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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 has considerable potential as a plant-based ingredient for partially replacing soybean meal in diets for giant gourami. Fermenting fig flour with Effective Microorganisms-4 (EM-4) is expected to enhance protein quality and improve nutrient utilization. This study evaluated the effects of substituting artificial feed with fermented fig flour on protein and lipid retention in giant gourami cultured under aquaculture conditions. The experiment employed a completely randomized design with five dietary treatments containing 0%, 10%, 20%, 30%, and 40% fermented fig flour, each with five replicates. All diets were formulated to be isonitrogenous, with a crude protein content of 32%. Fig flour was aerobically fermented for 72 hours using EM-4 prior to diet formulation. A total of 250 juvenile giant gourami (initial body weight 15–20 g) were reared for 70 days and fed twice daily at a feeding rate of 3% of total biomass. Fish length and weight were recorded at 14-day intervals. Protein and lipid retention were determined based on proximate analyses conducted at the beginning and end of the experiment. The results showed that dietary inclusion of fermented fig flour significantly affected protein and lipid retention ($p < 0.05$). The highest protein retention (18.41 ± 0.86%) and lipid retention (36.03 ± 1.60%) were observed in fish fed the diet containing 30% fermented fig flour. These findings indicate that partial substitution of artificial feed with 30% fermented fig flour improves nutrient retention efficiency and represents a promising strategy for developing cost-effective and sustainable diets for giant gourami culture.

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

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

***Ficus racemosa** memiliki potensi yang besar sebagai bahan pakan nabati untuk menggantikan sebagian tepung kedelai dalam pakan ikan gurami. Fermentasi tepung buah ara menggunakan Effective Microorganisms-4 (EM-4) diharapkan dapat meningkatkan kualitas protein dan memperbaiki pemanfaatan nutrien. Penelitian ini bertujuan untuk mengevaluasi pengaruh*

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substitusi pakan buatan dengan tepung buah ara terfermentasi terhadap retensi protein dan lipid pada ikan gurami yang dibudidayakan dalam lingkungan terkontrol. Percobaan menggunakan rancangan acak lengkap dengan lima perlakuan pakan yang mengandung tepung buah ara terfermentasi sebesar 0%, 10%, 20%, 30%, dan 40%, masing-masing dengan lima ulangan. Seluruh pakan diformulasikan secara isonitrogenus dengan kadar protein kasar sebesar 32%. Tepung buah ara difermentasi secara aerob selama 72 jam menggunakan EM-4 sebelum diformulasikan ke dalam pakan. Sebanyak 250 ekor benih ikan gurami (bobot awal 15–20 g) dipelihara selama 70 hari dan diberi pakan dua kali sehari dengan dosis 3% dari total biomassa. Panjang dan bobot ikan diukur setiap 14 hari. Retensi protein dan lipid ditentukan berdasarkan analisis proksimat yang dilakukan pada awal dan akhir percobaan. Hasil penelitian menunjukkan bahwa penambahan tepung buah ara terfermentasi dalam pakan berpengaruh nyata terhadap retensi protein dan lipid ikan gurami ($p < 0,05$). Retensi protein tertinggi (18,41 ± 0,86%) dan retensi lipid tertinggi (36,03 ± 1,60%) diperoleh pada ikan yang diberi pakan dengan kandungan 30% tepung buah ara terfermentasi. Temuan ini menunjukkan bahwa substitusi sebagian pakan buatan dengan 30% tepung buah ara terfermentasi dapat meningkatkan efisiensi retensi nutrien dan merupakan strategi yang menjanjikan untuk pengembangan pakan ikan gurami yang lebih ekonomis dan berkelanjutan.

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

INTRODUCTION

Aquaculture production in Indonesia continues to increase in response to the growing demand for fish as a source of animal protein. However, the high cost of formulated feeds remains a major constraint to the economic sustainability of commercial aquaculture, as feed accounts for approximately 50–70% of total production costs (Fitra & Zakaria, 2022). Consequently, efforts to reduce feed costs by substituting conventional ingredients such as fish meal and soybean meal with low-cost local alternatives are essential for improving the economic efficiency of aquaculture operations (Chen *et al.*, 2019; Kim & Cho, 2024). Therefore, developing feeding strategies that reduce costs without compromising zootechnical performance has become a central focus in modern aquaculture nutrition research.

