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ANALYSIS OF THE EFFECT OF FERMENTED DUCK BONE FLOUR IN ARTIFICIAL FEED ON TILAPIA (*Oreochromis niloticus*) PRODUCTION

Analisis Pengaruh Tepung Tulang Itik Terfermentasi dalam Pakan Buatan Terhadap Produksi Ikan Nila (*Oreochromis niloticus*)

Nur Halimah*, Surianti, Hasrianti

Fisheries Science, Faculty of Science and Technology, Muhammadiyah University of Sidenreng Rappang

Jl. Angkatan 45 No 1A. Sidrap 91651, Sulawesi Selatan

*Coresponding author: nurhalimah130403@gmail.com

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ABSTRACT

The problem of increasing fish feed prices in Indonesia, especially in Sidenreng Rappang Regency, South Sulawesi, is still a major challenge in the fish farming process. Therefore, alternative solutions are needed to overcome this problem. This study aims to determine the effect of different doses of mixed microorganisms in artificial feed on feed efficiency, survival and feed conversion ratio (FCR) of tilapia. This study used a completely randomized design (CRD) method with 5 treatments and 3 replications so that there were 15 experimental containers, the containers used were 15 meatballs with a diameter of 18 cm each with a water capacity of 15 liters. Treatment A = 10% fermented duck bone meal, treatment B = 15% fermented duck bone meal, treatment C = 20% fermented duck bone meal, treatment D = 25% fermented duck bone meal and treatment E = 30% fermented duck bone meal. Sampling was conducted weekly, to determine the weight of the test animals and adjust the feeding. Data were analyzed using analysis of variance (ANOVA) if there was a significant effect then continued with the W-Tukey test to see which treatment gave the best results. Water quality measurements were conducted daily using a digital thermometer and pH meter. Based on the results of the study showed that treatment D with a dose of 25% fermented duck bone meal was the best treatment in terms of survival parameters (86.67 ± 2.88a) and FCR (1.826 ± 0.07a) and treatment E with a dose of 30% fermented duck bone meal was the best treatment in terms of feed efficiency parameters (5.029 ± 0.35a). The results of water quality analysis during the study showed that temperature (27–29°C) and pH (7.7–8.5) were within a stable range and supported cultivation.

Keywords: FCR, Feed Efficiency, Survival Rate, Tilapia

ABSTRAK

Permasalahan kenaikan harga pakan ikan di Indonesia, khususnya di Kabupaten Sidenreng Rappang, Sulawesi Selatan, masih menjadi tantangan utama dalam proses budidaya ikan. Oleh karena itu, diperlukan alternatif solusi untuk mengatasi masalah ini. Penelitian ini bertujuan utnuk mengetahui pengaruh perbedaan dosis mikroorganisme mix pada pakan buatan terhadap efisiensi pakan, sintasan dan rasio konversi pakan (FCR) ikan nila. Penelitian ini menggunakan metode rancangan acak lengkap (RAL) dengan 5 perlakuan dan 3 ulangan sehingga terdapat 15 wadah percobaan, wadah yang digunakan yaitu 15 baksom berdiameter 18 cm masing-masing memiliki kapasitas air 15 liter. Perlakuan A = 10% tepung tulang itik terfermantasi, perlakuan B = 15% tepung tulang itik terfermentasi, perlakuan C = 20% tepung tulang tik terfermentasi, perlakuan D = 25% tepung tulang itik terfermentasi dan perlakuan E = 30% tepung tulang itik terfermentasi. Sampling dilakukan setiap minggu, untuk mengetahui bobot hewan uji dan penyesuaian pemberian pakan. Data di analisis menggunkan analisis ragam (ANOVA) apabila berpengaruh nyata maka dilanjutkan dengan uji W-Tukey untuk melihat perlakuan mana yang memberikan hasil terbaik. Pengukuran kualitas air dilakukan setiap hari dengan menggunakan alat ukur termometer digital dan pH meter. Berdasarkan hasil penelitian menunjukkan bahwa perlakuan D dengan dosis 25% tepung tulang itik terfermentasi menjadi perlakuan terbaik pada parameter sintasan (86,67 ± 2,88[a]) dan FCR (1,826 ± 0,07[a]) dan perlakuan E dengan dosis 30% tepung tulang itik terfermentasi menjadi perlakuan terbaik pada parameter efisiensi pakan (5,029 ± 0,35[a]). Hasil analisis kualitas air selama penelitian menunjukkan bahwa suhu (27–29°C) dan pH (7,7–8,5) berada dalam kisaran yang stabil dan mendukung untuk budidaya.

