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EFFECT OF FERMENTED FIG FLOUR (*Ficus racemosa* L.) SUBSTITUTION ON PROTEIN AND LIPID RETENTION IN GIANT GOURAMI (*Osphronemus goramy* Lacepede, 1801)

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ABSTRACT

Ficus racemosa is one plant species that can be used as a substitute for soybean meal in giant gourami feed. Substitution of fermented fig flour with Effective Microorganisms 4 (EM-4) can improve protein quality in feed and the growth of giant gourami. The objective of this study was to analyze the effect of feeding giant gourami with fig flour-based substitute feed on protein and lipid retention values in aquaculture systems. The method used was an experiment in a completely randomized design with five treatments (0%, 10%, 20%, 30%, 40% fermented fig flour) and five replicates. The feed formulation was prepared using the five isonitrogenous method with a protein content of 32%. The fermentation of fig flour was carried out aerobically, incubated for 72 hours using EM-4. The test fish used were 250 giant gourami weighing between 15 and 20 g. Feeding was carried out at 07:00 and 17:00 WIB with a dose of 3% of the fish biomass. Giant gourami fish were kept for 70 days, with length and weight measurements taken every 14 days. The results showed that treatment F4, with 30% fermented fig flour in the feed, had the highest protein retention (18.41 ± 0.86%) and lipid retention (36.03 ± 1.60%) in giant gourami. Treatment F4, with 30% fermented fig flour in the artificial feed, was the best treatment for producing effective and efficient protein and lipid retention values in giant gourami.

KEYWORDS: ***Ficus racemosa*; retention; protein; lipid; fermentation; giant gourami**

ABSTRAK*: Pengaruh Substitusi Tepung Buah Ara (Ficus racemosa* L.*) Fermentasi terhadap Retensi Protein dan Lemak Ikan Gurami (Osphronemus goramy Lacepede, 1801)*

Ficus racemosa adalah salah satu jenis tumbuhan yang dapat digunakan sebagai pengganti tepung kedelai dalam pakan ikan gurami. Substitusi tepung buah ara yang difermentasi dengan EM-4 dapat meningkatkan kualitas protein dalam pakan dan pertumbuhan ikan gurami. Tujuan penelitian ini adalah menganalisis pengaruh pemberian pakan pengganti berbasis tepung buah ara pada nilai retensi protein dan lemak dalam sistem budidaya perikanan. Metode yang digunakan adalah eksperimen dengan desain acak lengkap yang terdiri dari lima perlakuan (0%, 10%, 20%, 30%, 40% fermentasi tepung buah) dan lima ulangan. Formulasi pakan disiapkan menggunakan metode isonitrogenus dengan kandungan protein 32%. Fermentasi tepung buah ara dilakukan secara aerobik, diinkubasi selama 72 jam menggunakan EM-4. Ikan uji yang digunakan adalah 250 ekor ikan gurami dengan bobot berkisar 15-20 g. Pemberian pakan dilakukan pada pukul 07:00 dan 17:00 WIB dengan dosis

3% dari biomassa ikan. Ikan gurami dipelihara selama 70 hari, pengukuran panjang dan bobot ikan diukur setiap 14 hari. Hasil menunjukkan bahwa perlakuan F4, dengan 30% tepung buah ara fermentasi dalam pakan, memiliki retensi protein (18,41 ± 0,86%) dan retensi lemak (36,03 ± 1,60%) tertinggi pada ikan gurami. Perlakuan F4 dengan 30% tepung buah ara fermentasi dalam pakan buatan merupakan perlakuan terbaik untuk menghasilkan nilai retensi protein dan lemak yang efektf dan efisien pada ikan gurami.

