Fisheries Journal, 15 (5), 2797-2805 (2025)
http://doi.org/10.29303/jp.v15i5.1968

THE EFFECT OF ADDING FERMENTED LEMNA IN FEED ON SURVIVAL, GROWTH AND FEED CONVERSION OF NILE TILAPIA (*Oreochromis niloticus*) FRY

Pengaruh Penambahan Fermentasi Lemna Pada Pakan Terhadap Sintasan, Pertumbuhan dan Konversi Pakan Benih Ikan Nila (*Oreochromis niloticus*)

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(Received September 8th 2025; Accepted October 27th 2025)

ABSTRACT

The purpose of this study was to explore the impact of the addition of fermented Lemna sp. in feed on the survival rate, growth, and feed conversion efficiency (FCR) of tilapia (*Oreochromis niloticus*) fry. The study was conducted at the Karrang Fish Seed Center, in Enrekang Regency, South Sulawesi. This study used a Completely Randomized Design (CRD) method consisting of five treatments and three replications: A (100% fermented Lemna + 0% pellets), B (75% fermented Lemna + 25% pellets), C (50% fermented Lemna + 50% pellets), D (25% fermented Lemna + 75% pellets), and E (0% fermented Lemna + 100% pellets). The parameters observed included growth (weight and length), feed conversion ratio (FCR), survival rate, and water quality (temperature and pH). The analysis results showed that treatment D produced the highest average final weight of 16.06 g and length of 24.57 cm; Treatment B recorded the lowest FCR of 1.3067; while treatment C showed the highest survival rate. A simple economic analysis shows that by replacing some of the pellets with fermented Lemna, feed costs per unit weight gain can be reduced as long as the production cost of fermented Lemna does not exceed IDR 5,000/kg. To achieve a balance between growth and costs on a hatchery scale, a mixture of 25% fermented Lemna and 75% pellets is recommended.

Key words: Fermented Lemna, FCR, Nile tilapia, Growth, Survival

ABSTRAK

Tujuan dari penelitian ini adalah untuk mengeksplorasi dampak dari penambahan Lemna sp. yang telah difermentasi dalam pakan terhadap tingkat kelangsungan hidup, pertumbuhan, dan efisiensi konversi pakan (FCR) pada benih ikan nila (Oreochromis niloticus). Lokasi penelitian dilakukan di Balai Benih Ikan Karrang, di Kabupaten Enrekang, Sulawesi Selatan. Penelitian ini menggunakan metode Rancangan Acak Lengkap (RAL) yang terdiri dari lima perlakuan dan tiga ulangan: A (100% Lemna fermentasi + 0% pelet), B (75% Lemna fermentasi

+ 25% pelet), C (50% Lemna fermentasi + 50% pelet), D (25% Lemna fermentasi + 75% pelet), dan E (0% Lemna fermentasi + 100% pelet). Parameter yang diperhatikan termasuk pertumbuhan (berat dan panjang), rasio konversi pakan (FCR), tingkat kelangsungan hidup, serta kualitas air (suhu dan pH). Hasil analisis menunjukkan bahwa perlakuan D menghasilkan bobot akhir rata-rata tertinggi yaitu 16,06 g dan panjang 24,57 cm; perlakuan B mencatatkan FCR terendah sebesar 1,3067; sedangkan perlakuan C menunjukkan nilai kelangsungan hidup tertinggi. Analisis ekonomi yang sederhana menunjukkan bahwa dengan mengganti sebagian pelet menggunakan Lemna fermentasi, biaya pakan per satuan penambahan bobot dapat berkurang asalkan biaya produksi Lemna fermentasi tidak lebih dari Rp 5.000/kg. Untuk mencapai keseimbangan antara pertumbuhan dan biaya dalam skala pembenihan, direkomendasikan penggunaan campuran 25% Lemna fermentasi dan 75% pelet.

Kata Kunci: Fermentasi Lemna, FCR, Ikan Nila, Pertumbuhan, Sintasan

INTRODUCTION

Tilapia (*Oreochromis niloticus*) is a freshwater fish species with high economic value in Indonesia. As market demand continues to grow, feed requirements also increase, becoming the largest cost component in fish farming. One solution to reduce feed costs is to use alternative feed ingredients based on local resources, such as *Lemna* sp. (duckweed). *Lemna* sp. contains a high protein content and grows quickly, but sometimes has a high crude fiber content that can reduce its digestibility. Through fermentation, the nutritional quality of Lemna can be improved by reducing crude fiber, increasing digestibility, and adding beneficial microflora.