Kata Kunci: Efisiensi Pakan, FCR, Ikan Nila, Sintasan

INTRODUCTION

Tilapia (*Oreochromis niloticus*) is one of the freshwater fish that has an economical price and its cultivation process can be carried out with various systems, both traditional and super intensive. Compared to other freshwater fish, tilapia has several advantages, namely easy to cultivate, fast growth and high tolerance to environmental changes (Centyana et al., 2014), and has a distinctive and dense meat taste, does not have many bones, and is easy to obtain so it has the potential to be cultivated (Ardita et al., 2015).

Tilapia cultivation efforts in Sidenreng Rappang Regency have great potential to be developed because it is one of the fish that is popular in the community. Increasing tilapia production through intensive cultivation needs to be done (Putra et al., 2011), but there are efficiency problems in the tilapia production process, especially in intensive cultivation related to high production costs along with increasing feed prices. High costs, as well as raw materials for protein sources such as fish meal and soybean meal have increasingly high prices on the market because most of them are still imported and their availability is also decreasing in nature (Fatmawati et al., 2022). In addition, most farmers still rely on imported raw materials around 70% (Alim, 2016).

One alternative that must be done is to use local raw materials whose use does not compete with human needs, is easy to obtain and has high nutritional value, one of which is duck bone meal. Duck bones are waste from the poultry industry. Duck bones contain minerals such as calcium and phosphorus that support the growth and health of fish. Research (Qisti et al., 2021) shows that duck bone meal contains quite high protein, namely 40.7% protein with variations depending on the processing method. By using duck bone meal, feed costs can be reduced and dependence on fish meal whose prices fluctuate can be reduced. The use of duck bone meal as an alternative raw material is also in line with the principles of environmentally friendly waste processing, helping to reduce poultry industry waste and supporting sustainable fisheries cultivation (Nasution et al., 2020).

Duck bone meal obtained from duck bone waste will be the best alternative to be developed because it has a high nutritional content. In addition, duck bone meal can also be used as a substitute for feed raw materials. Meat and bone meal contains around 45 - 55%

protein (Qisti et al., 2021). However, the use of duck bone meal is still limited because its digestibility value is low so that before being mixed as a feed additive, duck bone meal must go through a fermentation process first. Fermentation is an effort to improve nutritional quality, reduce and even eliminate the effects of certain feed ingredients which can be done by using microorganisms (Nista et al., 2007).

Fermentation involves microorganisms in the process to convert organic matter into a form that is easier to digest. The use of mixed microorganisms, such as lactic acid bacteria, yeast, and protein-degrading bacteria, can improve the nutritional quality of duck bone meal by increasing protein digestibility, reducing anti-nutritional compounds, and increasing the availability of essential minerals. The same thing is explained by (Lukman et al., 2021), regarding the type of probiotic *Bacillus* sp. added to fish feed, where the addition of probiotic *Bacillus* sp. has been shown to accelerate weight gain in carp. Meanwhile, according to (He et al., 2011). Giving yeast containing *Saccharomyces cerevisiae* cells to feed can improve fish growth performance. Probiotic application can be done by mixing it in feed (oral) or adding it to the maintenance medium (environment) to increase growth and immune response in fish. Meanwhile, fermentation using probiotics of the *Rhizopus* sp. type is known to increase the nutritional value of food ingredients (Endrawati & Kusumaningtyas, 2017). This study aims to determine the effect of different doses of mixed microorganisms in artificial feed on feed efficiency, survival and feed conversion ratio (FCR) of tilapia. Thus, fermentation of duck bone meal using mixed microorganisms not only offers a solution to reduce feed costs, but also supports more environmentally friendly and sustainable fish farming practices.

