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THE EFFECT OF FERMENTATION TIME OF PAPAYA LEAVES (*Carica papaya*) ON THE GROWTH AND SURVIVAL RATE OF NILE TILAPIA (*Oreochromis niloticus*)

Pengaruh Lama Fermentasi Daun Pepaya (*Carica papaya*) Terhadap Pertumbuhan dan Sintasan Ikan Nila (*Oreochromis niloticus*)

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ABSTRACT

Tilapia (*Oreochromis niloticus*) aquaculture has high economic value and rapid growth; however, the high cost of commercial feed necessitates the use of more economical and nutritionally adequate alternative feed ingredients, such as fermented papaya leaves (*Carica papaya*). This study aimed to evaluate the effect of different fermentation durations of papaya leaves in commercial feed on the growth and survival rate of tilapia and to determine the optimal fermentation time. This study employed an experimental method using a Completely Randomized Design (CRD) consisting of four treatments and three replications: treatment A (control without fermentation), treatment B (3 days fermentation), treatment C (5 days fermentation), and treatment D (7 days fermentation). Tilapia fingerlings measuring ±5–7 cm with an initial weight of ±3–4 g were reared for 30 days at a stocking density of 20 fish per tank. The observed parameters included weight gain and survival rate, while the water quality parameters measured were temperature, pH, dissolved oxygen (DO), and ammonia. The data were analyzed using a One-Way ANOVA test followed by Duncan's multiple range test. The results showed that the addition of fermented papaya leaves had a significant effect ($P < 0.05$) on the weight gain of tilapia, but no significant effect ($P > 0.05$) on the survival rate. The best treatment was obtained at 7 days of fermentation, with an average weight gain of 19.53 g and a survival rate of 100%. Therefore, a fermentation duration of 7 days for papaya leaves in commercial feed is considered the most optimal time to enhance the growth of tilapia without affecting their survival rate.

Keywords: Aquaculture, Fermentation, Growth, Nile Tilapia, Papaya Leaves

ABSTRAK

Budidaya ikan nila (*Oreochromis niloticus*) memiliki nilai ekonomi tinggi dan pertumbuhan yang cepat, namun biaya pakan komersial yang tinggi menjadi kendala utama, sehingga diperlukan bahan pakan alternatif yang lebih ekonomis dengan kandungan nutrisi yang memadai. Salah satu bahan yang berpotensi dimanfaatkan adalah daun pepaya *(Carica papaya)* yang difermentasi. Penelitian ini bertujuan untuk mengetahui pengaruh lama fermentasi daun pepaya yang dicampurkan dalam pakan komersial terhadap pertumbuhan dan sintasan ikan nila serta menentukan waktu fermentasi yang paling optimal. Penelitian ini menggunakan metode eksperimen dengan Rancangan Acak Lengkap (RAL) yang terdiri dari empat perlakuan dan tiga ulangan, yaitu perlakuan A (kontrol tanpa fermentasi), perlakuan B (fermentasi 3 hari), perlakuan C (fermentasi 5 hari), dan perlakuan D (fermentasi 7 hari). Benih ikan nila berukuran ±5–7 cm dengan berat awal ±3–4 g dipelihara selama 30 hari dengan padat tebar 20 ekor per bak. Parameter yang diamati meliputi pertambahan berat dan sintasan ikan, sedangkan kualitas air yang diukur meliputi suhu, pH, oksigen terlarut (DO), dan amonia. Data dianalisis menggunakan uji One-Way ANOVA yang dilanjutkan dengan uji Duncan. Hasil penelitian menunjukkan bahwa penambahan daun pepaya terfermentasi berpengaruh nyata ($P<0,05$) terhadap pertambahan berat ikan nila, tetapi tidak berpengaruh signifikan ($P>0,05$) terhadap sintasan. Perlakuan terbaik diperoleh pada fermentasi selama 7 hari dengan pertambahan berat rata-rata sebesar 19,53 g dan sintasan mencapai 100%. Dengan demikian, fermentasi daun pepaya selama 7 hari dalam pakan komersial merupakan waktu fermentasi yang paling optimal untuk meningkatkan pertumbuhan ikan nila tanpa memengaruhi tingkat sintasan.

