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Effects of Dietary Coffee Husk Fermentation on The Growth of Catfish (*Pangasianodon hyphophthalmus*)

Azmi Afriansyah[1], Mohamad Amin[1]*, Ade Dwi Sasanti[1], Sefti Heza Dwinanti[1], Tanbiyaskur[1]

[1]Study Program of Aquaculture, Department of Fisheries, Faculty of Agriculture, Universitas Sriwijaya, Palembang-Prabumulih Highway Km 32, Indralaya–30662, Ogan Ilir, South Sumatra, Indonesia.

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E-mail addresses:
mohamadamin@fp.unsri.ac.id
*Corresponding author

ABSTRACT

Coffee husk fermentation (CHF) might be utilized as an alternative plant protein source. This research evaluated dietary CHF supplementation's effects on growth for striped catfish. This study consisted of five grade levels of CHF as a treatment. The treatments were P0 (without the addition of CHF), P1 (addition of 6% CHF), P2 (addition of 12% CHF), P3 (addition of 18% CHF), and P4 (addition of 24% CHF). The results determined that dietary CHF inclusion had no significantly different effect on specific growth rate (SGR) and feed efficiency ($P > 0.05$). However, the P1 group (6% CHF) produced the best protein retention (PR), which was significantly different from the control (P0) and other CHF treatments ($P < 0.05$). No significant differences were observed in survival rates among the treatments. The inclusion of CHF up to 24% in the diet was found acceptable, as it did not negatively impact the striped catfish's overall health or growth performance. Although growth rate, feed efficiency, and survival did not significantly differ ($P > 0.05$).

Keyword: feed utilization, fermented coffee husk, growth performance, catfish (*P. hyphophtalmus*)

INTRODUCTION

Catfish (*Pangasianodon hyphophthalmus*) is a type of freshwater fish with high economic value and is the most widely cultivated in the world (Hoque *et al.*, 2021). Striped catfish production from 2019 - 2023 has increased by an average of 4.17% annually (Ministry of Fisheries and Marine Affairs, 2024). This increase is due to the high demand of the world community for animal protein sources to meet nutritional needs.

Thus, the application of intensive cultivation systems for this species continues to be carried out to meet needs. On the other hand, the problem in implementing an intensive cultivation system is the increasing need for feed as one of the main aspects in aquaculture (Zannat *et al.*, 2023). Nearly 60% of the total production cost is allocated for feed (Daniel, 2018). Feed is a very important component in the growth rate and survival of fish. Currently, the source of protein in feed is still very dependent on fish meal and soybean meal, which are relatively more expensive (Ahmad *et al.*, 2020; Stockhausen *et al.*, 2023). Thus, one effort to reduce feed costs is by using alternative feed ingredients.

Generally, alternative proteins come from ingredients that are not used by humans but have nutritional content for the fish's body. One of these alternative feed ingredients is coffee skin, which is a waste product of coffee fruit processing, with a protein content ranging from 7-17% (Nuraisah *et al.*, 2013; Cangussu *et al.*, 2021; Afriansyah *et al.*, 2023). Coffee skin is a by-product (waste) of coffee beans and must be handled further so as not to cause pollution. Although it has not been utilized optimally (Vivas *et al.,* 2025). At least each coffee bean processing produces 35% coffee skin (Iriondo-Dehond *et al.*, 2020). Therefore, this considerable potential needs to be utilized. Coffee skin contains micro- and macronutrients that are very much needed by the body (Bondesson, 2015; Esquivel & Jiménez, 2012).

In addition, there are also phytochemical compounds of the polyphenol group that act as antioxidants that help improve fish health (Blinová *et al*., 2017; Rahimnejad *et al*., 2015; Ameca *et al*., 2018; Hoseini *et al*., 2021; Van Doan *et al*., 2021; Van Doan *et al*., 2022). Furthermore, the use of coffee skin in fish feed has been explored previously, especially in species such as red tilapia (*Oreochromis sp*). Supplementation of 4% coffee skin flour has a positive effect on growth performance and antioxidants (Afriansyah *et al.,* 2023). Meanwhile, fermented coffee skin in feed for *Boranomys Goniatus* produced the best intestinal villi growth (Dhani *et al*., 2023).