METHODS

Time and Place

This research was conducted in January-March 2025 located in Tonrong Rijang Village, Baranti District, Sidenreng Rappang Regency, South Sulawesi Province.

Tools and Materials

The tools and materials used in this study were basins, spoons, measuring cups, sieves, nets, digital scales, digital pH meters, cameras, duck bone meal, mixed microorganisms, corn flour, soybean flour, shrimp head flour, wheat flour, rice bran, tilapia, vitamins and minerals.

Research Preparation

Research Container

The container used in this study was 15 meatballs with a diameter of 18 cm, each with a water capacity of 15 liters.

Test Animals

The fish used in this study were 20 tilapia/container, with a size of ±2 grams/fish. The fish were obtained from the Baranti Fish Seed Center (BBI), Sidenreng Rappang Regency, South Sulawesi.

Preparation of Duck Bones and Microorganism Mix

The process of making duck bone flour is first done by cleaning, washing and reducing the size of the bones. Furthermore, boiling is carried out with a pressure cooker for 1 hour in order to obtain softer bones to make it easier to flatten after that the drying process is carried out under sunlight or using an oven for 20 hours at a temperature of 60^0C, the dried bones are blended until smooth and sieved after that duck bone flour is obtained.

The mix of microorganisms used in this study were *Bacillus* sp., *Rhizopus* sp. and *Saccharomyces* sp. mixed based on the method of Aslamyah et al. (2017) with a composition of 1 ml + 1g + 1g / 100g flour). *Bacillus* sp. used with a density of 1.5×10^8 cfu/ml, tempeh yeast with a density of 1.6×10^7 cfu/g from *Rhizopus* sp. and bread yeast with a density of 1.2

× 10^8 cfu/g from *Saccharomyces* sp. The three microorganisms were first refreshed by *Bacillus* sp. cultured by adding coconut water and granulated sugar, 2 ml + 2 l + 500g each for 24 hours. While *Rhizopus* sp. and *Saccharomyces* sp. A total of 7.5g each was added with 10g of granulated sugar and diluted by adding 100 ml of aquadest and refreshed for one hour. *Bacillus* sp., *Rhizopus* sp. and *Saccharomyces* sp. were homogenized by diluting a total of 12 ml.

Duck Bone Meal Fermentation Preparation Process

The duck bone meal fermentation process begins by adding 1.5 ml of mixed fermenter microorganisms per 100 g of duck bone meal, then incubated for 36 hours. The fermenter solution is sprayed evenly using a sprayer, then the bone meal is put into a plastic clip and tightly closed to prevent air from entering. The plastic containing the fermented bone meal is stored in a box to keep the room temperature stable during the fermentation process for 36 hours. After fermentation is complete, the duck bone meal is steamed at 60°C for one minute to stop enzyme activity, then cooled to room temperature. The final fermentation product is then analyzed in the Feed Chemistry Laboratory, Faculty of Animal Husbandry, Hasanuddin University, to identify changes in chemical composition resulting from the fermentation process.

Test Feed

The feed manufacturing process begins with the raw material preparation stage, followed by weighing each ingredient according to the required proportion. The weighed ingredients are then mixed evenly to ensure optimal nutrient distribution in the feed. After mixing, the feed mixture is molded according to the desired shape, then dried to a safe water content for storage and application. The dried feed is then packaged to maintain its quality. Once completed, the feed is ready to be applied to tilapia, and the development of the fish can be observed periodically to evaluate the effectiveness of the feed. The main raw materials used include fish meal, duck bone meal, soybean meal, corn meal, rice bran, vitamins and minerals, mixed microorganisms, and fish oil, all of which contribute to meeting the nutritional needs of tilapia.

