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The Effect of Adding Water Hyacinth *(Eichhornia crassipes)* Fermented with Aspergillus niger in Feed on Protein Retention of Tilapia *(Orechormis niloticus)*

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Abstract: Feed is one of the important factors in fish farming, because it can account for 60–70% of the total operational costs of cultivation. The purpose of this study was to analyze the effect of providing water hyacinth (Eichhornia crassipes) fermented with Aspergillus niger as feed on the growth performance of tilapia (Oreochromis niloticus). This study used an experimental method and a Completely Randomized Design (CRD) consisting of five treatments and three replications, with the composition of P0 (commercial pellets) as the control, P1 (30% unfermented water hyacinth flour), and P2 (10%), P3 (20%), and P4 (30%) fermented water hyacinth flour. The results of this study showed that the addition of water hyacinth flour fermented with Aspergillus niger had no significant effect ($P > 0.05$) on tilapia protein retention. It was also known that the water quality in the tilapia maintenance media was within the optimal range.

Keywords: Aspergillus niger; Feed; Protein; Tilapia; Water hyacinth

Introduction

Aceh Province offers promising prospects for freshwater fish farming, as evidenced by the high public demand for freshwater fish. Freshwater fish farming is a viable business option for fish farmers due to its high development potential and stable income potential (Taufiq et al., 2016). Tilapia *(Oreochromis niloticus)* is a leading freshwater fish commodity in Indonesia (Nugroho, 2024).

Tilapia is a freshwater fish species with high economic value and significant potential for cultivation (Afifah et al., 2025). According to data from the Ministry of Marine Affairs and Fisheries (2024), tilapia production experienced a significant increase from 2020 to 2024, averaging approximately 1.19%. This was driven by high consumer demand and competitive prices both locally and for export (Setiyowati et al., 2022). In terms of exports, tilapia is also a leading commodity intensively produced worldwide (FAO, 2017). Tilapia cultivation has reached global levels in various countries (Shen et al., 2021; Sherif & Kassab, 2023) and ranks third in the world (FAO, 2020).

The main factor supporting the commercial value of tilapia is its high protein content, making it a valuable source of animal protein for the human body (Afriani et al., 2016). This is important, considering that fish is a major source of protein (Youssef et al., 2023; Zaher et al., 2021), vitamins, and minerals that are highly beneficial for human life (Qu et al., 2022). The protein content in tilapia meat accounts for two-thirds of the total human animal protein requirement. This is because tilapia has a relatively high protein content, at 15-25% per 100 grams of fish meat (Sholahuddin & Prayoga, 2023). This protein

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content is higher than that of several other fish species, such as catfish, gourami, tuna, and skipjack tuna (Fillaili et al., 2020).

The nutritional value and growth of tilapia are influenced by internal and external factors. Internal factors include the strain and quality of superior seeds, while external factors include feed, water media, and disease (Setiyowati et al., 2022). Quality feed is a key factor significantly influencing tilapia growth and nutrition (Yang et al., 2022). In aquaculture, growth is a key factor in determining success. However, a common problem is the low protein content in feed, which results in less-than-optimal fish growth (Masitoh, 2015). Another frequently encountered problem is the relatively high price of commercial feed (Sari et al., 2017).

Currently, fish farmers generally rely on commercial feed, which accounts for 60–70% of total production costs (Azzahra et al., 2023; Zulkhasyni & Ratih, 2017). A promising approach to reducing commercial feed use is utilizing water hyacinth as a feed ingredient (Nagarjun et al., 2019) due to its high nutritional value, relatively low production costs, and abundant availability (Islama et al., 2023; Mustari et al., 2025).

A proximate analysis of water hyacinth (WH) indicates that water hyacinth is composed of 50% protein and 33% carbohydrates, with other nutrients consisting of fat, ash, and fiber (Adeyemi & Osubor, 2016). Therefore, it is expected to improve feed quality and protein retention in tilapia *(Oreochromis niloticus)*. However, water hyacinth has the disadvantage of containing high crude fiber (Irawati et al., 2019). One way to reduce crude fiber levels is through fermentation using Aspergillus niger (Nazlia, 2019). Therefore, it is necessary to test the effect of fermented water hyacinth flour in feed on tilapia protein retention.

Method

Time and Place

This research was conducted from April to May 2025. The rearing and treatment of the test fish were conducted at the Fish Hatchery and Breeding Laboratory, Faculty of Marine Affairs and Fisheries, Syiah Kuala University. Proximate analysis of feed and protein retention was conducted at the Nutrition Science, Technology, and Forage Laboratory, Faculty of Agriculture, Syiah Kuala University.