Giant gourami (*Osphronemus goramy*) is a high-value freshwater fish species widely cultivated in Indonesia. Despite its economic importance, giant gourami is characterized by relatively slow growth and specific nutritional requirements. Optimizing feed composition is therefore necessary to improve feed conversion efficiency, growth performance, and nutrient retention, particularly protein and lipid retention. Feed efficiency remains a limiting factor in giant gourami farming, as protein and lipid retention directly influence growth rate and flesh quality (Afriyanti *et al.*, 2020). Protein retention in fish is commonly used as an indicator of dietary protein quality and is strongly influenced by both the source and nutritional value of the protein in the feed (Chen *et al.*, 2019).

In practice, giant gourami farming relies heavily on commercial feeds, which can account for up to 60% of production costs and, consequently, limit profitability. Feed quality is a critical factor influencing fish growth and survival (Sonavel *et al.*, 2020), and the use of high-quality feed has been shown to enhance the growth rate of giant gourami (Suwarsito & Susylowati, 2024). Protein content and amino acid composition are among the most important nutritional factors required for optimal fish growth (Fitra & Zakaria, 2022). However, conventional aquaculture feeds are largely formulated with imported raw materials, such as fish meal and soybeans, which are costly and increasingly scarce. As a result, the exploration of alternative feed ingredients has gained considerable attention, particularly those derived from economical local resources with high nutritional value.

One potential local feed ingredient is fig fruit (*Ficus racemosa*), which contains high concentrations of bioactive compounds, including flavonoids, tannins, and saponins, as well as adequate levels of protein and fiber. These characteristics support its potential use as an alternative feed ingredient. The nutrient profile of fig fruit includes relatively high protein (28.125%) and carbohydrate (15.84%) contents, along with essential minerals (2%), calcium (30.5%), carotene (20%), ascorbic acid (5.3%), and notable amounts of phosphorus and iron (Kannan *et al.*, 2024; Rasyid *et al.*, 2017; Sharma *et al.*, 2020). Accordingly, plant-based protein derived from fermented fig flour has been proposed as a dietary ingredient to enhance the growth performance of giant gourami.

Previous studies have demonstrated that fig flour can be used as an alternative feed ingredient to partially substitute commercial feed and improve feed quality and growth performance in giant gourami (Zakaria *et al.*, 2022a; Zakaria *et al*., 2022b). The substitution of feed with fig flour is hypothesized to enhance digestive performance and feed utilization efficiency, thereby increasing protein and lipid retention in fish (Yonarta *et al.*, 2023). In addition, antioxidant compounds present in figs have been reported to strengthen fish immunity and further improve feed utilization efficiency (Prasad *et al.*, 2014). Therefore, partial replacement of conventional feed ingredients with fig flour may improve protein and lipid retention efficiency in giant gourami.

Research on the effects of feed substitution using fermented fig flour on protein and lipid retention remains limited. Therefore, the objective of this study was to evaluate the impact of dietary substitution with fig flour on protein and lipid retention in giant gourami. The findings of this study are expected to provide scientific evidence supporting the utilization of local feed resources and to contribute to the development of more efficient and sustainable giant gourami aquaculture practices.

MATERIALS AND METHODS

Time and Location

The research was conducted during the period of August–December 2021 at the Fish Seed Center in Bungus Timur Village, Bungus Teluk Kabung District, Padang, Indonesia, and 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, Indonesia.

Experimental Design

This study employed an experimental design with a completely randomized layout, comprising five treatments with five replicates each. The experimental treatments were as follows:
(F1) Artificial feed with 0% fermented fig flour
(F2) Artificial feed with 10% fermented fig flour
(F3) Artificial feed with 20% fermented fig flour
(F4) Artificial feed with 30% fermented fig flour
(F5) Artificial feed with 40% fermented fig flour

The quality of the feed used in this study was first determined by measuring proximate composition. The feed formulation was based on a study by Fitra (2021), in which the feed was supplemented with fermented fig. 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, Indonesia), and water, as well as fermentation materials, namely Effective Microorganism-4 (EM-4, Indonesia) and distilled water. Fermentation of fig flour was conducted under aerobic conditions using Effective Microorganisms 4 (EM-4) with an incubation period of 72 hours. Initially, 2,000 g of fig flour was weighed and gradually mixed with 1,200 mL of distilled water until a homogeneous slurry was obtained. The mixture was transferred into a heat-resistant plastic container and steamed for 30 minutes to reduce microbial contamination. After steaming, the fig flour was allowed to cool at room temperature for approximately 30 minutes. Subsequently, 2,000 g of the cooled fig flour was mixed thoroughly with a 5% EM-4 solution until uniform. The fermented mixture was then placed into a plastic bag measuring 14 × 30 cm for further incubation (Listiowati & Pramono, 2014).