However, the high amount of crude fiber, namely 17.2%, is one of the weaknesses of using coffee skins (Analianasari *et al*., 2022). High levels of crude fiber make feed more difficult for fish to digest, while the tolerance limit for crude fiber that can be digested by fish is in the range of less than 8% (Nuraisah *et al*., 2013). This weakness can be overcome through initial processing with fermentation (Nuraisah *et al*., 2013; Fitria *et al*., 2020; Siddik *et al*., 2024; Yafetto *et al*., 2023).

Through fermentation, complex molecules such as proteins, carbohydrates, and fats are converted into simpler and more digestible forms. CHF fermentation using several microbes can reduce crude fiber by 23.1% (Nuraisah *et al.,* 2013). The purpose of this study was to determine the effect of CHF as a feed supplement on the performance of striped catfish.

MATERIALS AND METHODS

Preparation of coffee husk fermented

The coffee skin used in this study came from a local plantation in Buay Rawan Regency, South Sumatra, Indonesia. The coffee skin was dried for about 7 hours and ground using a disk mill. The fermentation process of coffee skin flour refers to Warasto & Fitriani (2013), namely by making a fermentation solution by mixing commercial probiotics (EM4^{TM}) into water with a ratio of 1:100. Then, 150 grams of sugar was added as a carbon source. Furthermore, the coffee skin flour was mixed evenly with the fermentation solution. The mixing ratio is 3 ml of fermentation solution for 10 grams of coffee skin flour. The mixing results are then put into a plastic bag and stored at room temperature for seven days.

Experimental design

Catfish were obtained from local ponds in Indralaya, Ogan Ilir Regency, South Sumatra Province. catfish were kept in a 2 × 2 × 1 m^3 hapa for one week to adapt to the research environment. The hapa used in this study measured 50 × 50 × 50 cm^3 with a total concrete pool size of 4 × 4 × 1 m^3. A total of 300 striped catfish with an average initial weight of 5.54 ± 0.38 g were used in this study. This study used a completely randomized design (CRD) with five treatments and three replications. The percentage dose of coffee husk given was different for each treatment, namely P0 (0% CHF), P1 (6% CHF), P2 (12% CHF), P3 (18% CHF), and P4 (24% CHF). This dose refers to the research of Fitria *et al.* (2020) and Afriansyah *et al.* (2023), which is arranged in a feed formulation with a protein content of 30% (Table 1). Proximate analysis using the Association of Official Analytical Chemists (AOAC, 2012). Maintenance of striped catfish was carried out during six weeks, and feeding at satiation was carried out 3 times a day, namely in the morning (08.00 am), afternoon, and evening (12.00 and 16.00 pm).

Growth Performance and Feed Utilization

During the research period, fish per cage were counted and weighed to calculate weight gain (WG), specific growth rate (SGR), feed efficiency (FE), survival rate (SR) and protein retention according to Nahida *et al.* (2025) and Tola *et al.* (2025):

$$SGR = \frac{(Ln\ Final\ weight - Ln\ Initial\ Weight)}{Days} x\ 100$$

$$WG = final\ body\ weight - initial\ body\ weight$$

$$FE = \frac{(Final\ biomass - Initial\ biomass)}{total\ feed}$$

$$SR(\%) = \frac{(Final\ number\ of\ fish)}{initial\ number\ of\ fish} x\ 100$$

$$PR(\%) = \frac{\left(\begin{matrix} Final\ biomass\ protein\ (g) - \\ Initial\ biomass\ protein\ (g) \end{matrix}\right)}{total\ protein\ consumed} x\ 100$$

Water Quality Measurement

Water quality has a significant effect on fish survival and growth. The parameters observed are water pH, dissolved oxygen, ammonia, and temperature.

Data analysis

All data obtained were analyzed using analysis of variance (ANOVA) to determine the effect of the treatment. Furthermore, Duncan's test with a 95% confidence interval (SPSS 22.0) was used to determine the differences between each treatment.

RESULTS AND DISCUSSIONS

Results

Growth Performance and Feed Utilization

The results showed that the addition of CHF did not have a significant effect on the specific growth rate, absolute weight gain, or survival rate of catfish ($P > 0.05$), including on feed consumption and efficiency. However, the addition of 6% CHF (P1) to the feed was able to significantly increase protein retention ($P < 0.05$) compared to other treatments. While treatments P2, P3, and P4 did not provide a significant difference with P0 ($P > 0.05$). All growth performance and feed utilization data are listed in Table 2.

