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THE STUDY OF LEMNA MINOR FLOUR AS FISH MEAL SUBTITUTION IN FISH FEED FORMULATED

Studi Penggunaan Tepung Lemna Minor Sebagai Bahan Subtinusi Tepung Ikan pada Pakan Ikan Buatan

Rina Puji Astuti, Teguh Harijono, Atika Marisa Halim, Agus Widodo, Annisa Bias Cahyanurani*, Ali Usman

Fisheries Cultivation Engineering Study Program, Sidoarjo Marine and Fisheries Polytechnic

Buncitan Highway KP 1, Buncitan, Sedati, Sidoarjo, East Java, 61253

*Corresponding author: annisacahyanurani@gmail.com

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ABSTRACT

Lemna minor is a floating aquatic plant with a high protein content, making it a potential substitute for fishmeal in formulated fish feeds. This study aimed to evaluate the utilization of *L. minor* meal as a partial replacement for fishmeal and to provide supporting information regarding its application in aquaculture. Feed formulations were prepared with *L. minor* meal at substitution levels of 10% and 20%, and tested using a completely randomized design with three replicates, employing Nile tilapia as the test organism. The results showed that the 10% substitution level produced the best growth performance, with a 0.53% higher growth rate compared to both the control and the 20% substitution. Additionally, the inclusion of *L. minor* meal improved feed buoyancy and water stability. These findings indicate that *L. minor* meal has promising potential as a feed ingredient to reduce the reliance on relatively expensive fishmeal.

Keywords: Feed Conversion Ratio*, Lemna Minor*, Average Daily Gain, Protein

ABSTRAK

Lemna minor merupakan tumbuhan air mengapung dengan kandungan protein tinggi sehingga berpotensi sebagai bahan substitusi tepung ikan dalam formulasi pakan ikan. Penelitian ini bertujuan mengevaluasi pemanfaatan tepung *L. minor* sebagai pengganti sebagian tepung ikan pada pakan buatan, sekaligus memberikan informasi mengenai potensi aplikasinya dalam bidang perikanan. Formulasi pakan disusun dengan substitusi tepung *L. minor* sebesar 10% dan 20%, menggunakan rancangan acak lengkap dengan tiga ulangan dan ikan nila sebagai hewan uji. Hasil penelitian menunjukkan bahwa substitusi 10% menghasilkan laju pertumbuhan 0,53% lebih tinggi dibandingkan kontrol maupun substitusi 20%. Penambahan tepung *L. minor* juga meningkatkan daya apung dan kestabilan pakan dalam air. Dengan demikian, tepung *L. minor* berpotensi digunakan sebagai komponen pakan untuk mengurangi ketergantungan terhadap tepung ikan yang relatif mahal.

Kata Kunci: *Feed Conversion Ratio, Lemna Minor*, Laju Pertumbuhan, Protein

INTRODUCTION

Oreochromis niloticus is a high-value fish species that can be cultured across various production stages, including hatchery, nursery, and grow-out. In the grow-out phase, commercial pellet feed is commonly used; however, its relatively high price and large required volume substantially increase production costs. Feed expenses can account for 60–70% of the total production cost in aquaculture, making them one of the major challenges in fish farming (Mose & Manganang, 2020).

Currently, fishmeal is used as the primary protein source in the production of pellet feed, although it is the most expensive ingredient compared to other components. The cost of pellet production is directly related to the amount of fishmeal used, creating a need for alternative protein sources that are more affordable yet still high in protein. The use of high-protein plant-based ingredients is believed to reduce dependence on costly fishmeal. Lemna minor is a small, floating aquatic plant with a wide distribution and has potential uses as feed for livestock and fish, as well as a bioremediation agent (Xu and Chang, 2017; Nurrasyida, 2024; Tanuwiria and Christi, 2020). This plant contains approximately 20–35% protein and offers additional advantages, including ease of cultivation in both concrete and earthen ponds, and flexibility of use either in fresh form or as dried meal (Saselah *et al*., 2019).