KATA KUNCI*: Ficus racemosa; retensi; protein; lemak; fermentasi; ikan gurami*

INTRODUCTION

Aquaculture production in Indonesia continues to grow in line with increasing demand for fish protein as an animal protein source. One of the main constraints in commercial fish farming is feed costs, which account for the most significant portion of total production costs (50–70%) (Fitra and Zakaria, 2022). Therefore, efforts to reduce feed costs by substituting conventional feed ingredients (e.g., fish meal or soybean meal) with low-cost local ingredients are crucial to improving the economic efficiency of aquaculture businesses (Chen *et al.*, 2019; Kim & Cho, 2024). Therefore, strategies to reduce feed costs without compromising fish performance are a key focus in modern aquaculture nutrition research.

Giant gourami (*Osphronemus goramy*) is a high value commodity in Indonesia, but often exhibits relatively slow growth and specific feeding requirements. Optimizing feed composition is necessary to improve feed conversion efficiency, growth rate, and protein and lipid retention in fish. One of the main challenges in gurami fish farming is feed efficiency, particularly in improving protein and lipid retention, which directly impacts fish growth and meat quality (Afriyanti *et al.*, 2020). The quality of fish feed protein can also be seen from the protein retention value in the fish body. The source and quality of protein influences protein retention value in the feed (Chen *et al*., 2019).

Giant gourami farming generally uses commercial feed, which can account for up to 60% of production costs, thereby reducing giant gourami production. Feed is a major factor affecting fish growth and survival (Sonavel *et al.*, 2020). One effort made to increase giant gourami is by using high-quality feed (Suwarsito & Susylowati, 2024). One of the nutritional factors required for fish growth is protein content and amino acid components (Fitra & Zakaria, 2022). Therefore, feed containing plant-based protein derived from fermented fig flour (*Ficus racemosa*) is used to improve the growth performance of giant gourami.

The use of fig flour has been proven in alternative feeding as a substitute for commercial feed for giant gourami to improve feed quality and fish growth (Zakaria *et al*., 2022). Partial substitution of feed with fig flour is expected to improve the digestive profile and increase feed utilization efficiency, thereby positively impacting protein retention and lipid retention in fish (Yonarta *et al*., 2023).

Conventional feed used in fish farming is generally based on imported raw materials such as fish meal and soybeans, which are expensive and limited in availability. The use of alternative raw materials in fish feed formulation is an increasingly interesting topic, especially for reducing dependence on conventional feed ingredients such as fish meal and soybeans. Therefore, economical local alternatives with high nutritional value are needed. One potential local ingredient is fig fruit (*F. racemosa*), which is rich in bioactive compounds such as flavonoids, tannins, and saponins, and contains adequate levels of protein and fiber to serve as a feed substitute. The nutrients contained in figs are 28.125% protein, 2% minerals, 30.5% calcium, 15.84% carbohydrates, 20% carotene, 5.3% ascorbic acid, and are rich in phosphorus and iron (Kannan *et al*., 2024; Rasyid *et al*., 2017; Sharma *et al*., 2020).

Several studies have shown that the antioxidant content in figs can increase immunity and feed efficiency in fish (Prasad *et al*., 2014). Substituting fig flour into artificial feed has a significant effect on feed quality and the growth of the giant gourami (Zakaria *et al*., 2022). Therefore, partially substituting feed with fig flour has the potential to improve protein and lipid retention efficiency in giant gourami.

Research on the effects of feed substitution with fermented fig flour (*F. racemosa*) on protein and lipid retention. This study aims to analyze the effects of feeding giant gourami with fig flour feed substitutes on protein and lipid retention in aquaculture systems. The results of this study are expected to provide scientific information on the use of local resources in fish feed formulation and support the development of more efficient and sustainable fish farming.

MATERIALS AND METHODS

Time and Location

This research was conducted from August to December 2021 at the Fish Seed Center, Bungus Timur Village, Bungus Teluk Kabung District, Padang. Data analysis was carried out at the Animal Ecology Research Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Andalas University, Padang, West Sumatra.