Table 1. Diet formulation of five grade levels CHF

Ingredients (%)	Treatments of diet				
	P0	P1	P2	P3	P4
Coffee husk fermentation	0	6	12	18	24
Fish meal	43	43	43	43	43
Soybean meal	18	17	16	15	14
Rice bran	23	18	13	8	3
Wheat flour	10	10	10	10	10
Vitamin mix	2	2	2	2	2
Fish oil	3	3	3	3	3
Diet proximate contents (%)					
Protein	29.82	30.16	30.89	30.90	30.05
Lipid	15.11	14.49	13.84	14.84	13.94
Moisture	8.50	9.48	8.71	8.97	8.26
Ash	12.96	12.50	7.88	7.26	11.57

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Diet proximate contents (%)					
Crude fiber	6.80	7.21	7.28	10.90	9.94
NFE)*	26.82	26.15	31.39	27.11	26.23
GE* (kcal/kg diet)	487.96	481.33	476.89	468.41	455.12

* NFE = nitrogen free extract; * GE = Gross energy (Watanabe, 1988).

Tabel 2. Growth and feed utilization after rearing

Parameter	Treatments of diet				
	P0	P1	P2	P3	P4
W_o (g)	5.31±0.34^a	5.33±0.09^a	5.48±0.18^a	6.17±0.19^a	5.43±0.13^a
W_t (g)	12.58±1.63^a	13.68±0.34^a	13.24±1.178^a	13.31±0.55^a	13.34±0.,63^a
FI (g)	843.30±1.51^a	859.43±0.78^a	862.51±0.61^a	866.76±0.63^a	866.68±0.11^a
SGR(%)	4.04±0.38^a	4.24±0.03^a	4.09±0.13^a	3.83±0.14^a	4.08±0.22^a
FE (%)	89.09±8.63^a	95.54±1.76^a	92.11±6.43^a	92.15±3.23^a	92.23±3.73^a
PR (%)	34.62±5.24^b	45.45±3.25^a	30.84±4.28^b	30.80±1.31^b	31.49±2.25^b
SR (%)	100.00±0.,00^a	100.00±0.00^a	100.00±0.00^a	100.00±0.00^a	98.33±2.89^a

Note: different superscript letters on the same line, show a significant difference (P < 0.05). Wo = Initial weight, Wt = Final weight, FI = Feed intake, SGR = Specific growth rate, FE = Feed efficiency, PR = Protein retention, SR = Survival rate.

Tabel 3. Water quality during rearing of striped striped catfish

Parameter	Results of measurement	Optimal range
Temperature (°C)	29,5 - 29,9	25 - 31 (Agriansa, 2020)
pH	6,0 - 7,9	6 - 8 (Agriansa, 2020)
Dissolved oxygen (mg.L^{-1})	3,97 - 6,66	> 3 (Akash *et al*., 2024)
Ammonia (mg.L^{-1})	0,03 - 0,19	<0,2(Chen *et al*.,., 2019)

Water Quality

The results determined that water quality during the rearing of striped catfish was in normal conditions that could be tolerated to support fish survival (Table 3).

Discussion

CHF can be used as additional fish feed (Prakash & Doan, 2022). The experiment results showed that using up to 24% of CHF was not significantly different from the control treatment (P0) on the growth rate. However, there was an increase in feed consumption in all CHF treatments compared to the control. The increase in feed consumption is thought to be due to the taste of coffee that striped catfish like, which increases the fish's appetite. According to Nuraisah *et al.* (2013), the increase in the amount of feed consumption is caused by the palatability of the feed, both in terms of aroma and texture that fish like. Although no research is available, it is suspected that the increase in feed utilization is due to the aroma that arises from CHF, which comes from the Maillard reaction. This reaction produces a distinctive coffee aroma from the roasting process, thus inducing the formation of aroma precursors (Cardoso *et al.*, 2023; Tarigan *et al.*, 2022).

The feed consumed by fish will be converted into energy. The greater the energy available, the more it will be able to meet maintenance needs while the remaining energy is used for growth (Afriansyah *et al.*, 2023). The amount of feed given will result in growth if striped catfish can consume and digest the feed. The same study by Nuraisah *et al.* (2013) showed that using fermented coffee skin flour up to 20% in feed resulted in growth that was not significantly different from the control treatment in tilapia. This energy will be used for maintenance and growth so it can be ensured to meet the needs of fish maintenance (Suprayudi *et al.*, 2017).