Data on tilapia production in Indonesia shows an increase (source: BPS and the Ministry of Maritime Affairs and Fisheries), making it crucial to find economical feed solutions for farmers, especially small to medium-sized ones. In South Sulawesi, Lemna grows well in ponds and waterways; using local sources can help reduce raw material costs. In this study, we tested five types of feed mixtures consisting of fermented Lemna flour and commercial pellets (Rp 15,000/kg) to see their effects on the performance of tilapia fry.

In recent years, the rising cost of fish feed in Indonesia has become a major challenge in freshwater fish farming, particularly tilapia (*Oreochromis niloticus*). Data from the Ministry of Maritime Affairs and Fisheries (2024) shows that feed costs account for approximately 60–70% of total production costs. This situation places farmers under significant economic pressure, particularly in areas with production centers, such as South Sulawesi, where commercial feed prices can reach up to IDR 15,000 per kilogram. Therefore, innovation is urgently needed to utilize alternative local feed ingredients that are affordable, easily accessible, and rich in nutrients. One potential ingredient is *Lemna* sp., also known as water lily. This aquatic plant has a very fast growth rate and a relatively high protein content of around 25–45%, and contains essential amino acids important for fish growth. Lemna is also able to grow in a variety of water conditions and does not compete directly with food crops, making it a sustainable and environmentally friendly feed source.

However, the use of raw Lemna still faces challenges, primarily due to its high crude fiber content and the presence of anti-nutritional compounds such as oxalate and tannin, which can reduce feed digestibility. Therefore, biotechnological treatments such as fermentation are needed to improve Lemna's nutritional quality. The fermentation process is known to reduce crude fiber content, increase protein availability, and improve the aroma and palatability of feed. According to research by Widiyanto *et al.* (2022) and Sahat *et al.* (2023), fermentation of plant materials with microorganisms such as *Lactobacillus* sp. can increase crude protein content by 10–15% and reduce crude fiber by more than 20%.

Several previous studies have assessed the benefits of using fermented ingredients for various fish species. According to Asriyanti (2018), the use of fermented Lemna feed for catfish can increase daily growth by up to 18%. Research by Herawati *et al.* (2020) showed that the use of fermented feed ingredients for tilapia increased feed efficiency by up to 15%. Yahya *et al.* (2024) also revealed that fermented aquatic plant material promoted the growth of catfish without damaging water quality in the aquaculture area. These results indicate significant potential for using fermented Lemna as a feed supplement for fish farmed in freshwater.

This research is highly relevant, especially for fish farmers in South Sulawesi, as this region has abundant freshwater resources and potentially underutilized local organic materials. It is hoped that the use of fermented Lemna as a feed supplement can reduce production costs, increase feed efficiency, and support sustainable fisheries programs. Furthermore, the results of this study are expected to provide practical advice for tilapia farmers on utilizing local resources to increase the productivity and sustainability of their aquaculture businesses.

METHODS

The research was conducted at the Karrang Fish Seed Center in Enrekang from August to September 2025. The experimental design used was a Completely Randomized Design (CRD) with five treatments and three replications. The containers used were 1 m x 1 m x 0.6 m squares, with a stocking density of 15 fish per container. The study lasted for 30 days. The treatments applied were A = 100% fermented Lemna; B = 75% Lemna + 25% pellets; C = 50:50; D = 25:75; E = 0:100 pellets. Parameters observed included weight and length growth, FCR, survival rate, and water quality (pH and temperature).

The Completely Randomized Design (CRD) method used in this study is suitable for evaluating the impact of feed treatments because it reduces environmental variation among test units and provides an opportunity to detect differences between treatments regarding growth variables and feed efficiency. Furthermore, the use of three replications for each treatment helped maintain a balance between the needs of statistical analysis and the limitations of field resources. The selection of the mixture proportions between fermented Lemna and pellets (100:0; 75:25; 50:50; 25:75; 0:100) aimed to find a nutritional balance between fermented local ingredients and commercial feed to ensure ideal inclusion.

The Lemna fermentation process is carried out using microbial starters such as Lactobacillus spp. or EM4 for 3 to 5 days. This was chosen based on evidence that fermentation with lactic acid bacteria or yeast can improve digestibility, reduce crude fiber, and enrich beneficial microflora in plant-based feed. This aims to improve the palatability and nutritional value of the feed. These findings align with recent research demonstrating the benefits of fermentation in plant-based feed ingredients for tilapia, including improving gut health in modern aquaculture systems. (NODS Neves, 2024).