Research Objects

The subjects of this study were 180 tilapia fish with an average weight of 1.17–1.39 ± 0.064 g and a body length of 4.07–4.27 ± 0.057 cm per fish. These fish were obtained from the Brackishwater Aquaculture Center (UPTD) of Ujung Batee, Aceh Besar Regency, along with water hyacinth, which was used as tilapia feed.

Research Design

This research was quantitative, using an experimental method with a non-factorial Completely Randomized Design (CRD) consisting of 6 treatments and 3 replications, resulting in 18 experimental units. According to Kurniawan et al. (2022), the treatments in this study were:
Treatment P0 = Commercial pellets (control)
Treatment P1 = 30% water hyacinth flour
Treatment P2 = 10% fermented water hyacinth flour
Treatment P3 = 20% fermented water hyacinth flour
Treatment P4 = 30% fermented water hyacinth flour
Treatment P5 = 40% fermented water hyacinth flour

Research Procedures

Test Feed Preparation

Water Hyacinth Flour Preparation

Feed preparation began with collecting water hyacinth from the Cot Irie area, Krueng Barona Jaya District, Aceh Besar. After collecting the water hyacinth, it was washed thoroughly. Next, it was cut into smaller pieces and dried in the sun for 3–4 days. Once dry, the water hyacinth was ground using a flour mill until it was finely ground. The water hyacinth flour was then fermented using the fungus Aspergillus niger.

Water Hyacinth Flour Fermentation Procedure

The fermentation process involved placing the water hyacinth flour in a heat-resistant plastic bag and sterilizing it in an oven at 121°C for 15 minutes. After cooling, the substrate was placed into the container, where 10% Aspergillus niger was added. The mixture was then stirred until homogeneous, and sterile water was added as needed. The container was then covered with plastic wrap and punctured with a sterile needle. The substrate was incubated for three days at room temperature. After incubation, the substrate was dried again. A proximate test was then performed to determine the crude fiber content of the fermented water hyacinth flour.

Feed Formulation

The test feed used in this study was a pellet formulation containing 32% protein. The proportion of fermented water hyacinth flour in the feed was adjusted for each treatment, and the composition of other formulation ingredients was determined based on previously prepared calculations. The ingredients for making alternative feed for tilapia consisted of fermented water hyacinth flour, fish meal, rice bran, tapioca flour, wheat flour, corn flour, fish oil, corn oil, premix, and CMC. Before use, all raw feed ingredients that were not in flour form were air-dried. Once dry, they were ground using a flour mill to form a fine flour and then sieved. The following table shows the feed formulation used in this study.

Table 1. Feed Formula Used in Research with 32% Protein Content

Feed Ingredients	Protein Raw Material (%)	Amount of Feed Ingredients (%)				
		P0	P1	P2	P3	P4
Fish meal	58.60	42	42	42	42	42
Rice bran	45.06	5	5	5	5	5
FWHF	12.75	0	10	20	30	40
Tapioca flour	9.00	5	5	5	5	5
Wheat flour	8.90	5	5	5	5	5
Corn flour	11.00	41	31	21	11	1
Fish oil	0.50	0.5	0.5	0.5	0.5	0.5
Corn oil	0.00	0.5	0.5	0.5	0.5	0.5
Premix	0.00	0.5	0.5	0.5	0.5	0.5
CMC	0.30	0.5	0.5	0.5	0.5	0.5
Total Formulation Content (%)		100	100	100	100	100
Total Feed Protein (%)		32.27	32.44	32.62	32.79	32.97

Description: FWHF (Fermented Water Hyacinth Flour)

The feed formulation table above has been adjusted based on the nutritional needs of tilapia. The calculations used in formulating the feed were based on a trial-and-error method. The pelleting process began with mixing the feed ingredients from the smallest to the largest quantities according to the predetermined ratios for each treatment. During the pelleting process, 2% of the total weight of the ingredients was added as a binder. The pelleting ingredients were then stirred until thoroughly mixed. Once thoroughly mixed, 30% of the total ingredients was added using warm water. The water was added while stirring until the ingredients were evenly distributed and smooth. This allowed the feed to be formed into pellets using a mill and dried until the feed reached constant moisture content and was dry.

Preparation for Test Fish

Acclimatization Procedure

The acclimatization process involved placing the plastic bag containing the test fish in a bucket of water for 30 minutes. After the acclimatization process was completed, the fish were fasted for 24 hours to eliminate any residual feed and encourage them to consume the water hyacinth feed. After the fast, each sample of test fish was weighed to determine its initial weight and body length.