Kata Kunci: Akuakultur, Daun Pepaya, Fermentasi, Ikan Nila, Pertumbuhan

INTRODUCTION

Fish farming is the activity of breeding and raising fish with the aim of increasing annual production (Rismayanti *et al*., 2025). This activity is part of aquaculture, which plays a crucial role in providing a sustainable source of animal protein for the community. With the increasing demand for fishery products, the aquaculture sector has become a strategic solution to meet food needs while supporting aquatic resource-based food security. One widely cultivated commodity is tilapia (*Oreochromis niloticus*) due to its rapid growth, good adaptation to environmental conditions, and high economic value (Sitepu *et al*., 2024). Furthermore, tilapia also contains healthy nutrients, such as protein, vitamins, minerals, and low-cholesterol omega-3 fatty acids (Kusmiyati *et al*., 2023). Increasing market demand for tilapia drives the need for efficient and sustainable production improvements (Wulandari *et al*., 2024).

One important factor influencing the success of fish farming is feed. High-quality feed can support fish growth, physiological development, and survival (Nuraini *et al*., 2023). Problems that often hamper fish growth and survival are feed and water quality (Sari *et al*., 2022). However, successful cultivation is determined not only by feed quality but also by good maintenance management, particularly in water quality management. Optimal water quality management is crucial for maintaining stable cultivation conditions, thus supporting metabolic processes, increasing appetite, and supporting optimal fish growth and survival. Poor water quality can disrupt fish metabolism, reduce appetite, and inhibit fish growth and survival (Martini, 2024). Therefore, providing high-quality feed needs to be balanced with good cultivation management, particularly in maintaining water quality at an optimal range for fish growth and survival. However, the use of commercial feed is often a constraint for cultivators because the costs are quite high, reaching 60–85% of the total cultivation production costs (Yudiarini *et al*., 2024). This situation has prompted the need to utilize alternative feed ingredients that are more economical while still maintaining adequate nutritional content. This is because the use of large amounts of feed and the long maintenance period are major constraints in fish farming activities. Feed is the largest cost component in fish farming, so high feed requirements can reduce business efficiency and potentially cause losses for farmers (Wirantari *et al*., 2023). Therefore, utilizing alternative feed ingredients that are cheaper but still nutritious is one way to improve production cost efficiency in fish farming activities.

One ingredient with potential use as an alternative feed is papaya leaves (*Carica papaya*). Papaya leaves are known to contain protein, vitamins C and E, and bioactive compounds such as flavonoids, saponins, and alkaloids that have the potential to improve fish health and digestive systems (Wulandari *et al*., 2022; Anonymous, 2007). Several studies have also shown that the fermentation process of feed ingredients can improve nutrient digestibility and feed utilization efficiency by fish (Aini *et al*., 2021). Fermentation using microorganisms such as *Saccharomyces cerevisiae* and *Lactobacillus* sp. can break down complex compounds into simpler compounds, making them more easily absorbed by cultivated organisms (Pokhrel, 2024).

However, one important factor in the fermentation process is the length of fermentation time. Fermentation that is too short can result in suboptimal material decomposition, while fermentation that is too long can reduce the nutritional quality of the feed. Therefore, research is needed to determine the most appropriate fermentation duration so that the use of papaya leaves as an alternative feed ingredient can provide optimal results for the growth and survival of tilapia.

Based on this description, this study aims to determine the effect of papaya leaf fermentation time in feed on the growth and survival of tilapia and to determine the most optimal fermentation time.

METHODS

Research Location and Time

This research was conducted at the Faculty of Mathematics and Natural Sciences, Ganesha University of Education, Bali, using tilapia (*Oreochromis niloticus*) fry obtained from the Ringdikit Fish Seed Center, Buleleng Regency, Bali. The research lasted for 30 days, beginning with preparation of the rearing media, fermentation of papaya leaves, and acclimatization of the fish before treatment.