The test fish were 250 giant gourami, weighing 15-20 g, obtained directly from the Padang City Fish Seed Center, Indonesia. 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. The experimental fish were reared for 70 days, and growth parameters (length and weight) were measured at 14 days intervals (Arifiina *et al*., 2020). Fish weight and length were observed every 14 days by weighing all fish from each treatment container (Fitra, 2021).

The total length of fish was measured from the anterior snout tip to the posterior end of the caudal fin using either a measuring board or a digital calliper 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 experimental unit 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. Chemical analyses to determine the protein and lipid contents of fish bodies at the start and end of the experiment were conducted at the Chemistry Laboratory, Bung Hatta University, Padang City, Indonesia. Protein and lipid levels in fish and feed samples were analyzed using standard Kjeldahl and Soxhlet methods, as described in AOAC (2019).

Crude protein levels in fish and feed samples were quantified using the Kjeldahl procedure following AOAC Official Methods 978.04 and 984.13. This method involved determining total nitrogen by acid digestion, distillation, and titration, after which nitrogen values were converted to crude protein using a conversion factor of 6.25. Crude lipid content was determined by Soxhlet extraction in accordance with AOAC Official Method 920.39, where oven-dried samples were subjected to continuous extraction with a non-polar solvent and lipid content was subsequently measured gravimetrically.

Parameters Assessed

This study assessed protein retention and lipid retention of giant gourami. Protein retention is defined as the proportion of dietary protein that is deposited in the fish body relative to the total protein intake during the rearing period. The increase in fish body protein is calculated by multiplying the 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. The protein retention value was obtained using the formula provided in equation (1) (Willer *et al*., 2024).

$$RP(\%) = \frac{Pt\text{-}Po}{Pp} \times 100 \quad \text{...(1)}$$

Note:
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 as the product of the dry weight at the end of the study and its final body lipid content, minus the product of the dry weight at the start of the study and its initial body lipid content. The calculation is generally performed using the formula presented in equation (2) (Van Nguyen *et al*., 2024).

$$RP(\%) = \frac{Lt\text{-}Lo}{Lp} \times 100 \quad \text{...(2)}$$

Note:
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 (%)

Ethical Statement

All experimental procedures involving *Osphronemus gouramy* were conducted in accordance with Indonesian animal welfare regulations (Law No. 18/2009; Government Regulation No. 95/2012). Fish were maintained under controlled aquaculture conditions following Good Aquaculture Practices (SNI 2729:2013). Stocking density, feeding regime, and water quality were managed to minimize stress. Fish were handled carefully during sampling, and anesthesia (MS-222) was applied when necessary. The study adhered to the principles of the 3Rs and complied with ARRIVE 2.0 guidelines.

Statistical Analysis

Protein and lipid retention data were subjected to one-way analysis of variance (ANOVA) at a 5% significance level ($\alpha = 0.05$). When significant differences among treatments were detected, Duncan's New Multiple Range Test (DNMRT) was applied using SPSS software version 26. Prior to analysis, data normality and homogeneity of variances were assessed using the Shapiro–Wilk and Levene's tests, respectively (Zakaria *et al*., 2022b).

RESULTS AND DISCUSSION

Protein Retention

Based on one-way ANOVA, variation in the proportion of fermented fig flour included in the artificial diet had a significant effect on protein retention in giant gourami ($p < 0.05$). Further analysis using Duncan's New Multiple Range Test revealed significant differences between treatment F4 and the control (F1), F2 and F3 (Figure 1). However, treatment F3 did not difference significantly from treatment F2. Treatment F2 had the same effect on protein retention as treatment F1 or the control in giant gourami.