Research Procedure

Treatment and Experimental Design

This study used a completely randomized design (CRD) with 5 treatments and 3 replications, so that there were 15 experimental containers, where each container was filled with 15 test animals, the treatments given were as follows:

1. Treatment A = 10% fermented duck bone meal;
2. Treatment B = 15% fermented duck bone meal;
3. Treatment C = 20% fermented duck bone meal;
4. Treatment D = 25% fermented duck bone meal;
5. Treatment E = 30% fermented duck bone meal.

Maintenance

The tilapia used were put into a basin with an initial density of 20 fish/container. Before the start of the study, the fish were acclimatized for approximately 20 minutes. In addition, the fish were fasted for 24 hours before the study began.

The fish maintenance process was carried out for 30 days. During the maintenance period, the fish were fed twice a day, namely at 08.00 WITA and 16.00 WITA. Feeding was carried out with a dose of 5% of the total body weight of the fish in each container. Water quality parameters, such as temperature and pH, were monitored periodically to ensure that the fish's living environment remained optimal during the study period. After 30 days, final data collection was carried out, including weighing the fish to measure growth, as well as other parameters relevant to the research objectives.

Observed Parameters

Survival Rate

The survival rate was measured using the formula according to Effendie (1997) as follows:

$$SR = \frac{No - Nt}{No} \times 100\%$$

Description:
SR : Fish survival (%);
Nt : Number of fish at the end of the study (fish);
No : Number of fish at the beginning of the study (fish).

Feed Efficiency

The feed consumed will be utilized, one of which is for growth. The utilized feed is called feed efficiency. Feed Efficiency (EP) can be found using the formula (NRC, 1983) in Ariyana (2015):

$$EPP = \frac{Wt - Wo}{F} \times 100\%$$

Description:
EPP : Feed Efficiency
Wt : Total weight of test samples at the end of the study (g);
Wd : Total weight of test samples that died during the study (g);
Wo : Total weight of test samples at the beginning of the study (g);
F : Total weight of feed consumed during the study (g).

Feed Conversion Ratio (FCR)

Feed conversion ratio (FCR) is the ratio between the weight of fish produced and the amount of feed given. Effendie (1997) stated that FCR can be calculated using the following formula:

$$FCR = \frac{F}{(Wt + D) - Wo} \times 100\%$$

Description:
FCR : Feed conversion ratio;
F : Amount of feed consumed;
D : Number of dead fish;
Wo : Weight of test animals at the beginning of maintenance;
Wt : Weight of test animals at the end of the study.

Water Quality

Water quality measurements are carried out every day using a digital thermometer and pH meter. The water quality measured is temperature, pH, the water source used is fresh water from a drill and collected in a bucket.

Data Analysis

The data analysis used in this study is analysis of variance or Analysis of Variance (ANOVA) test if the results have a significant effect, then it is continued with the W-Tukey test to see which treatment gives the best results, while the water quality analysis is carried out descriptively with the viability of tilapia.

RESULTS

Survival Rate

Survival with the provision of fermented duck bone meal artificial feed with different treatments (10% fermented duck bone meal, 15% fermented duck bone meal, 20% fermented duck bone meal, 25% fermented duck bone meal and 30% fermented duck bone meal) is shown in Table 1.

Table 1. Average Survival Rate of Tilapia During the Study

Treatment	Parameter ± Std
	Survival Rate (%/day)
A	66.67 ± 2.88^{c}
B	70.00 ± 5.00^{c}
C	73.33 ± 2.88^{bc}
D	86.67 ± 2.88^{a}
E	81.67 ± 2.88^{ab}

Description: Different superscript letters in the same column indicate significant differences between treatments at the 95% confidence level (P<0.05).

Feed Efficiency

The feed efficiency of tilapia fish with artificial feed of fermented duck bone meal with different treatments (10% fermented duck bone meal, 15% fermented duck bone meal, 20% fermented duck bone meal, 25% fermented duck bone meal and 30% fermented duck bone meal) is shown in Table 2.