Tools and Materials

Table 1. Research Tools and Materials

No.	Tools	Materials
1.	Plastic Container (55x70cm)	Tilapia Seeds (240 fish)
2.	Aerator	Papaya Leaves (3 kg)
3.	Digital Scale	Brown Sugar (1.5 kg)
4.	Blender	Mineral Water (15 L)
5.	Measuring Cup	EM4 (90 ml)
6.	Jar	Commercial Pellets PF 1000 (7 kg)
7.	Thermometer	Progol (1 pack)
8.	pH Meter	
9.	DO Meter	
10.	Ammonia Test Kit	
11.	Fish Filter	
12.	Siphon Hose	
13.	Camera	

Research Design

This research used an experimental method with a Completely Randomized Design (CRD) consisting of four treatments and three replications, resulting in 12 experimental units. The treatments included varying lengths of papaya leaf fermentation mixed into commercial feed:

A: Commercial feed without added papaya leaf fermentation (control)

B: Commercial feed with 3 days of papaya leaf fermentation
C: Commercial feed with 5 days of papaya leaf fermentation
D: Commercial feed with 7 days of papaya leaf fermentation

The papaya leaf fermentation liquid was mixed into the pellet feed at a dose of 11 ml per 100 g of feed (±10%). Each experimental unit contained 20 fish in 50 liters of water. The fingerlings used were approximately 5–7 cm long and weighed approximately 3–4 g. Feed was provided three times daily, in the morning, afternoon, and evening, with a feeding rate of 5% of the fish's body weight.

Research Procedure

The initial stage of the research began with the preparation of rearing containers, consisting of plastic boxes equipped with an aeration system and drainage system. Each container was filled with 50 liters of water and an aerator installed to maintain dissolved oxygen availability. The papaya leaf fermentation process involves washing the papaya leaves thoroughly, then chopping them into small pieces and grinding them in a blender with water. The solution is then mixed with brown sugar and EM4 probiotics, then fermented in a closed container for 3, 5, and 7 days, depending on the treatment. After the fermentation process is complete, the fermented liquid is filtered and used as a feed pellet mixture.

The tilapia fry are first acclimatized before being placed in the rearing tank to reduce stress caused by environmental changes. During the rearing period, the fish are fed according to the prescribed treatment. To maintain the quality of the rearing medium, approximately 30% of the water is changed daily (Safrun *et al*., 2022). Parameters observed in this study included fish growth, survival, and water quality. Growth data were obtained through periodic weighing of the fish using a simple random sampling technique, which sampled approximately 10% of the fish population in each pond. Water quality parameters measured included temperature, pH, dissolved oxygen (DO), and ammonia, which were measured in situ using individual measuring instruments (Antari, 2022).

Data Analysis

The data used were obtained from experimental research findings in the form of survival rates and growth of tilapia, as measured by fish weight compared to the duration of papaya leaf fermentation. Fish growth was calculated based on body weight gain using the formula:

$$W = W_1 – W_o$$

where W is the weight gain, W_1 is the final weight, and W_o is the initial weight (Lingga, 2018).

The fish survival rate was calculated using the formula:

$$SR = (N_t / N_0) \times 100\%$$

where SR is the survival rate, N_t is the number of fish alive at the end of the study, and N_0 is the number of fish at the beginning of the study. The data obtained were then statistically analyzed using one-way ANOVA to determine the effect of treatments on fish growth and survival (Nuryadi *et al*., 2017). Prior to analysis, the data were tested using the Shapiro–Wilk normality test to ensure normal distribution and Levene's homogeneity test to determine the equality of variance between treatment groups (Usmadi, 2020).

If the ANOVA results showed a significant difference ($P < 0.05$), the analysis was continued with Duncan's Multiple Range Test to determine the treatment that produced the best results. Water quality data were analyzed descriptively to determine the suitability of the rearing conditions to the tilapia's living needs.

RESULTS

Nutritional Composition of Papaya Leaves and Fermented Products

A proximate analysis of papaya leaves (*Carica papaya*) and their fermented products was conducted at the Integrated Services Laboratory of Udayana University, Bali. Parameters analyzed included water content, ash content, fat, protein, carbohydrates, and energy (calories). The results of the proximate analysis are presented in Table 2.