Nile tilapia (*Oreochromis niloticus*) is one of the most economically valuable freshwater aquaculture species, with continuously increasing market demand. The species is generally categorized as herbivorous with carnivorous tendencies, but it is also considered omnivorous, with feeding habits that vary according to sex, size, and season (Satia *et al*., 2011; Setiawati & Pangaribuan, 2017; Shalloof *et al*., 2020). Based on these characteristics, the inclusion of Lemna minor in the diet may be suitable for tilapia and potentially enhance its growth performance. Feed compatibility, adequate protein levels, and feed quality are critical factors determining the success of fish growth. Properly formulated pellet feed supports feed efficiency, growth acceleration, fish health, and overall economic sustainability in aquaculture.

Previous studies have demonstrated that the use of *L. minor* in fish feed positively influences growth, whether applied in fresh or dried form. Kristiana *et al*. (2022) reported that incorporating 10% dried *L. minor* into a mixed feed containing pellets and fishmeal increased the growth and survival rates of pearl catfish fry compared to the 5% inclusion level and the control treatment. Furthermore, Manganang and Mose (2019) found that adding 20% fermented *L. minor* improved growth rate and feed efficiency compared to both lower and higher inclusion levels. From an economic perspective, the use of this ingredient has also been shown to reduce production costs and is considered feasible for further application (Jamis *et al*., 2022).

This study aims to evaluate the potential use of *L. minor* meal as a substitute for fishmeal in formulated fish feed and to contribute supporting information regarding the utilization of *L. minor* in aquaculture.

METHODS

Time and Place

This study was conducted over a period of 30 days at the Wet Laboratory of the Teaching Factory, Teknik Budidaya Perikanan, Politeknik Kelautan dan Perikanan Sidoarjo. The nutritional analysis of the feed was carried out at the Fish Health and Environmental Laboratory Unit (UPT Laboratorium Kesehatan Ikan dan Lingkungan) under the Department of Marine Affairs and Fisheries of East Java Province.

Tools and Materials

The equipment used in this study included a grinder, milling machine, extruder, weighing scale, tarpaulin tank with a volume of 785.4 L, hoses, and aeration stones. The materials used

consisted of black Nile tilapia (9 cm in size), *Lemna minor*, fish meal, tapioca flour, wheat flour, rice bran flour, and vitamin–mineral premix.

Pellet Preparation

The feed was formulated using the same basic ingredients, with varying percentages of *Lemna minor* meal added to each treatment. The main ingredients used included fishmeal, rice bran, tapioca flour, and *L. minor* meal. The inclusion levels of *L. minor* in the feed formulations were 0%, 10%, and 20%. Each formulated feed was subjected to a proximate analysis to determine its crude protein, lipid, ash, and moisture content.

Fish Rearing

Nile tilapia were stocked at a density of 40 fish per tank, with each tank containing 400 L of water. The fish used in the experiment had uniform initial body weights. The rearing period was conducted for 4 weeks.

Growth Bioassay

The formulated feeds were evaluated to compare their effects on the growth performance of Nile tilapia. The measured parameters included:

a. **Feeding response.** Feeding response was assessed by recording the time interval between feed administration and the moment the fish began consuming the pellets. The feeding rate was set at 3% of the total fish biomass.
b. **Weight gain.** Fish body weight was measured using a digital scale. Measurements were taken weekly throughout the experiment.
c. **Feed Conversion Ratio (FCR).** FCR was calculated as the ratio of total feed consumed to biomass gained using the formula:

$$FCR = \frac{F}{Bt - Bo}$$

where:
F = total amount of feed consumed,
Bt = biomass at the end of the experiment,
Bo = biomass at the beginning of the experiment
(Putra *et al*., 2020; Idris, 2025).

RESULTS

Chemical Composition of the Feed

The chemical composition of the formulated feeds varied according to the inclusion levels of *Lemna minor* meal (Table 2). Crude protein content increased substantially with higher substitution levels, from 19.19% in the control feed to 22.51% and 36.78% at 10% and 20% inclusion, respectively. Ash content showed a slight decrease at 10% substitution (14.13%) before increasing again to 14.92% at the 20% level. Moisture content remained relatively stable across treatments, ranging between 9.17% and 10.28%.