Experimental Design and Formulated Feed

The method used in this study was an experimental design with a completely randomized design consisting of 5 treatments and 5 replicates. The treatments given in this study were as follows:

(F1) Feed with 0% fermented fig flour
(F2) Feed with 10% fermented fig flour
(F3) Feed with 20% fermented fig flour
(F4) Feed with 30% fermented fig flour
(F5) Feed with 40% fermented fig flour

The feed to be used in this study was first analyzed proximately to determine its nutritional content. The feed formulation used was based on the study (Fitra, 2021) with fig fermentation. The feed formulation was prepared using the isonitrogenous method with a protein content of 32%. The raw materials used in the feed mixture were soybean meal, fish meal, tapioca flour, corn flour, fine bran, fish oil, vitamins and minerals (Premix Aquavita), and water, as well as fermentation materials, namely Effective Microorganism-4 (EM-4) and distilled water. The fermentation of fig flour was carried out aerobically, incubated for 72 hours using EM-4. Weigh 2.000 g of fig flour, then gradually pour in 1.200 ml of distilled water until a uniform mixture is obtained. The mixture is placed in a heat-resistant plastic container and steamed for 30 minutes. Allow the fig flour to cool for 30 minutes. Next, 2.000 g of fig flour is weighed and mixed a 5% EM-4 solution until homogeneous. The mixture of fig flour and EM-4 is placed in a 14×30 cm plastic bag (Listiowati & Pramono, 2014).

The test fish used were 250 giant gourami weighing 15 - 20 g, obtained directly from the Padang City Fish Seed Center. The experiment was carried out in a 12 × 8 m earthen pond fitted with hapa nets to separate experimental units and maintain uniform rearing conditions. Water depth was consistently maintained between 60 and 75 cm throughout the experimental period. Feeding was carried out at 07:00 and 17:00 WIB with a dose of 3% of the fish biomass. Giant gourami were reared for 70 days, and their length and weight were measured every 14 days (Arifiina *et al.*, 2020). Fish weight and length were observed every 14 days by weighing all fish from each treatment container (Fitra, 2021).

Total length was measured from the anterior tip of the snout to the posterior end of the caudal fin using a measuring board or digital caliper with a precision of 0.1 cm. All measurements were conducted under consistent handling procedures to reduce stress and measurement bias. After measurement, the fish were immediately returned to their respective rearing containers. The collected data were used to calculate growth performance parameters during the experimental period. Prior to measurement, all fish from each treatment container were carefully collected to ensure accurate biomass estimation. Excess water on the fish body surface was gently removed using a soft cloth to minimize weighing error. Individual fish were weighed using a digital balance with a precision of 0.01 g to obtain accurate body weight data.

Three fish samples for each treatment were taken at the beginning and end of the study and analyzed for moisture, protein, lipid, crude fiber, and ash content to determine protein and lipid retention in giant gourami. To determine the protein and lipid content in fish bodies at the beginning and end of the study, tests were conducted at the Chemistry Laboratory at Bung Hatta University in Padang City. The protein and lipid content of fish and feed were analyzed using the Kjeldahl and Soxhlet methods based on AOAC (2019).

The crude protein content of fish and feed samples was determined using the Kjeldahl method in accordance with AOAC Official Methods 978.04 and 984.13, based on total nitrogen determination following acid digestion, distillation, and titration, with nitrogen values converted to crude protein using a factor of 6.25. Crude lipid content was analyzed by Soxhlet extraction following AOAC Official Method 920.39, in which dried samples were continuously extracted with a non-polar solvent and the lipid residue was quantified gravimetrically.

Parameters Assessed

The parameters observed in this study were protein retention, lipid retention, and the relationship between feed quality and the length and weight of fish.