Table 2. Nutritional Composition of Fresh Papaya Leaves and Fermented Products

Sample Name	Water Content (% bb)	Ash Content (% bb)	Fat (% bb)	Protein (% bb)	Carbohydrate (% bb)	Calories (kkal/100 g)
A	77.47	3.56	6.49	1.98	10.51	85.76
B	97.32	0.49	0.59	0.73	0.87	12.44
C	97.41	0.36	0.44	0.63	1.16	12.10
D	97.42	0.40	0.43	0.79	0.96	12.64

Description: A: Fresh Papaya Leaves, B: 3-Day Fermented Papaya Leaves, C: 5-Day Fermented Papaya Leaves, D: 7-Day Fermented Papaya Leaves (Source: Personal Data, 2025)

According to Table 1, fresh papaya leaves contain 10.51% carbohydrates, 1.98% protein, 6.49% fat, 77.47% water, and 85.76 kcal/100 g of energy. These nutritional contents indicate that papaya leaves have the potential to be used as a feed additive because they contain nutritional components that can support the metabolic needs and growth of fish.

After undergoing a fermentation process for 3, 5, and 7 days, changes in the nutrient composition of papaya leaves occurred. These changes were characterized by an increase in water content and changes in protein, fat, and carbohydrate content. The fermentation process enables microorganisms to break down complex compounds into simpler ones through enzymatic processes. This activity can affect the nutrient composition of feed ingredients, making nutrients more readily available for use by cultured organisms. Thus, fermentation plays a role in improving feed quality and increasing its potential for supporting fish growth.

Tilapia Growth

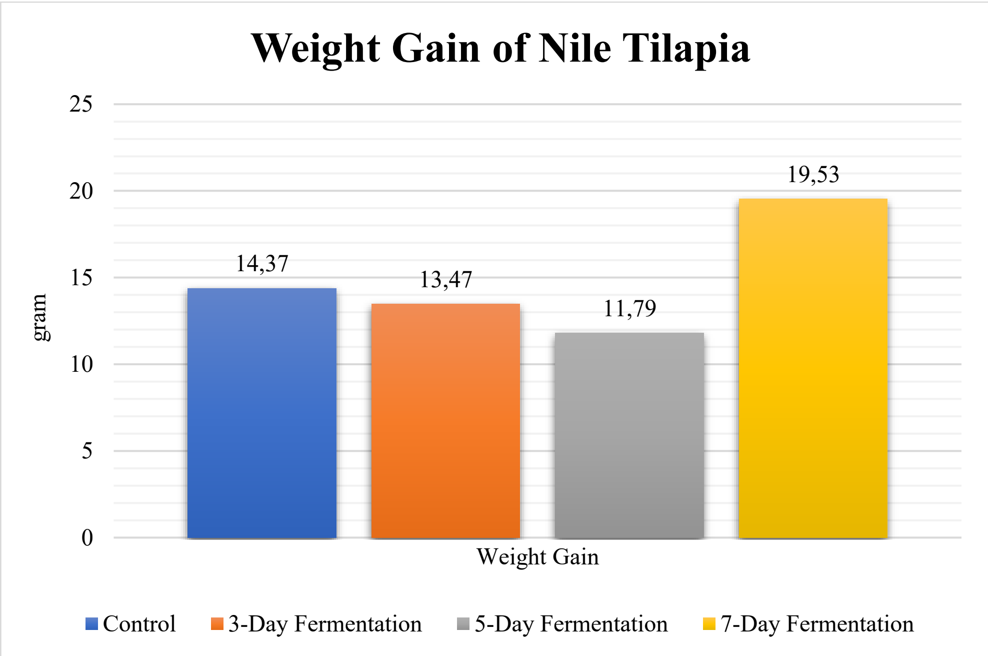

Figure 1. Tilapia Weight Gain

According to Figure 1 and Table 3, the growth of tilapia during the 30-day rearing period shows differences in weight gain values for each feed treatment. Weight gain is a key indicator in assessing the success of a feed treatment, as it reflects the fish's ability to utilize the nutrients contained in the feed for metabolism, body maintenance, and growth.

Table 3. Average Weight Gain and Survival Rate of Tilapia

Treatment	Weight Gain (g)	Survival Rate (%)
A (control)	14.37	88.33
B (3-day fermentation)	13.47	88.33
C (5-day fermentation)	11.79	95.00
D (7-day fermentation)	19.53	100

Source: Personal Data (2025)

The results showed that the 7-day papaya leaf fermentation treatment (treatment D) resulted in the highest weight gain of tilapia, at 19.53 g, while the lowest weight gain was found in the 5-day fermentation treatment (treatment C), at 11.79 g. This indicates that the length of fermentation can affect feed quality and nutrient utilization by the fish.