Treatment Test Procedure

The research containers used in this study were 18 plastic buckets (26 L capacity). The buckets were then filled with 6 L of water to a height of 20 cm. Fifteen test fish were then stocked in each rearing bucket. The fish were then fed Aspergillus niger-fermented water hyacinth feed according to the prescribed treatment for 42 days. Feeding frequency was three times daily: in the morning at 08:00, at 12:00, and in the evening at 16:00. The feed amounted to 5% of the total body weight of the tilapia. Every 14 days, the tilapia were weighed again to determine their weight and body length. During the rearing process, siphoning was performed to remove any unconsumed feed after 2 hours of feeding. Water was then added again until the volume reached its original level.

Research Parameters

Protein Retention

Protein retention was calculated using the Formula 1 (Muchlisin, Afrido, et al., 2016).

$$Protein\ Retention = \frac{\text{(Final body protein−initial body protein) g}}{\text{Total protein given (g)}} \text{ x } 100\% \quad (1)$$

Water Quality Measurement

Water quality parameters in this study included water temperature, measured using a thermometer, and water pH, measured using a pH meter (Muchlisin, Arisa, et al., 2016).

Data Analysis

Data were analyzed using Statistical Product and Service Solutions (SPSS) version 25 with analysis of variance (ANOVA). If a significant effect was found, further testing was conducted using Duncan's multiple range test.

Results and Discussion

Tilapia Protein Retention

Protein retention reflects the amount of protein provided and utilized by fish to build or repair damaged cells and support their metabolic processes (Wiradana et al., 2024). The growth rate of tilapia is influenced by the amount of protein that can be absorbed and utilized by the body as a building material (Ibrahim et al., 2024). Fish require higher amounts of protein in their feed than other vertebrates (Sulivany et al., 2024). Currently, the feed formulation of Aspergillus niger-fermented water hyacinth flour used in this study contains 32% protein.

Based on the results of the 42-day fish rearing period, the addition of Aspergillus niger-fermented water hyacinth *(Eichhornia crassipes)* flour to the feed formulation resulted in an average protein retention value of tilapia *(Orechromis niloticus)* ranging from 17.42 to 28.56. The analysis of variance results showed that the protein retention parameter had no significant effect (P>0.05) on the addition of fermented water hyacinth flour. The average protein retention values for tilapia are shown in Table 2 below.

Table 2. Tilapia Protein Retention Results

Treatment	Protein Retention (%)
P0	22.55 ± 4.03
P1	17.42 ± 7.11
P2	25.08 ± 10.13
P3	26.48 ± 3.38
P4	28.56 ± 4.68
P5	24.45 ± 7.96

Description: P0 (commercial pellets); P1 (30% unfermented water hyacinth flour feed); and P2 (10%); P3 (20%); P4 (30%); P5 (40%) fermented water hyacinth flour feed.

The results of this study indicate that tilapia have average protein retention values that do not differ significantly between each treatment, as can be seen in Figure 1 below. The analysis of variance showed that the highest protein retention value for tilapia was achieved with the addition of 30% fermented water hyacinth flour with Aspergillus niger (P4) with an average value of 28.56 ± 4.68%. The lowest value was found in the treatment with 30% unfermented water hyacinth (P1) with an average value of 17.42 ± 7.11%.

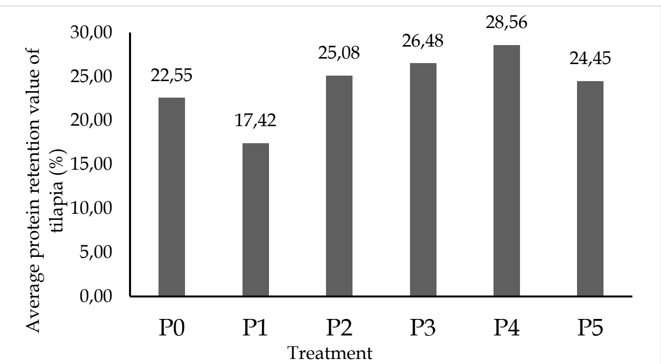

Figure 1. Average Protein Retention Graph of Tilapia Fish

The average protein retention values of tilapia did not differ significantly between treatments. This is likely due to tilapia maintaining stable protein levels. This finding aligns with research Masfirotun & Luthfiyah (2021) on protein retention in vannamei shrimp, which consistently maintains stable protein levels in the body. This finding also aligns with research Subekti et al. (2011) on eel protein retention, which showed no significant effect because each feed treatment had the same effect. This is likely due to the relatively similar protein content in the fish feed.

The results of this study showed that the highest analysis of variance (ANOVA) value was obtained in treatment (P4) with a 30% water hyacinth flour supplementation. This is likely due to the nutritional suitability of the feed in treatment (P4). As stated by Khalida et al. (2017), high-biological-value protein content in feed will stimulate greater protein accumulation in the fish's body compared to low-biological-value protein content in feed. This aligns with Sahendra et al. (2023), who stated that in fish, protein feed is digested to release amino acids for absorption and distribution throughout the body's organs and tissues through the bloodstream. Similarly, Teodósio et al. (2022) also revealed that protein utilization in feed is primarily influenced by the amino acid profile of the fish.