Growth performance did not show a significant difference between treatments. This concludes that fermented CHF has the potential to be used as an alternative raw material for rice bran and soybean flour. This can be seen from the study results, which showed that feed containing CHF up to 24% in the feed formulation was still acceptable to striped catfish and improved the growth performance of striped striped catfish. Afriansyah *et al.* (2023) reported that using 4% coffee skin flour positively affected growth performance and antioxidants. The use of CHF up to 24% positively affected the quality of tilapia fillets (Fitria *et al.*, 2020).

Feed efficiency refers to growth and consumption (Rodde *et al.*, 2021). Feed efficiency provides an overview of the utilization of the feed given to increase fish growth (Nuraisah *et al.*, 2013). P4 treatment with a CHF content of up to 24% produced feed efficiency no different from P0. This is likely because the fermentation results can reduce crude fiber in CHF from 33.80% to 23.1% (Nuraisah *et al.*, 2013).

Based on these results, the use of CHF up to 24% in feed can still be digested, resulting in striped catfish growth. The decrease in crude fiber is thought to be due to the role of microbes that degrade cellulose in CHF (Nuraisah *et al.*, 2013). In addition, the natural microorganisms used for this fermentation are divided into four main groups, namely photosynthetic bacteria, fermentation fungi, lactic acid bacteria and *Actinomycetes* sp. all of which play a role in breaking down lignocellulose bonds, namely releasing lignin and cellulose, which then proteolytic microbes will produce protease enzymes that function to break down proteins into amino acids (Al Barru *et al.*, 2022). The crude fiber in the control treatment feed was 6.80%, while the crude fiber in the coffee skin feed ranged from 7.21 - 10.90%.

Protein retention reflects protein saved in the body. The protein retention value in the P1 treatment (45.45%) was significantly higher compared to the P0, P2, P3, and P4 treatments ($P < 0.05$). The higher the PR value, shown the more protein in the body from diet protein (Suprayudi *et al.*, 2014). In previous studies utilizing CHF supplementation, the highest protein retention was found at a dose of 4% CHF for tilapia feed (Afriansyah *et al.*, 2023). This is thought to be due to the contribution of energy derived from higher non-protein which makes fish able to digest and absorb feed sourced from high energy for maintenance and growth needs (Van Doan *et al.*, 2022; Giri *et al.*, 2016). In addition, giving 30% fermented coffee husk feed to *Barbonymus gonionotus* showed the best intestinal villi growth in terms of height and width as viewed from its histology (Dhani *et al.*, 2023). Increased intestinal villi result in increased surface area for nutrient absorption which has a positive impact on growth performance and feed utilization in animals (Saleh *et al.*, 2022). As stated by Kpundeh *et al.* (2015), high protein retention occurs when the protein content in the diet is efficiently utilized by the fish.

Based on research, the overall water quality is within the range that can be tolerated by fish. The water temperature ranged from 29.5 - 29.9 $^{\circ}$C, and the water pH during catfish maintenance ranged from 6.0 - 7.9. The dissolved oxygen content during maintenance ranged from 3.97 - 6.70 mg/L^{-1}, and the ammonia value ranged from 0.03 - 0.19 mg/L^{1}. According to Agriansa (2020), the good water temperature and pH for catfish maintenance range from 25-31°C and 6-8. The optimal ammonia range for fish life is <0.2 mg/L^{-1} (Chen *et al.*, 2019). According to the Akash *et al.* (2024), the optimal dissolved oxygen for catfish is 5-7 mg/L^{-1}.

CONCLUSION

Application of CHF up to 24% in feed formulation may not interfere with growth performance and feed utilization in striped catfish. However, it does not significantly affect growth performance and feed efficiency.

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AUTHORS' CONTRIBUTIONS

Each author's contribution includes among others, AA: collecting data, conceptualization, software, experimental design, data curation, manuscript writing; MA: conceptualization, software, manuscript writing, data curation; ADS: conceptualization, software, experimental studies, manuscript writing, data curation; SHD: conceptualization, software, experimental studies, manuscript writing, data curation; TBY: conceptualization, software, experimental studies, manuscript writing, data curation.

CONFLICT OF INTEREST

All authors declare that there are no conflict of interests are reported.

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