1. **BUKTI SUBMIT ARTIKEL**
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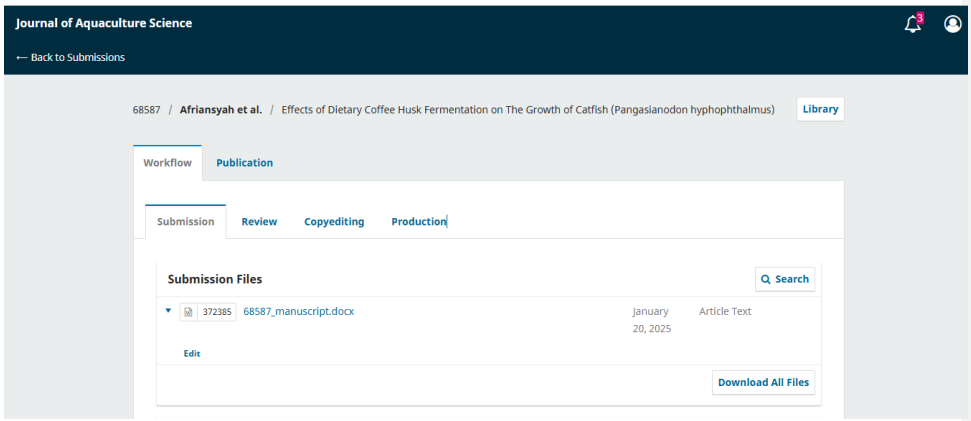

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Effects of dietary coffee husk fermented on the growth performance and feed utilization in Striped Catfish (*Pangasianodon hyphophthalmus*)

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ABSTRACT

Coffee husk fermented (CHF) might be utilized as other preference plant protein source. This research focused on evaluating the effects of dietary supplementing CHF for striped catfish on growth and fed application. This study consisted of five grade levels of CHF. The treatments were P0 (without the addition of CHF) P1 (addition of 6% CHF), P2 (addition of 12% CHF), P3 (addition of 18% CHF), P4 (addition of 24% CHF). The results determined that a weight growth of striped catfish in the P0 was 12.58 g ± 1.63, P1 13.68 g ± 0.34, P2 13.24 g ± 1.17, P3 13.31 g ± 0.55 and P4 was 13.34 g ± 0.63, the feed efficiency value in the P0 was 89.10 % ±10.57, P1 95.54 % ±2.16, P2 92.11 % ±7.87, P3 92.15 % ±3.96 and P4 92.23 % ±4.57, the value of protein retention in the P0 was 34.78 % ± 6.68, P1 45.45 % ± 3.99, P2 30.84 % ± 5.24, P3 30.80 % ± 1.61 and P4 31.83 % ± 2.63. The use of CHF up to 24% in the feed formulation was still acceptable to applied and did not negative effect of striped catfish although which results in growth rate, feed efficiency and survival that are not different (P > 0.05).

Keyword: feed, striped catfish, coffee husk fermented, growth

INTRODUCTION

Striped catfish is a valuable freshwater species with high economic importance, playing a significant role in boosting aquaculture production thus it included among the most widely cultivated species (Hoque *et al*. 2021). The value of catfish production from 2019-2023 has risen by an average of 4.17% each year (Ministry of Fisheries and Marine Affairs, 2024). Globally, catfish has also ranked as the ninth massive freshwater fish production around the globe (FAO, 2022). Increasing catfish production based on the high demand of the world society for animal protein sources in human nutritional needs which continues to grow as the world's population grows. An attempt to fulfill this demand has encouraged the development of catfish culture such as the application of intensive farming systems. On the other hand, the problem in the application of intensive farming systems will also improve the nutritional needs as well as feed as one of the aspects in the successfully of aquaculture (Zannat *et al*. 2023). Diet is an essential component in the growth rate and survival of fish. Furthermore, nearly 60% of the total production cost is devoted to feed (Daniel, 2018). Currently, protein as the main nutrient component in the diet is still highly dependent on fishmeal and soybean flour, which have relatively more expensive prices (Putri *et al*. 2012; Ahmad *et al*. 2020). Attempts to reduce feed costs are by using alternative feed ingredients. These ingredients generally are derived from materials that are not utilized by humans but have nutritional content for fish stuff. One of these alternative feed ingredients is coffee husk, which is the waste from processing coffee fruit (Afriansyah *et al*. 2023; Nuraisah *et al*. 2013).

The utilization of coffee husk as a fish feed ingredient was grounded by the potential of coffee plantations in South Sumatra, which has a land area of 254.374 hectares with coffee

production of 147.090 tons per year (Directorate General of Plantations, 2015). Coffee husk is a by-product of coffee bean which if not handled further will cause pollution and has not been utilized properly yet (Diniyah *et al*. 2013). Coffee bean processing produces 65% coffee beans and 35% husk waste, thus providing considerable potential to be utilized (Iriondo-Dehond *et al*. 2020). Coffee husk containing micronutrient and macronutrient essential for diet. (Bondesson, 2015; Esquivel & Jiménez, 2012). Besides, there are also phytochemical compounds of the polyphenol class that act as antioxidants that help improve the health status of fish (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). Murib *et al*. (2016) explained that the protein content of coffee husk was around 11.18%, while the results of proximate tests at the Fish Nutrition Laboratory of IPB University obtained the nutritional value of coffee husk, which were protein of 9.03%, fat of 1.6%, BETN of 41.34% and crude fiber of 34.96%. The high crude fiber is a weakness in the use of coffee husk. This weakness can be overcome through prior processing, namely the fermentation process (Nuraisah, 2013; Fitria *et al.* 2020; Siddik *et al.* 2024; Yafetto *et al.* 2023).