The absolute weight gain of fish can be calculated using the formula (1) of Effendie (1997):

$$\mathrm{Wm} = \mathrm{Wt} - \mathrm{Wo} \quad \ldots\ldots (1)$$

Notes:

Wm : Average absolute weight gain of fish (g)

Wt : Average individual weight of fish at the end of the study (g)

Wo : Average individual weight of fish at the start of the study (g)

The absolute length increment of fish can be calculated using the formula (2) of Effendie (1997):

$$\mathrm{Lm} = \mathrm{Lt} - \mathrm{Lo} \quad \ldots\ldots (2)$$

Notes:

Lm : Average absolute length gain of fish (mm)

Lt : Average individual length of fish at the end of the study (mm)

Lo : Average individual length of fish at the start of the study (mm)

Protein retention is the ratio of the amount of protein stored in the fish's body to the amount of protein provided during maintenance. The increase in fish body protein is calculated by multiplying the fish's dry weight at the end of the study by its final body protein content, minus the dry weight at the start of the study multiplied by its initial body protein content. Protein retention is calculated using the formula (3) (Willer *et al.*, 2024).

$$\text{RP (\%)} = \left(\frac{\text{Pt}-\text{Po}}{\text{Pp}}\right) \times 100 \quad \text{.......... (3)}$$

Notes:

RP = Protein retention (%)

Pt = Total protein in fish at the end of the study (%)

Po = Total protein in fish at the beginning of the study (%)

Pp = Total protein in feed consumed by fish (%)

Lipid retention in fish is the percentage of lipid from feed that is stored as body tissue during the maintenance period. The increase in fish body lipid was calculated by multiplying the fish's dry weight at the end of the study by its final body lipid content, minus the dry weight at the start of the study multiplied by its initial body lipid content. It is generally calculated using the formula (4) (Van Nguyen *et al.*, 2024).

$$\text{RL (\%)} = \left(\frac{\text{Lt}-\text{Lo}}{\text{Lp}}\right) \times 100 \quad \text{.......... (4)}$$

Notes:

RL = Lipid retention (%)

Lt = Total body lipid of fish at the end of the study (%)

Lo = Total body lipid of fish at the beginning of the study (%)

Lp = Total feed lipid consumed by fish (%)

Data Statistic

The protein and lipid retention data were analyzed using one-way ANOVA at the 5% significance level. If there were significant differences among treatments, DNMRT was performed in SPSS version 26. Normality and homogeneity were validated using the Shapiro-Wilk and Levene's tests (Zakaria *et al*., 2022).

RESULTS AND DISCUSSION

Protein Retention

Based on the results of the one-way ANOVA statistical test, it was found that differences in the percentage of fermented fig flour in artificial feed had a significant effect ($p<0.05$) on the protein retention of giant gourami. The results of Duncan's New Multiple Range Test showed that treatments F4 and F1 (control) were significantly different, and that treatments F2 and F3 were significantly different (Figure 1). However, treatment F3 did not differ significantly from treatment F1. Treatment F2 had the same effect on protein retention as treatment F1 or the control in giant gourami.

