An imbalance in dissolved oxygen levels can cause stress in fish because the brain does not receive an adequate oxygen supply, and death due to oxygen deprivation (anoxia) occurs when body tissues are unable to absorb oxygen dissolved in the blood (Dahril et al., 2017).

CONCLUSION AND RECOMMENDATIONS

Conclusion

Fermented gamal leaf flour can be used as an alternative feed ingredient because it can increase the growth of red tilapia (*Orochormis niloticus*) fry, particularly in terms of weight growth.

The best dose in this study was 5% (Treatment D), which produced the highest growth in length and weight compared to other doses. Statistically, the administration of gamal leaf flour (*Gliricidia sepium*) did not significantly affect growth in length ($p>0.05$), but did significantly affect weight growth ($p<0.05$).

Recommendations

This study recommends further research with wider or higher dosage variations to determine the optimal limit for the use of gamal leaf flour in fish feed.

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