Table 1. Pellet Formula Composition

Ingredient	*L. minor* Meal Addition (grams)		
	A (0%)	B 10 (%)	C (20%)
Fishmeal	450	450	350
Rice bran	245	145	145
Tapioca flour	200	200	200
Wheat flour	100	100	100
L. minor meal	0	100	200
Vitamin and minerals	5	5	5

Table 2. Chemical Composition of the Feed

Composition Parameter	*L. minor* Meal Addition (grams)		
	A (0%)	B 10 (%)	C (20%)
Crude protein (%)	19,19	22,51	36,78
Ash (%)	16,45	14,13	14,92
Moisture (%)	9,17	10,28	9,91

Growth Performance

The growth performance of Nile tilapia fed diets containing different inclusion levels of *Lemna minor* meal is presented in Figure 1. Weight gain increased progressively throughout the 32-day rearing period across all treatments. At the beginning of the experiment (Day 1), all treatments showed relatively similar initial weights, ranging from 11.33 to 11.75 g. By Day 7, the control group exhibited a weight of 20.00 g, while fish fed diets containing 10% and 20% *L. minor* meal reached 16.00 g and 18.33 g, respectively. This indicates that the 20% inclusion supported better early-stage growth compared to the 10% diet.

A more pronounced difference was observed on Day 16. Fish receiving the 10% *L. minor* diet achieved the highest mean weight (24.33 g), followed by the 20% inclusion (23.67 g) and the control (23.33 g). This trend continued until Day 32, where the 10% *L. minor* treatment produced the highest final weight (28.30 g), outperforming both the control (25.60 g) and the 20% inclusion level (25.30 g).

Overall, the 10% *L. minor* diet resulted in the greatest cumulative weight gain throughout the experiment, as also reflected by the higher slope of its linear regression trendline (R^2 = 0.9813). Meanwhile, the 20% inclusion showed moderate growth, comparable to the control but not superior. These results indicate that *L. minor* meal at 10% inclusion provides the optimal balance of nutrients to support growth in Nile tilapia.

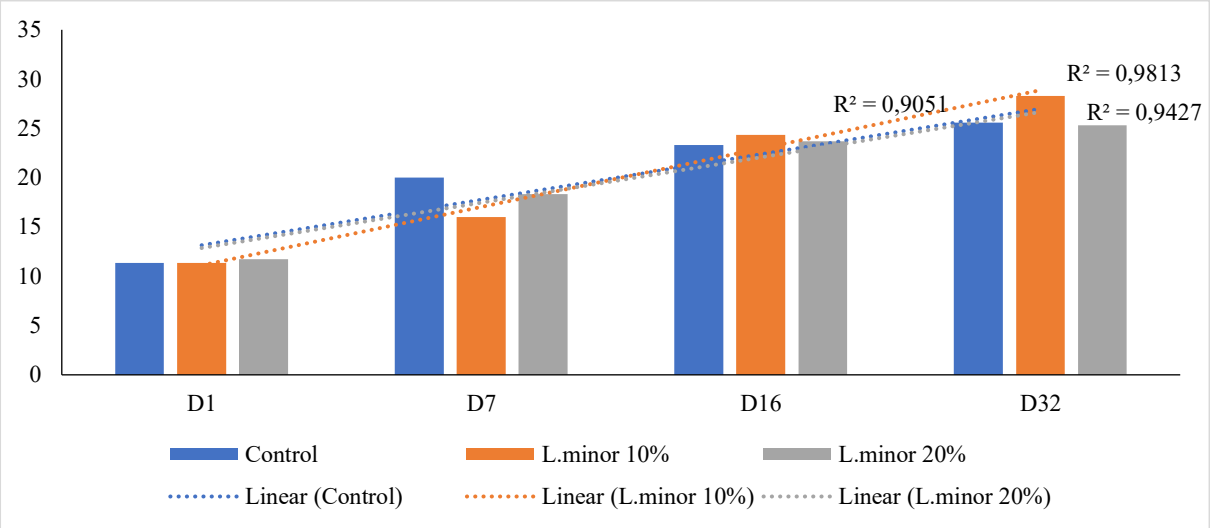

Figure 1. Weight Gain of Fish Fed *Lemna minor* Meal Pellets at Different Concentrations