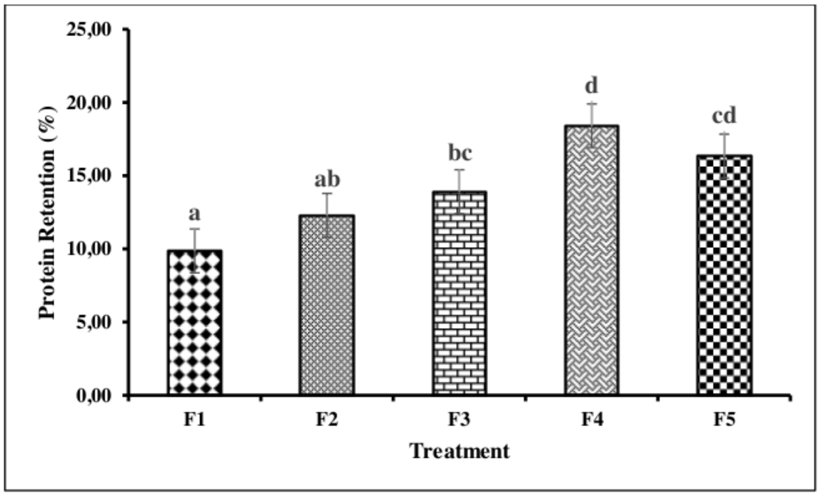

Figure 1. Giant gourami fish protein retention in each treatment: (F1) Feed with 0% fermented fig flour, (F2) Feed with 10% fermented fig flour, (F3) Feed with 20% fermented fig flour, (F4) Feed with 30% fermented fig flour, (F5) Feed with 40% fermented fig flour. Different letters above the bar in each treatment indicate significant differences at the 95% confidence level ($p<0.05$).

Protein retention is the ratio between the amount of protein in the fish's body and the amount of protein consumed in the feed. Based on the research data the highest average protein retention value for giant gourami was observed in treatment F4, with the addition of 30% fermented fig flour to the artificial feed, at 18.41 ± 0.86% (feed protein content 35.46%). Meanwhile, treatment F1 or the control, had the lowest average protein retention value with artificial feed without fermented fig flour, at 9.86 ± 0.10% (feed protein content 31.65%).

Treatment F4 is the best feed for achieving effective, efficient retention in giant gourami. The protein content in treatment F4 feed is 32%, indicating that the addition of 30% fermented fig flour is suitable for the needs of giant gourami, enabling optimal absorption by the giant gourami's body. This indicates that feed containing fermented fig flour is better for giant gourami than feed without it, which served as the control.

According to Langi *et al.* (2024), the protein requirement range for carnivorous fish is 35–45%, whereas herbivorous fish generally require only 25–35%, depending on growth phase and environmental conditions. This is in line with the results of research that giant gourami fish as a herbivorous fish is able to produce optimal protein retention. Serra *et al*. (2024), stated that protein utilization efficiency is also greatly influenced by alternative protein sources such as single-cell protein, insect meal, and fermented plant materials, which can improve digestibility and support higher protein retention values than conventional sources when formulated appropriately.

The balance of essential amino acids and the protein-to-energy ratio has a significant effect on protein retention and growth efficiency in various species of fish and crustaceans (Xing *et al*., 2024). Feed protein quality is not only determined by total protein content, but also by amino acid bioavailability and crude protein digestibility, which are the main factors determining the level of protein retention in fish (Buttle *et al*., 2024). Thus, protein retention can be used as a key indicator of feed protein quality, as high retention values reflect the ability of fish to utilize protein for tissue synthesis and growth (Serra *et al*., 2024).

Lipid Retention

Based on the results of the one-way ANOVA statistical test, it was found that differences in the percentage of fermented fig flour formulated in artificial feed had a significant effect ($p<0.05$) on the lipid retention value of giant gourami. The results of DNMRT showed significant differences between treatments F4 and F1 (control), F2, F3 and F5 (Figure 2). However, treatments F3 and F5 had the same effect on lipid retention in giant gourami.

The highest lipid retention value for giant gourami during the study was observed in treatment F4, at 36.30%. The results showed that treatment F4, with 30% fermented fig flour in the feed, was able to increase the lipid retention value in giant gourami compared to the control treatment, which was given feed without fermented fig flour.