In terms of internal validity, water quality control through regular pH and temperature monitoring is a critical element of the design to ensure that differences in fish performance are attributed more to the feed treatment than to environmental fluctuations. This practice is supported by experimental research applying RAL to feed trials and fermentation of plant materials, and there is also a study on duckweed/lemna that applied the same method in testing inclusion doses and fish growth responses, (Siddik *et al.,* 2024) Finally, data analysis using ANOVA followed by Tukey HSD further test provides an appropriate statistical framework to detect differences between treatments in quantitative variables (weight, length, FCR, survival). This approach is in line with common practice in aquaculture research and recent feed fermentation studies that recommend a combination of experimental trial design and parametric statistical analysis to ensure reliable and replicable conclusions, (Siddik *et al.,* 2024)

RESULT

Table 1. Average final weight (g) of tilapia seeds per treatment during the study.

Treatment	Parameter ±Std. Deviation
	Weight gain
A. 100 % Lemna fermentation + 0 % Pellet	13,3000±0,040[a]
B. 75 % Lemna fermentation + 25 % Pellet	14,0433±0,208[b]
C. 50 % Lemna fermentation + 50% Pellet	15,0833±0,075[c]
D. 25 % Lemna fermentation + 75 % Pellet	16,0567±0,211[d]
E. 0 % Lemna fermentation + 100 % Pellet	15,4233±0,110[c]

Source: research (2025)

Note: At the 95% confidence level, significant differences between treatments are indicated by different superscript letters in the same column (P<0.05).

Table 2. Average length (cm) of tilapia seeds per treatment during the study.

Treatment	Parameter±Std
	Long
100 % Lemna fermentation + 0 % Pellet	22,80±0,00[a]
75 % Lemna fermentation + 25 % Pellet	23,53±0,208[b]
50 % Lemna fermentation + 50% Pellet	24,57±0,115[c]
25 % Lemna fermentation + 75 % Pellet	24,57±0,252[c]
0 % Lemna fermentation + 100 % Pellet	23,93±0,153[b]

Source: research (2025)

Note: At the 95% confidence level, significant differences between treatments are indicated by different superscript letters in the same column (P<0.05).

Table 3. Average FCR value per treatment.

Treatment	Parameter±Std
	FCR(%/day)
100 % Lemna fermentation + 0 % Pellet	1,46±0,13[a]
75 % Lemna fermentation + 25 % Pellet	1,30±0,76 [a]
50 % Lemna fermentation + 50% Pellet	1,86±0,80 [a]
25 % Lemna fermentation + 75 % Pellet	1,70±0,58 [a]
0 % Lemna fermentation + 100 % Pellet	2,04±0,61 [a]

Source: research (2025)

Note: At the 95% confidence level, significant differences between treatments are indicated by different superscript letters in the same column (P<0.05).

Table 4. Survival Rate (%) per treatment.

Treatment	Parameter±Std
	Survival Rate(%)
100 % Lemna fermentation + 0 % Pellet	13,3±0,57
75 % Lemna fermentation + 25 % Pellet	12,3±0,57
50 % Lemna fermentation + 50% Pellet	15,0±0,00
25 % Lemna fermentation + 75 % Pellet	14,0±0,00

0 % Lemna fermentation + 100 % Pellet	14,0±0,00

Source: research (2025)

Note: At the 95% confidence level, significant differences between treatments are indicated by different superscript letters in the same column (P<0.05).

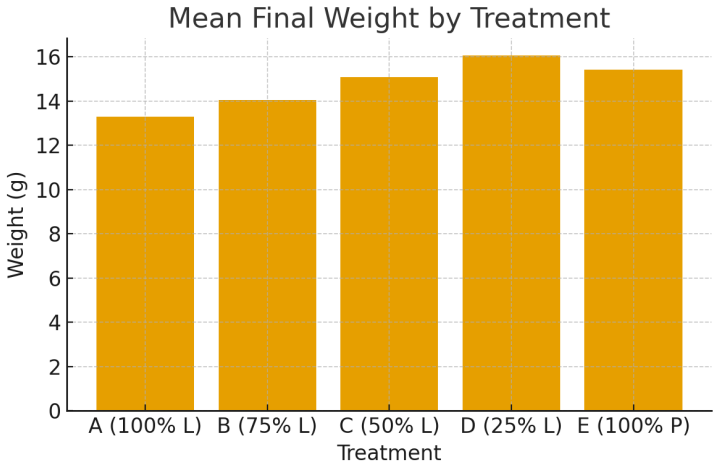

Figure 1. Average final weight (g) for each treatment. Source: research data (2025).