Table 2. Average Feed Efficiency of Tilapia During the Study

Treatment	Parameter ± Std
	Feed Efficiency
A	3.880 ± 0.12^{b}
B	4.081 ± 0.08^{b}
C	4.754 ± 0.72^{a}
D	4.908 ± 0.39^{a}
E	5.029 ± 0.35^{a}

Description: Different superscript letters in the same column indicate significant differences between treatments at the 95% confidence level (P<0.05).

Feed Conversion Ratio

The feed conversion ratio of tilapia fish fed with fermented duck bone meal with different treatments (10% fermented duck bone meal, 15% fermented duck bone meal, 20% fermented duck bone meal, 25% fermented duck bone meal and 30% fermented duck bone meal) is shown in Table 3.

Table 3. Average Feed Conversion Ratio of Tilapia During the Study

Parameter	Parameter ± Std
	Feed Conversion Ratio
A	2.906 ± 0.08^{c}
B	2.663 ± 0.31^{c}
C	2.326 ± 0.11^{b}
D	1.826 ± 0.07^{a}
E	2.063 ± 0.06^{ab}

Description: Different superscript letters in the same column indicate significant differences between treatments at the 95% confidence level (P<0.05).

Water Quality

The average water quality values are shown in Table 4.

Table 4. Average Water Quality Values of Tilapia During Maintenance

Parameter	Treatment				
	A	B	C	D	E
Temperature	29.72°C	27.20°C	29.23°C	28.61°C	27.27°C
pH	8.5	7.9	8.0	7.7	8.2

DISCUSSION

Survival Rate

The results of the analysis of variance showed that the provision of fermented duck bone meal artificial feed had a significant effect on the survival of tilapia ($P<0.005$). The W-Tukey test showed that the provision of fermented duck bone meal artificial feed was different in treatment D and treatments A, B and C but the same as treatment E

The results of the study showed that the survival of tilapia that had been maintained for 30 days with the provision of fermented duck bone meal artificial feed with different treatments. The highest survival value was in treatment D with a value of 86.67%, treatment E 81.67%, treatment C 73.33%, treatment B 70.00% and the lowest survival value was in treatment A with a value of 66.67%.

The survival value obtained in treatment D was relatively high, this is thought to be due to the addition of microorganisms that can improve feed quality and meet feed requirements for the survival of tilapia during maintenance. According to Rahim et al. (2021), probiotic bacteria are safe and relatively beneficial bacteria in the digestive tract, these bacteria produce substances that are not harmful to fish but actually destroy pathogenic bacteria that disrupt the digestive system so that they can increase the immunity of fish which can make fish survive. Thus, the use of feed given probiotics can reduce the mortality rate caused by pathogens and waste in research containers. This is supported by Prananti (2022), that the use of probiotics can increase the survival rate and resistance of fish to pathogen infections and reduce the environmental burden due to the accumulation of waste in maintenance containers. Thus, the use of feed given probiotics can reduce the mortality rate caused by pathogens and waste in research containers.

Research conducted by Fitriyanto et al. (2020) shows that fish that consume probiotic feed have a higher survival rate, with a survival rate reaching 90%, compared to the control group which only reached 75%. This is due to the increase in the fish's immune system due to the consumption of probiotics, which plays a role in increasing the fish's immune system against various pathogen infections. The same thing is explained by Abrar et al. (2019) that the provision of probiotics in feed is useful for increasing fish digestibility of feed by increasing digestive enzymes that can hydrolyze proteins into simpler compounds so that they are easily absorbed and used for growth

Fermented feed is easier for fish to digest than unfermented feed so that fish only need less energy to digest it and the excess energy can be used for growth, one of which is for increasing fish weight. fermentation itself is breaking down materials that are not easily digested such as cellulose into simple sugars that are easily digested with the help of microorganisms. The enzymes produced in the fermentation process can improve nutritional value, growth, and increase the digestibility of crude fiber, protein and other feed nutrients (Amarwati, 2015).