Feed Conversion Ratio

The feed conversion ratio (FCR) of fish fed with different levels of *L. minor* meal is presented in Figure 2. The lowest FCR value was observed in the 10% *L. minor* treatment (1.27), indicating more efficient feed utilization compared to the control (1.47). The highest FCR value was recorded in the 20% inclusion group (1.60), suggesting reduced feed efficiency when higher proportions of *L. minor* meal were used.

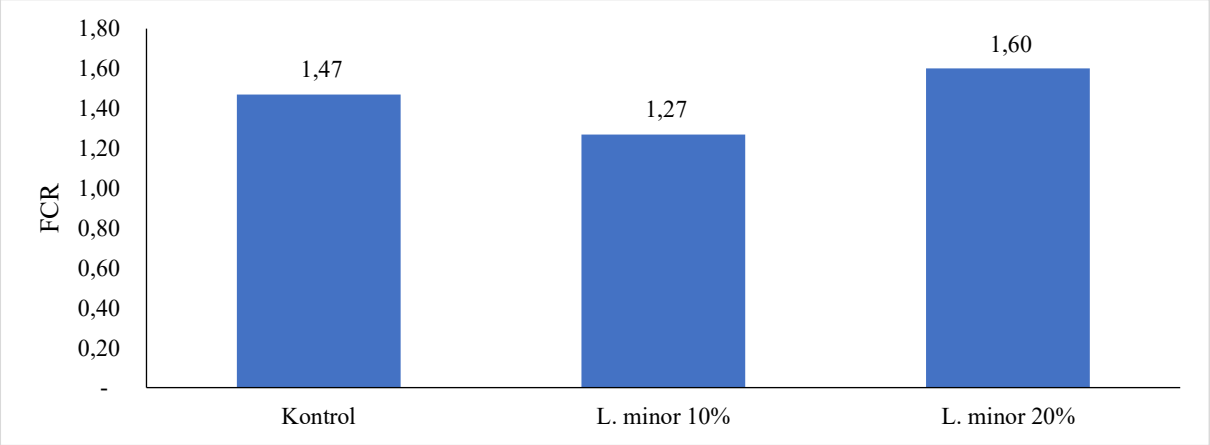

Figure 2. Feed Conversion Ratio (FCR)

DISCUSSION

The inclusion of *Lemna minor* meal in the feed formulation demonstrated its potential to increase the protein content of the pellets. In this study, the highest crude protein level was recorded at 36.78% in the feed containing 20% *L. minor* meal. This finding is consistent with Al-Snafi (2019), who reported that *L. minor* contains 16–45% protein, 4% fat, 8–10% fiber, 4–5% ash, carotenoids, and flavonoids such as luteolin-7-glucoside (0.38 ± 0.01%). Additionally, *L. minor* contains 4,990 mg/100 g of calcium, as well as essential amino acids (39.20%) and non-essential amino acids (53.64%). Among these amino acids, glutamic acid represents 25.87% of the total non-essential amino acids. *L. minor* also contains polyunsaturated fatty acids (PUFA) ranging from 60–63%, with α-linolenic acid (41–47%) and linoleic acid (17–18%) as the major components. Furthermore, Skillicorn *et al*. (1993) stated that the amino acid

profile of Lemnaceae plants closely resembles that of animal proteins, making them suitable as an ingredient for fish feed.

In this study, the protein content increased proportionally with the level of *L. minor* inclusion. The addition of 20% *L. minor* resulted in a protein content of 36.78%, compared to 22.51% with 10% inclusion and 19.19% in the control diet. This pattern is expected, as *L. minor* itself contains approximately 36% protein, contributing significantly to the overall protein level of the formulated feeds, as shown in Table 1. Leng *et al*. (1995) also reported that the protein content of *Lemna* spp. ranges between 10–43%.