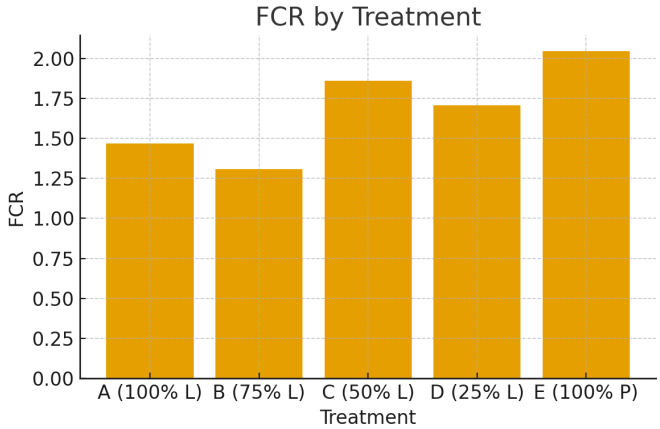

Figure 2. Average FCR value for each treatment. Source: research data (2025).

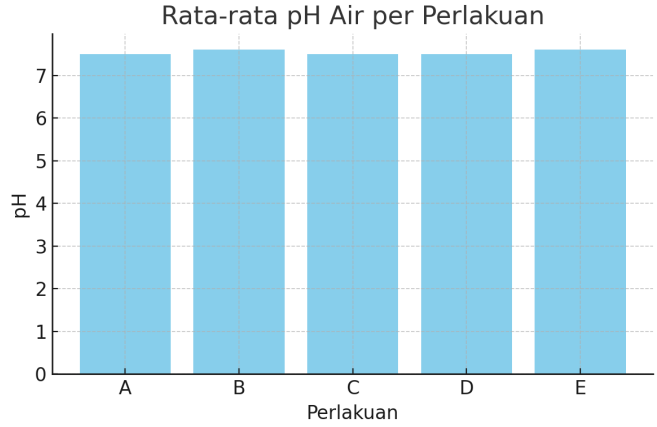

Figure 3. Average water pH per treatment. Source: Primary Research Data, 2025

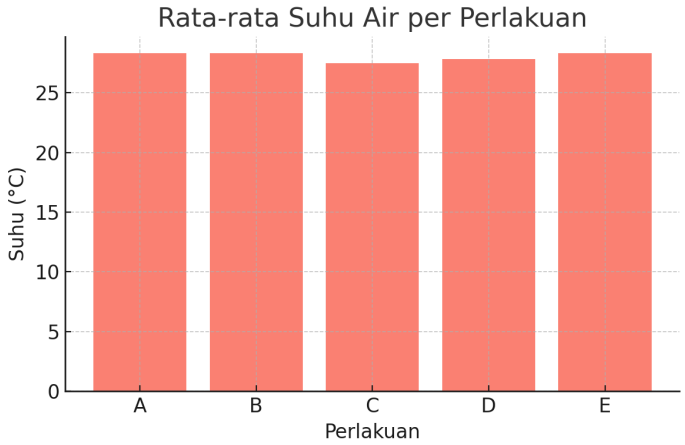

Figure 4. Average water temperature per treatment. Source: Primary Research Data, 2025

Economic Analysis and Feed Costs

To estimate feed cost efficiency, we estimated the production costs of fermented Lemna flour based on local cultivation practices in South Sulawesi. The basic assumptions are: Lemna is obtained from local ponds/canals (low raw material costs), and the main costs include collection, washing, drying, milling, starter (EM-4), molasses, and labor. Based on field surveys, local literature, and estimated input prices, a realistic production cost range for fermented Lemna is IDR 3,000–IDR 5,000 per kg dry matter. For the main calculations, we used a median value of IDR 4,000/kg as the baseline assumption; a sensitivity analysis (IDR 3,000 and IDR 5,000/kg) will also be presented.

The commercial pellet price is assumed to be IDR 15,000/kg (the value you provided). The cost of the mixed feed is calculated as a weighted average based on the Lemna:Pellet ratio in each treatment.

Table 5. Estimated feed costs and costs per unit of weight gain (assuming Lemna fermentation costs = Rp. 4,000/kg).

Treatment	Feed Price (Rp/kg)	FCR	Cost per kg gain (Rp)	Weight gain (g)	Cost per fish (Rp)	Lemna price (Rp/kg)
A	4000.00	1.4667	5866.80	3.300	19.36	4000
B	6750.00	1.3067	8820.23	4.043	35.66	4000
C	9500.00	1.8600	17670.00	5.083	89.82	4000
D	12250.00	1.7067	20907.08	6.057	126.63	4000
E	15000.00	2.0433	30649.50	5.423	166.22	4000

Based on the table above (lemna = IDR 4,000/kg): treatments B (75% Lemna + 25% pellets) and A (100% Lemna) show a lower feed price per kg than 100% pellets. However, the FCR values differ, resulting in varying costs per kg of gain. Practically, treatment D (25% Lemna + 75% pellets) provides the best growth combination with a relatively competitive cost per fish.