In treatments B and A, the survival rate was relatively low, namely below 73%. According to Andriyan et al. (2018), the average good fish survival rate ranges from 73.5-86.0%. According to Mustofa et al. (2018), survival is influenced by environmental factors, such as fish handling and water quality, if the handling is not done properly, it can cause fish stress, so that the health condition of the fish decreases and can cause death. In the same study conducted by Fitriyanto et al. (2020) that the provision of probiotics in feed obtained the results of the survival rate of sangkuriang catfish seeds of 80%. While in this study, the addition of probiotic microorganisms mixes to artificial feed resulted in a survival rate of tilapia of 66.67-86.67%.

Feed Efficiency

The results of the analysis of variance showed that the provision of fermented duck bone meal artificial feed had a significant effect on the feed efficiency of tilapia (P>0.05). The W-Tukey test showed that the provision of fermented duck bone meal artificial feed was different in treatment E and treatments A, B, but the same as treatments C and D.

The results showed that the provision of fermented duck bone meal artificial feed to test animals had the highest value in treatment E with a value of 5.029%, then treatment D with a value of 4.908%, treatment C with a value of 4.754%, treatment B with a value of 4.081% and the lowest feed efficiency value in treatment A with a value of 3.880%.

The highest feed efficiency value was in treatment E with a value of 5.029%, this is thought to be due to the increased efforts of fish to maximize the nutritional content, especially protein in feed for growth. This is supported by Tjodi et al. (2016) providing quality feed, liked by fish, and according to fish needs in addition to increasing the degree of feed efficiency can also stimulate fish growth, the higher the feed efficiency value means that fish can respond well to feed which is indicated by faster fish growth. According to Trisnasari et al. (2020) the higher the feed efficiency value indicates that the quality of the feed given is better.

Another factor that causes high feed efficiency in treatment E is thought to be due to the bacterial content from the *Bacillus* sp. type which plays a role in helping to increase feed digestibility. Bacillus plays a role in the field of pathogen control, as a decomposer of aquatic waste by reducing the level of organic pollution and increasing the availability of oxygen for fish and increasing the digestive ability of fish with the production of digestive enzymes that are very helpful for fish in digesting the feed consumed so that feed efficiency can increase and fish growth is more optimal. It was further reported Efendi et al. (2017) that *Bacillus subtilis* bacteria have proteolytic bacterial/microbial activity, and are able to hydrolyze proteins into simple amino acids (Fitriana & Asri, 2022).

The presence of bacteria (*Saccharmyces cerevisiae*) in fermented feed causes the breakdown of complex compounds into simpler ones so that fish can utilize feed more efficiently to support growth (Manganang & Mose, 2019). This is in line with Lumbanbatu (2018) who stated that probiotic bacteria in feed are able to produce enzymes that function to break down nutrients so that they can optimize nutrient absorption in the digestive tract. And with the presence of probiotics in feed which then enter the digestive tract, it can suppress the development of pathogenic bacteria in the intestines, thereby helping digestion of food faster.

In treatment A with a value of 3.880% is the lowest efficiency value, this is thought to be due to several factors including the level of fish's preference for the feed given, their eating habits and the dose of probiotics given. This is reinforced by the opinion of Surianti et al. (2020) who added that in addition to eating habits, the ability of organisms to digest the feed given is also influenced by several factors, such as the nutritional value of the feed and the availability of feed. When associated with the performance of enzymes in the fish's digestive tract, the dose of probiotics given is thought to also affect the feed efficiency value because the ineffectiveness of the probiotic bacterial mechanism in producing digestive enzymes in the fish's digestive tract is the cause of low feed efficiency because it will affect the level of absorption of feed nutrients by fish.

Another factor that affects low efficiency is the provision of feed with unbalanced nutrition so that it can cause tilapia to not be able to utilize the feed optimally. This is in accordance with the opinion of Yudiarini et al. (2024) that poor quality or unbalanced feed can make it difficult for fish to digest and absorb nutrients, so that the feed is not efficient and fish growth is slow or even causes death.