The lowest average protein value was found in treatment (P1) with an unfermented water hyacinth feed formulation. This indicates that less energy is obtained and stored in the fish's body, thus inhibiting their growth rate. According to Saputra et al. (2020), low protein retention is caused by excessively high crude fiber content in the feed, which accelerates the passage of the consumed feed through the intestines, reducing nutrient absorption and ultimately leading to low protein retention in the fish. Therefore, feed should be fermented with Aspergillus niger to reduce crude fiber levels due to the enzyme activity of molds capable of degrading crude fiber (Ikhwanuddin et al., 2018). Ningrum et al. (2023) added that Aspergillus niger can also convert substrates into high-energy products.

Water Quality Analysis Results

The results of the study showed that the water quality in the laboratory where the tilapia were raised was in good and normal condition. The average water temperature during the study was in the range of 27.1-28.8°C, with a water pH ranging from 6.3-7.5. This is supported by the opinions of Azhari & Tomasoa (2018); Muarif (2016), who stated that a good water temperature range during tilapia rearing is 25-30°C, while the optimal pH range for tilapia growth and reproduction is

6-8 (Iskandar et al., 2024). The results of water quality tests during the study can be seen in Table 3 below.

Table 3. Water quality values during rearing

Treatment	Temperature (°C)	pH
P0	27.4-28.7	6.8-7.4
P1	27.3-28.3	6.5-7.3
P2	27.6-28.5	6.9-7.5
P3	27.5-28.8	6.7-7.4
P4	27.2-28	6.4-7.2
P5	27.1-28.1	6.3-7.1

Description: P0 (commercial pellets); P1 (30% unfermented water hyacinth flour feed); and P2 (10%); P3 (20%); P4 (30%); P5 (40%) fermented water hyacinth flour feed.

Water quality during the 42-day rearing period significantly influences the growth performance of tilapia, as water quality plays a crucial role in increasing fish farming production (Abdel-Wahed et al., 2018). According to Scabra & Setyowati (2019), water quality can be assessed from both physical and chemical parameters. If these parameters meet the fish's needs, the water quality in the rearing pond is considered good. Indicators used to measure water quality in this study included water temperature and pH. The results of the study indicate that environmental and feed quality during the rearing period positively impacted tilapia adaptation. This is likely due to suitable environmental conditions that support optimal growth rates for tilapia.

Temperature is an important factor in supporting the survival and productivity of tilapia. According to Pramleonita et al. (2018) the higher the water temperature, the lower the oxygen solubility and the higher the toxicity. Arifin (2016) stated that fish can survive optimally at normal temperatures but can also experience lethality at temperatures that are too low or too high, thus disrupting their survival. Lethal temperatures range from 10-11°C. Ridwantara et al. (2019) also added that low temperatures cause the metabolism of fish enzymes and growth hormones to function suboptimally. High temperatures increase the rate of metabolism, respiration, and oxygen consumption in fish. This agrees with Putra (2015)who stated that increasing temperature increases the respiration process. According to Nadiro et al. (2023), energy for respiration is included in the basal metabolic rate (the minimum energy required for fish to survive). Therefore, increasing temperature will increase basal metabolic rate.

PH plays a crucial role in aquaculture because it is related to the ability to grow and reproduce. This is also in line with Swain et al. (2020), who stated that changes in pH, whether increasing or decreasing, can inhibit physiological or metabolic functions of fish, such as growth, reproduction, and ecological distribution. Dahril et al. (2017) stated that suboptimal acidity (pH) can cause fish to experience stress, be susceptible to disease, and have low productivity and growth. Thus, acidity (pH) is an important factor and acts as a limiting factor in waters (Anasiru et al., 2024). Therefore, this study proves that good water quality parameters during the maintenance period are a key factor in the success of the research, thus encouraging the use of fish feed to support high growth rates and survival.

Conclusion

Based on the research results, it can be concluded that the addition of water hyacinth flour fermented with Aspergillus niger to feed had no significant effect ($P > 0.05$) on tilapia protein retention. However, it had a significant role in maintaining water quality during the 42-day rearing period, thereby supporting tilapia growth performance.

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Author contributions

S. Azzahra, F. Firdus, and L. Fitri formulated the idea and conceptualized the research presented; S. Azzahra developed the theory and performed the data analysis; F. Firdus and L. Fitri verified the analytical method; S. Azzahra provided writing, revision, and editing. All authors discussed the research results, contributed to, and approved the publication of the final manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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