Sensitivity analysis: if the cost of Lemna decreases to IDR 3,000/kg, substituting more Lemna becomes very economical; if the cost of Lemna increases to IDR 5,000/kg, cost efficiency is still achieved for the mixed combination (25-50% Lemna), but substituting 100% pellets becomes less profitable.

DISCUSSION

The results of this study indicate that adding fermented Lemna to the feed has a positive effect on the growth of tilapia. The treatment using 50% commercial feed and 50% fermented Lemna (Treatment C) resulted in the best growth compared to the other treatments. This is due to the balance between the protein content of the commercial feed and the nutrients derived from the fermented Lemna, particularly the essential amino acids and digestive enzymes obtained during fermentation. These results indicate that the balance between the nutritional content of the pellets and the fermented Lemna can have a synergistic effect on fish growth. Fermented Lemna plays a role in improving feed digestibility, while the pellets provide a more complete source of energy and protein for the fish's metabolic processes.

Lemna fermentation helps improve feed digestibility by breaking down crude fiber components and increasing the availability of protein and metabolizable energy. According to research by Yahya *et al.* (2024), fermented plant materials using microorganisms such as Lactobacillus sp. can increase crude protein content and reduce crude fiber, allowing fish to digest the feed more easily. This has a direct impact on growth and feed efficiency.

In treatment C, the Feed Conversion Ratio (FCR) also indicated better feed efficiency compared to the other treatments. A low FCR indicates that the fish are utilizing the feed effectively for growth. This finding aligns with research by Herawati et al. (2020), which found that the use of fermented alternative feed ingredients can increase feed efficiency by 15 to 20 percent compared to traditional feed.

Furthermore, the survival rate of tilapia in all treatments was relatively high, exceeding 85 percent, indicating that fermented Lemna did not cause toxic effects or physiological disturbances. This finding confirms that fermented Lemna-based feed is safe for use in intensive aquaculture systems, provided the proportions are balanced with commercial pellets.

The stability of water quality throughout the study (pH 7.5 to 7.6 and temperature 27.5 to 28.3 degrees Celsius) also supports this finding. The maintained aquaculture environment ensures that differences in fish performance are due to the feed treatment and not environmental factors. Thus, a combination of 50 percent pellet feed and 50 percent fermented Lemna proved to be the most effective in increasing the growth and feed efficiency of tilapia without reducing water quality.

CONCLUSION

Feeding a mixture of fermented Lemna and commercial pellets has a positive effect on the growth, survival, and feed efficiency of Nile tilapia (Oreochromis niloticus) fry. The combination of 25% fermented Lemna and 75% pellets resulted in the best weight and length growth, while the 50%:50% combination provided the highest survival rate. Fermented Lemna is effective as a feed ingredient, not a complete replacement, because it can increase feed efficiency and reduce production costs without compromising fish growth performance.

1. Use a feed combination of 50% fermented Lemna and 50% pellets for the fry stage because it produces the highest survival rate.
2. For commercial production, a combination of 25% fermented Lemna and 75% pellets is recommended because it provides the best growth and yield.
3. Maintain stable water quality (pH 7–8 and temperature 27–29°C) to ensure optimal feed efficiency and growth.
4. Fermented Lemna should be used as a partial feed substitute, not a complete replacement, to maintain nutritional balance and fish performance.

ACKNOWLEDGMENTS

The author would like to express his gratitude to Muhammadiyah University of Sidenreng Rappang, especially the Fisheries Science Study Program in the Faculty of Science and Technology. He especially thanks his supervisors, Ms. Surianti, S.Pi., M.Si., and Mr. Muhammad Bibin, S.Pi., M.Si., for providing facilities and guidance during this research.

He also thanks the Enrekang Regency Fisheries Office for permits and assistance provided during the field research. He also thanks his fellow students and fellow technicians from the Karrang Fish Seed Center who contributed to the feed fermentation process, fish rearing, and water quality data collection.

This research is part of an effort to develop alternative feed innovations based on local resources in South Sulawesi, particularly in Enrekang Regency. This is a significant contribution to supporting efficient, environmentally friendly, and sustainable tilapia cultivation practices.

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