Feed Conversion Ratio

The results of the analysis of variance showed that the provision of fermented duck bone meal artificial feed had a significant effect on the feed efficiency of tilapia (P>0.05). The W-Tukey test showed that the provision of fermented duck bone meal artificial feed was different in treatment D and treatments A, B and C but the same as treatment E

The results showed that the provision of fermented duck bone meal artificial feed to test animals had the highest value in treatment A with a value of 2.906%, then treatment B with a value of 2.663%, treatment C with a value of 2.326%, treatment E with a value of 2.063% and the lowest feed efficiency value in treatment D with a value of 1.826%.

A smaller FCR value indicates a better level of feed utilization efficiency and a high FCR value indicates a poor level of feed utilization efficiency. In accordance with the statement Lestari et al. (2022) feed conversion is the comparison between the amount of feed given and the amount of fish weight produced. According to Surnawati et al. (2020), a low feed conversion value indicates that the feed given to farmed fish can be optimally absorbed by the fish's body and used for weight gain. Furthermore, Iskandar & Elrifadah (2015) also explain that the smaller the feed conversion ratio, the better the level of feed efficiency, conversely, the higher the feed conversion value, the lower the level of feed efficiency.

The high feed conversion value indicates that more feed is needed to be converted into meat. This has an impact on feed costs which will be higher. The high feed conversion value in treatment A is thought to be related to the low efficiency of feed utilization in treatment A. This is due to the level of fish's preference for the feed given and the low dose of probiotics given so that the fish's digestive ability to feed nutrients is reduced and the lack of decomposing bacteria contained in the feed so that more feed is not absorbed and wasted. Probiotics help increase the efficiency of digestion and absorption of nutrients, so that with less probiotics, fish cannot utilize feed optimally and the cause of low feed efficiency will affect the level of absorption of feed nutrients by fish (Armin et al., 2024). The same thing is explained by Hariani & Purnomo (2017) that giving probiotics in feed can reduce FCR from treatments that are not given probiotics.

Another factor that causes the high feed conversion value is thought to be due to the high level of fish stress caused by changes in environmental conditions. The same thing is explained by Zulkarnain et al. (2017), that mortality can be caused by stress arising from environmental conditions and high density which causes the immune system to decrease. This stress can reduce the ability of the immune system to fight disease, thereby increasing the risk of death.

Water Quality

Based on Table 4, the water quality, namely temperature and pH during the 30-day maintenance period, is in good condition. This is because the measured parameters have met the Indonesian National Standard (SNI) for tilapia maintenance (Octarina et al., 2018). The results of observations of tilapia maintenance water quality show that it is still in a stable range and supports tilapia cultivation. The temperature ranges from 27-29°C with a pH range between 7.7-8.5.

The average water temperature during the study was in the optimal range, namely at a temperature of 27-29°C. This is in accordance with the opinion of Siegersa et al. (2021) that the optimum temperature for tilapia maintenance is around 25-32◦C. This opinion is reinforced by Indriati & Hafiludin (2022) that the standard for water quality based on SNI regarding tilapia temperature is 25-30°C.

During the study, the water pH ranged from 7.7 to 8.5. This is in accordance with the explanation Indriati & Hafiludin (2022) that the standard for water quality based on SNI regarding the production of tilapia (*Oreochromis niloticus*) is 6.5-8.5. The same thing is explained by Siegersa et al. (2021) that saline tilapia can survive at pH 6-9. Thus, the pH and temperature range in this study is still suitable for the life of tilapia (*Oreochromis niloticus*).

CONCLUSION

Based on the results of the study, it can be concluded that the use of fermented duck bone meal in artificial feed can be used as a source of protein in tilapia feed with a protein content of 40.71%. Treatment D - with 25% fermented duck bone meal had the best results in terms of survival and feed conversion ratio of tilapia, while treatment E - with 30% fermented duck bone meal had the best results in terms of feed efficiency. This combination percentage is superior in the use of feed that can reduce commercial feed costs. The results of water quality analysis during the study showed that temperature (27–29°C) and pH (7.7–8.5) were in a stable range and supported cultivation.

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