The results of the statistical analysis using One-Way ANOVA showed a Sig. = 0.014 ($P < 0.05$), indicating that the difference in fermentation time significantly affected tilapia weight gain. Furthermore, the results of the Duncan Multiple Range Test (DMRT) showed that treatment D was in a different group compared to the other treatments, while treatments A, B, and C were in the same group, indicating that 7-day fermentation had the best effect on tilapia growth.

Tilapia Survival

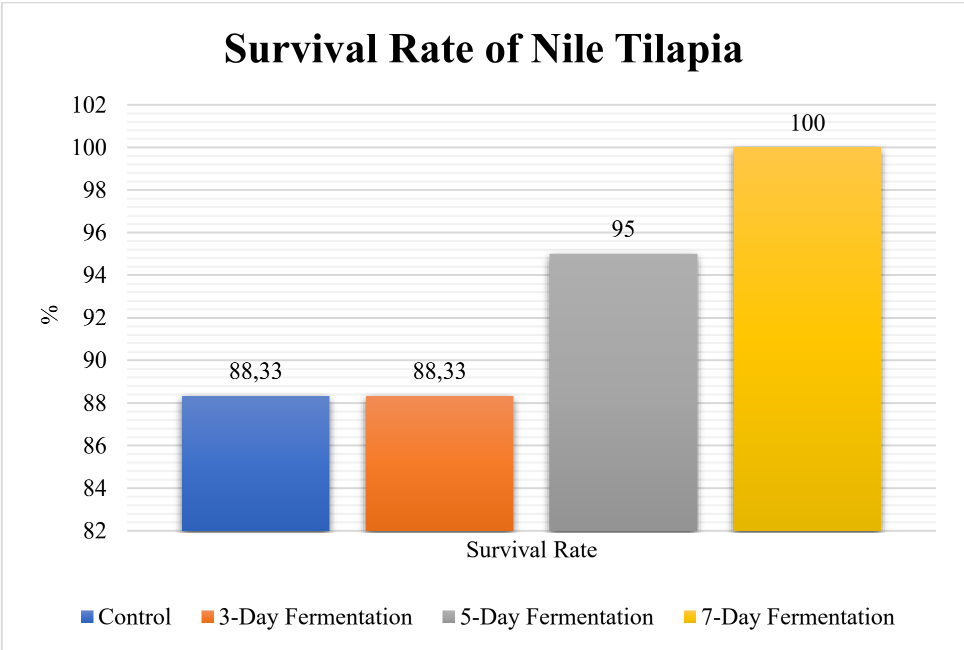

Figure 2. Survival

Based on Figure 2 and Table 3, tilapia survival was observed during the 30-day culture period by counting the number of fish surviving at the end of the study. Observations showed that the control (A) and 3-day fermentation (B) treatments each had a survival rate of 88.33%, while the 5-day fermentation (C) treatment had a survival rate of 95.00%. The highest survival rate was achieved in the 7-day fermentation (D) treatment, at 100%. Statistical analysis using One-Way ANOVA showed a Sig. = 0.152 ($P > 0.05$), indicating that the difference in treatment did not significantly affect tilapia survival.

Water Quality

During the study, several water quality parameters were measured, including temperature, pH, dissolved oxygen (DO), and ammonia. These measurements were intended to determine the environmental conditions of the fish during the study and to ensure that water quality remained within a range that supports fish growth and survival. Water quality parameters are a crucial factor in fish farming because they can affect metabolism, appetite, and fish health. Average water quality values during the study are presented in Table 4.

Table 4. Average Water Quality Parameters During the Study

Parameter	**A**	**B**	**C**	**D**	**Optimal Standards**
Temperature (°C)	25.65	25.53	25.45	25.47	25–30°C (Khairuman & Amri, 2013)
pH	7.67	7.66	7.67	7.66	6.5–8.5 (Pradhana *et al.,* 2021)
DO (mg/L)	5.86	5.65	5.63	5.68	≥5 mg/L (Antari, 2022)
Ammonia (mg/L)	<0.5	<0.5	<0.5	<0.5	<1 mg/L (Novita *et al.,* 2024)

Source: Personal Data (2025)

All water quality parameters during the study were within the optimal range for tilapia cultivation, ensuring that environmental conditions supported fish growth and survival.