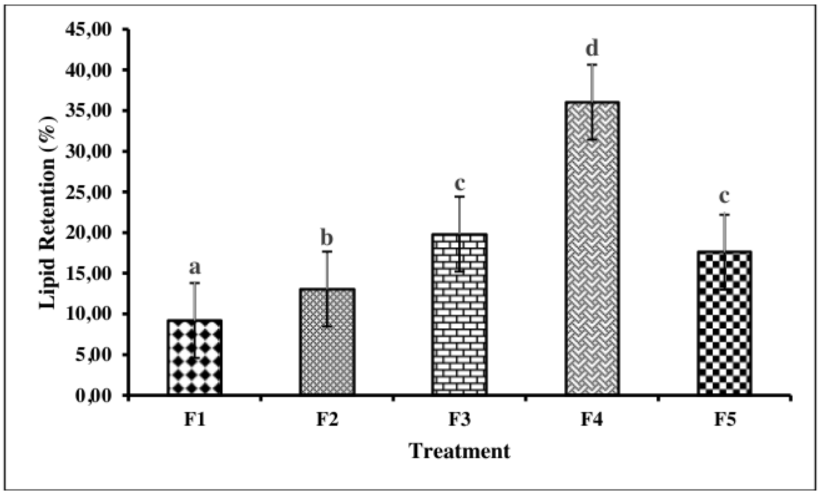

Figure 2. Giant gourami fish lipid retention in each treatment: (F1) Feed with 0% fermented fig flour, (F2) Feed with 10% fermented fig flour, (F3) Feed with 20% fermented fig flour, (F4) Feed with 30% fermented fig flour, (F5) Feed with 40% fermented fig flour. Different letters above the bar in each treatment indicate significant differences at the 95% confidence level ($p<0.05$).

Lipid retention is an indicator of the efficiency of energy utilization from feed by fish, defined as the ratio of lipid stored in the fish's body to the lipid provided during maintenance. This parameter is closely related to feed nutrient composition, protein-to-lipid ratio, and lipid metabolism processes (Li *et al*., 2023; Všetičková *et al*., 2020). The inclusion of fermented fig in artificial feed can increase lipid retention in giant gourami. Based on the research data treatment F4 had the highest average lipid retention of 36.03 ± 1.60% (feed lipid content: 5.71%). Meanwhile, the lowest average lipid retention value was observed in treatment F1 (control), at 9.19 ± 0.09% (feed lipid content 6.35%).

The higher the lipid retention value, the more efficiently fish utilize energy from feed for tissue growth, rather than just as a metabolic energy reserve (Phan *et al.*, 2021; Tacon & Metian, 2015). According to Li *et al*. (2023), increasing the lipid content of feed to an optimal level can improve the protein-to-energy (P:E) ratio and shift the main energy source from protein oxidation, thereby simultaneously increasing protein and lipid retention efficiency.

However, excessively high lipid levels (>15%) can lead to visceral fat accumulation and reduced retention efficiency due to an imbalance in energy metabolism.

In addition to fatty acid composition, feed quality and fermentation processes also significantly affect lipid retention. According to Sartipiyarahmadi *et al*. (2023), fermentation of plant materials can reduce crude fiber content, increase lipid digestibility, and improve lipid retention efficiency without causing excessive Lipid accumulation in fish tissue. A similar finding was reported by Mao *et al.* (2024), who discovered that supplementing feed with naturally fermented ingredients can improve Lipid digestibility and increase the lipid retention ratio in freshwater fish.

CONCLUSIONS

The difference in the percentage of fermented fig flour (*Ficus racemosa*) in the artificial feed had a significant effect ($p<0.05$) on protein and lipid retention in giant gourami. Treatment F4, with 30% fermented fig flour in the artificial feed, was the best treatment for producing effective and efficient protein and lipid retention values in giant gourami.

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AUTHOR CONTRIBUTION

All authors have contributed to the completion of this research. The contributions of each author were as follows: RF; conceptualization, data curation, formal analysis, investigation, methodology, resources, software, visualization, writing original draft, review, and editing. IJZ; conceptualization, data curation, funding acquisition, project administration, supervision, and validation. FAF; conceptualization, data curation, funding acquisition, project administration, supervision, and validation. WW; investigation and methodology. MF; investigation and methodology. All authors discussed the results and contributed to the final manuscript.

DECLARATION OF COMPETING INTEREST AND USE GENERATIVE AI

The authors declare no competing interests. "During the preparation of this work, the authors used Consensus, Chat GPT and Quillbot in order to enrich the literature and do paraphrasing. The authors reviewed and edited the content of the created material as needed and take full responsibility for the content of the publication".

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