The use of *L. minor* as a fishmeal substitute is further supported by the results in Table 1. Substituting fishmeal by 10% and adding 20% *L. minor* increased the crude protein level by 1.6-fold (comparison between control). Likewise, a 10% inclusion increased protein by 1.2-fold compared to the control. These results are consistent with previous findings by Mahendra *et al*. (2020), Umaya (2018), and Ilyas *et al*. (2014), who noted that *L. minor* can serve as a fish feed ingredient and as a substrate in Tubifex sp. culture. Another species, *L. perpusilla,* has also been used as a partial fishmeal substitute, where a 20% inclusion yielded a protein retention value of 32.75%. According to Sosa *et al*. (2024), incorporating *L. minor* into fish feed can improve the nutritional value of common carp by increasing protein, fat, amino acids, and omega-3 content. Similarly, Irabor *et al*. (2022) found that replacing 50% of the basal diet of tilapia and freshwater prawns with *L. minor* enhanced growth rate and body weight after four months of culture.

L. minor can be used either fresh or dried. When provided as a fresh diet or in combination with pellets, *L. minor* has been shown to improve fish growth performance. Nekoubin and Sudagar (2013) reported that the specific growth rate (SGR) of grass carp increased by 0.5% when fed a diet containing 20% Lemna sp. Similar positive effects on SGR were observed in other studies on *L. minor* (Nekoubin & Sudagar, 2013; Sulawesty, 2014). In the present study, the highest average daily growth rate of Nile tilapia was observed in fish fed the diet containing 10% *L. minor* (0.53 g/day), followed by the control diet (0.45 g/day), and the lowest growth rate was recorded in the 20% inclusion group (0.42 g/day). These differences are likely due to the variation in protein levels among the diets. However, the reduced growth at 20% inclusion may also be attributed to the increased crude fiber content and reduced proportion of animal-based protein, as shown in Tables 1 and 2. As stated by Asriyanti *et al*., (2018), fish may have difficulty digesting diets with high crude fiber content.

Physical pellet quality is an important factor following nutritional quality, as it influences the condition of the rearing environment (Yulianto, 2018). In this study, the control feed (0% *L. minor*) exhibited the shortest floating time (0–11 minutes). Pellets containing *L. minor* showed better buoyancy: 23–37 minutes (10% inclusion) and 25–37 minutes (20% inclusion). This improvement may be associated with the plant-derived components of *L. minor*, such as its high fiber content, which contributes to a lighter structure and enhanced buoyancy. The waxy surface of Lemna leaves may also contribute to improved floating properties. Pellet buoyancy is influenced by density; pellets with a density lower than water tend to float (Mujiman, 2008; Hutagalung *et al*., 2022). Since *L. minor* is an aquatic floating plant (Sosa *et al*., 2024), it likely has a relatively low density, which contributes to the better floating performance of pellets containing its meal. The buoyancy duration recorded in this study (15–30 minutes) can be categorized as good, particularly for pellets containing *L. minor*, compared with pellets without *L. minor*.

Moisture content is also an important indicator of feed quality. According to Zaenuri (2014), lower moisture content is preferable because it reduces the risk of fungal contamination.

CONSLUSION

This study demonstrates that *Lemna minor* meal has strong potential as a partial substitute for fishmeal in Nile tilapia feed formulations. The inclusion of *L. minor* significantly increased the crude protein content of the pellets, with the highest value observed at 20% inclusion. The 10% *L. minor* diet produced the best growth performance, indicating that moderate inclusion levels optimize nutrient availability for tilapia. Although the 20% inclusion increased protein content, growth performance declined, likely due to higher fiber levels and reduced digestibility. Pellet physical quality also improved with the addition of *L. minor*, particularly in terms of buoyancy, which is beneficial for feeding behavior and water quality management. Overall, *L. minor* meal is a promising, nutrient-rich, plant-based ingredient that can enhance feed quality and partially replace fishmeal in tilapia aquaculture, especially at inclusion levels up to 10%.

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