Protein retention represents the proportion of dietary protein that is deposited in the fish body relative to the total protein intake. Based on the experimental results, the highest mean protein retention in giant gourami was observed in treatment F4, corresponding to a diet containing 30% fermented fig flour, at 18.41 ± 0.86% at a dietary protein level of 35.46%. Meanwhile, treatment F1 (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 was identified as the most effective diet for achieving efficient protein retention in giant gourami. The protein content of the F4 diet (32%) indicates that the inclusion of 30% fermented fig flour was appropriate to meet the nutritional requirements of giant gourami and promote efficient protein utilization. These results indicate that diets containing fermented fig flour are more effective for giant gourami than those without it (control treatment).

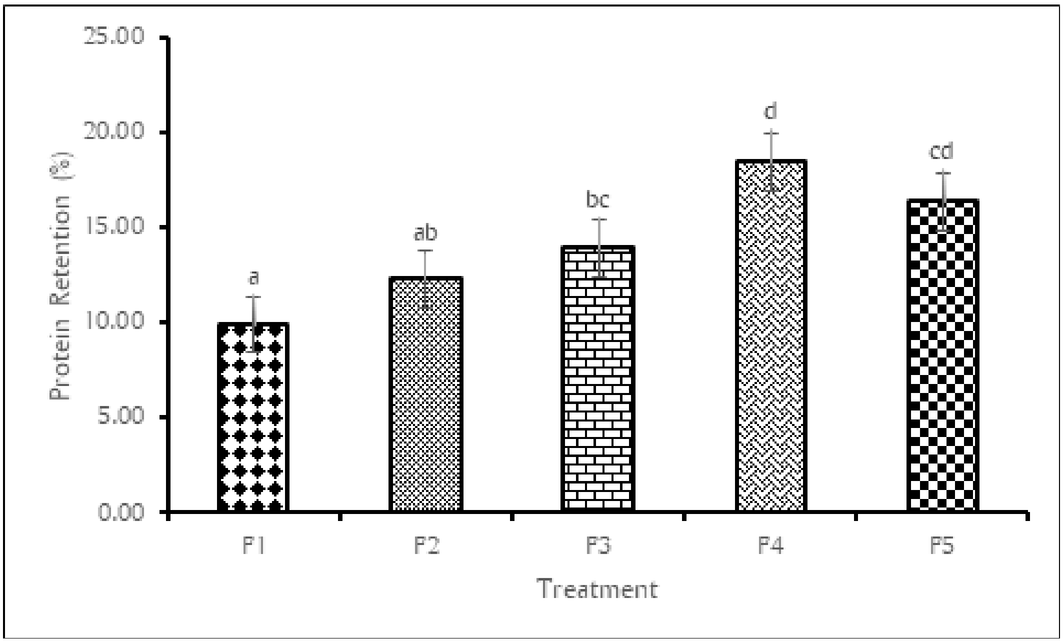

Figure 1. Protein retention of giant gourami fed diets containing different levels of fermented fig flour. (F1) Diet containing 0% fermented fig flour; (F2) diet containing 10% fermented fig flour; (F3) diet containing 20% fermented fig flour; (F4) diet containing 30% fermented fig flour; and (F5) diet containing 40% fermented fig flour. Different superscript letters above each bar indicate statistically significant differences among treatments at the 95% confidence level ($p < 0.05$)