DISCUSSION

Research results show that the addition of fermented papaya leaves to commercial feed significantly improves the growth of tilapia, particularly after a 7-day fermentation treatment. Fermentation is known to improve the nutritional quality of feed ingredients by breaking down complex compounds into simpler forms, making them more easily digested by fish (Lingga, 2018). The papaya leaf fermentation process using the probiotic EM4 involves various microorganisms such as *Lactobacillus* sp., photosynthetic bacteria, *Actinomycetes* sp., and *Saccharomyces cerevisiae*. These microorganisms play a role in producing enzymes that can break down complex compounds into simpler compounds that are easily absorbed by the fish's digestive system (Mardede, 2020).

According to Setyawan *et al*. (2014), probiotic microorganisms can break down polysaccharides into monosaccharides that are more easily utilized by the body. This hydrolysis process converts complex carbohydrates such as starch, glycogen, and cellulose into simple sugars that can be used as an energy source for fish. Carbohydrates in feed serve as the primary energy source for fish. Once energy requirements are met, the protein in the feed can be optimally utilized for tissue formation and fish growth. This explains why a 7-day fermentation treatment results in higher fish growth compared to other treatments. Handayani *et al*. (2017) stated that adding fermented ingredients to feed can increase nutritional content, particularly carbohydrates and protein, which play a role in supporting fish growth.

Furthermore, papaya leaves are known to contain various essential amino acids, such as leucine, isoleucine, valine, lysine, and arginine, which play a role in tissue formation, enzyme and hormone production, and improving the fish's immune system (Putri *et al*., 2021). The availability of essential amino acids in feed is crucial because these compounds cannot be synthesized by the fish and must be obtained from the feed. The fermentation duration also plays a crucial role in determining the quality of fermented feed ingredients. Too short a fermentation time can result in microbial activity not reaching optimal levels, thus inhibiting the nutrient degradation process (Muni *et al*., 2021). Conversely, longer fermentation allows microorganisms to grow and produce digestive enzymes optimally (Hatma *et al*., 2018).

Although papaya leaf fermentation affected fish growth, it did not significantly impact tilapia survival. The high survival rates across all treatments are thought to be influenced by optimal water quality conditions and good maintenance management, such as regular water changes and the use of healthy fish fry (Safrun *et al*., 2022). In addition to feed, environmental quality also plays a crucial role in supporting fish survival. Water quality parameters such as temperature, pH, dissolved oxygen, and ammonia levels throughout the study were within the appropriate range for tilapia growth. According to Khairuman & Amri (2013), the optimal temperature for tilapia growth is between 25–30°C, while the optimal pH is between 6.5–8.5 (Pradhana *et al*., 2021). Adequate dissolved oxygen availability is also crucial for supporting fish respiration and metabolism. DO values above 5 mg/L are still considered good for fish life (Antari, 2022). Furthermore, low ammonia levels (<0.5 mg/L) indicate that the water conditions during the study were still safe for tilapia (Novita *et al*., 2024). Overall, the results of this study indicate that 7 days of papaya leaf fermentation provided the best results in increasing tilapia growth, thus potentially being used as an alternative feed additive in tilapia cultivation activities.

CONCLUSION

The addition of fermented papaya leaves (*Carica papaya*) to commercial feed has an effect on the growth of tilapia (*Oreochromis niloticus*), especially on the weight gain parameter, but has no significant effect on fish survival. Variations in fermentation duration indicate that 7 days of fermentation is the most optimal duration in increasing tilapia growth with an average weight gain of 19.53 g, compared to the control treatment (14.37 g), 3 days of fermentation (13.47 g), and 5 days of fermentation (11.79 g). However, the difference in papaya leaf fermentation duration did not have a significant effect on the survival rate of tilapia, with a survival rate range of 88.33–100% during the rearing period. Thus, 7 days of papaya leaf fermentation has the potential to be used as an alternative feed additive that can increase tilapia growth without reducing its survival rate.

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