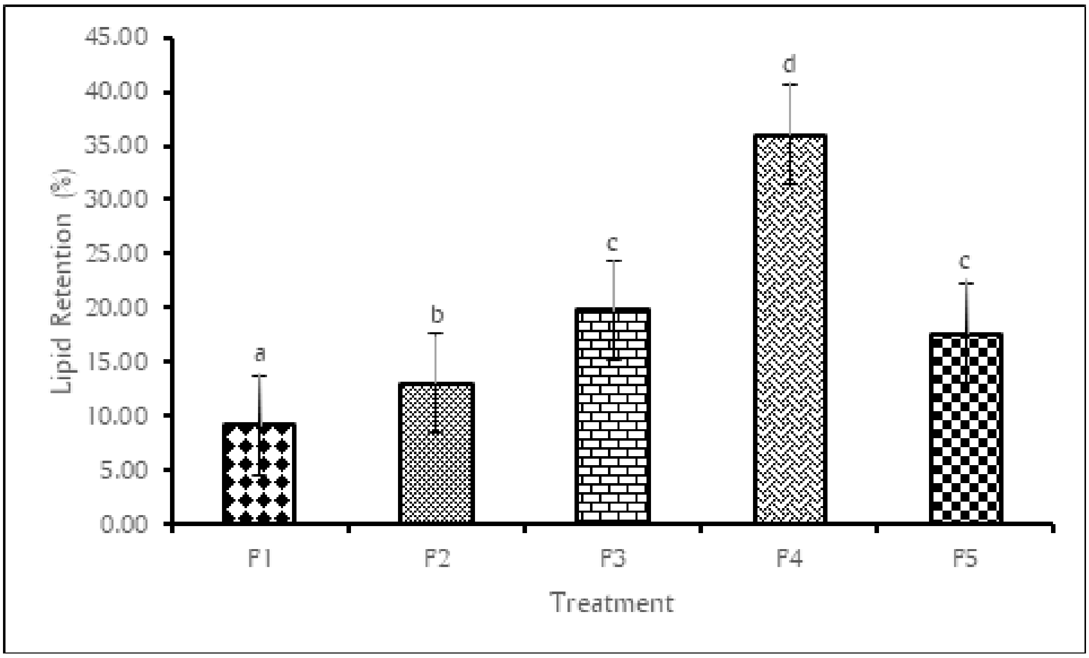

Figure 2. Lipid retention of giant gourami fed diets containing different levels of fermented fig flour. (F1) Diet containing 0% fermented fig flour; (F2) diet containing 10% fermented fig flour; (F3) diet containing 20% fermented fig flour; (F4) diet containing 30% fermented fig flour; and (F5) diet containing 40% fermented fig flour. Different superscript letters above each bar indicate statistically significant differences among treatments at the 95% confidence level ($p < 0.05$)

According to Langi *et al.* (2024), the dietary protein requirement for carnivorous fish ranges from 35–45%, while herbivorous fish generally require only 25–35%, depending on growth stage and environmental conditions. This finding is consistent with the present study, in which giant gourami, a herbivorous species, demonstrated optimal protein retention within this protein range. Furthermore, Serra *et al.* (2024) reported that protein utilization efficiency is strongly influenced by alternative protein ingredients, including single-cell protein, insect meal, and fermented plant-based materials, which have been shown to enhance digestibility and achieve higher protein retention than conventional protein sources when properly formulated.

An appropriate balance of essential amino acids and an optimal protein-to-energy ratio significantly influence protein retention and growth performance in fish and crustaceans (Xing *et al.*, 2024). Dietary protein quality is not determined solely by its concentration but is also strongly affected by amino acid bioavailability and digestibility, which ultimately govern protein retention in fish (Buttle *et al.*, 2024). Therefore, protein retention can be considered a key indicator of feed protein quality, as higher retention values reflect the ability of fish to efficiently utilize dietary protein for tissue synthesis and growth (Serra *et al.*, 2024).

Lipid Retention

One-way ANOVA indicated that variations in the proportion of fermented fig flour incorporated into the formulated diet significantly affected lipid retention in giant gourami ($p < 0.05$). Subsequent analysis using Duncan's New Multiple Range Test revealed that treatment F4 differed significantly from the control (F1) as well as from treatments 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 36.03%. The findings demonstrated that treatment F4, incorporating 30% fermented fig flour into the diet, resulted in higher lipid retention in giant gourami compared with the control group, which received a diet without fermented fig flour.

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, whereas treatment F1 (control) had the lowest.

The higher the lipid retention value, the more efficiently fish use energy from feed for tissue growth rather than 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 inclusion of fermented fig flour in formulated diets improves nutrient utilization in giant gourami, as evidenced by increased protein and lipid retention. The findings indicate that an appropriate inclusion level of fermented fig flour can optimize dietary nutrient efficiency, likely through improved digestibility and energy utilization. In particular, the diet containing 30% fermented fig flour demonstrated the greatest potential to support efficient protein and lipid deposition, highlighting its suitability as a functional local feed ingredient. These results support the use of fermented fig flour as a sustainable alternative to conventional feed components and provide a basis for developing cost-effective and nutritionally efficient diets for giant gourami aquaculture.

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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 participated in the discussion of the results and contributed to the preparation of the final manuscript.

DECLARATION OF COMPETING INTEREST AND USE GENERATIVE AI

The authors declare no competing interests. Artificial intelligence–based tools were used to assist in literature retrieval and language refinement. All content was reviewed and approved by the authors, who assume full responsibility for the final manuscript.

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