A fermentation is a biological processing, which utilizes microorganisms which produce enzymes to make changes to complex molecules such as proteins, carbohydrates and fats into simpler and easily digestible molecules (Nuraisah, 2013). These natural microorganisms in EM4 used for fermentation are divided into four main groups: photosynthetic bacteria, fermentation fungi, lactic acid bacteria and Actinomycetes sp, all of which contribute to the breakdown of lignocellulosic bonds, namely releasing lignin and cellulose that proteolytic microbes will produce protease enzymes which function to break down proteins into amino acids (Winedar *et al*., 2006; Al Barru *et al*., 2022). 2022). The implemented of this study for look forward the influences of CHF in striped catfish. The benefit of this research was expected to provide information on the utilization of CHF into feed stuff.

MATERIALS AND METHODS

Preparation of coffee husk fermented

The coffee husk derived from the local plantation of Buay Rawan Disctrict, South Sumatra, Indonesia. The coffee husk was sun-dried for approximately 7 hours and then ground using a disk mill. Fermentation of coffee husk flour was carried out in refer to Warasto *et al*. (2013) by first making a fermentation solution by mixing commercial probiotics brand EM_4 into water in a ratio of 1:100. Then, 150 grams of sugar was added as a carbon source. Next, the coffee husk flour was mixed evenly with the fermentation solution. The mixing ratio is 3 ml of fermentation solution for 10 grams of coffee husk flour. The results of the mixing were then put in a plastic bag and stored at room temperature for seven days.

Experimental diets

The diet used in this study consisted of 5 types of diet, namely: P0 (0% CHF), P1 (6% CHF), P2 (12% CHF), P3 (18% CHF), P4 (24% CHF) which were arranged in a feed formulation with a protein content of 30%. (Table 1). Association of Official Analytical Chemists (AOAC, 2012) used for analysis of proximate.

Experimental design

Striped catfish acquired from local farm of Indralaya, Ogan Ilir Regency. they were kept in a hapa 2×2×1 m^3 for one week to adapt to the research environment. Then, the hapa used in this study was 50×50×50 cm^3. It was installed in a 4×4×1 m^3 concrete pond. A total of 300 catfish were distributed into 15

hapa with 3 replicates using a completely randomized design (CRD). Fish rearing was conducted for 6 weeks and during rearing, treatment feeding was applied at satiation 3 times daily at 08.00 a.m, 12.00 a.m and 16.00 p.m.

Absolute weight growth

Absolute weight growth determined based on (Effendie, 1997):

$$W = Wt - Wo$$

Specific growth rate

Specific growth rate calculated based on (Afriansyah *et al.* 2023):

$$SGR = \left(\sqrt[t]{\frac{Wt}{Wo}} - 1\right) \times 100$$

Feed efficiency

Feed efficiency calculated based on NRC (1993), namely:

$$FE = \frac{(Wt + Wd) - Wo}{F} \times 100$$

Survival rate

The survival rate calculated refers to (Mulchlisin *et al*., 2016).

$$SR = \frac{Nt}{No} \times 100$$

Protein R

The protein retention determined refers to (Zehra and Khan, 2016).

$$PR = \frac{F - I \times 100}{P}$$

Water quality measurement

The water quality has a significant influence on fish survival and growth. Water quality parameter monitoring was carried out to examine water environment. The parameters observed were water pH, dissolved oxygen, ammonia and temperature.

Data analysis

Data analysis determined by analysis of variance (ANOVA), and treatments that exhibited significant differences were further examined using Duncan test with a 95% confidence interval through the SPSS 22.0 software

Table 1. Diet formulation of five grade levels CHF

Ingredients (%)	Treatments of diet				
	P0	**P1**	**P2**	**P3**	**P4**
Coffee husk fermented	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
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).

RESULTS AND DISCUSSIONS

Results

Growth Performance and Feed Utilization

The results indicated that an adition of CHF no effect significantly different impact on specific growth rate, an absolute weight growth and survival rate of striped catfish ($P > 0.05$). While CHF in the diet did not result in a significantly different affect on feed intake and feed efficiency ($P > 0.05$), the addition of 6% CHF in the diet significantly for protein retention ($P < 0.05$) compared to the other treatments. On the other hand, P2, P3, and P4 treatments not significant difference from P0 ($P > 0.05$). All data regarding growth performance and feed utilization are listed in Table 2.

Water Quality

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

Tabel 2. Growth and feed utilization after rearing

Parameter	Treatments of diet				
	P0	P1	P2	P3	P4
Wo (g)	5,31±0,34[a]	5,33±0,09[a]	5,48±018[a]	6,17±0,19[a]	5,43±0,13[a]
Wt (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[a]	45,45±3,25[b]	30,84±4,28[a]	30,80±1,31[a]	31,49±2,25[a]
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 catfish

Parameter	Results of measurement	Optimal range
Temperature (°C)	29,5 - 29,9	27 - 30 (SNI, 2002)
pH	6,0 - 7,9	6,5 - 8,5 (SNI, 2009)
Dissolved oxygen ($mg.L^{-1}$)	3,97 - 6,66	>3 (SNI, 2009)
Ammonia ($mg.L^{-1}$)	0,03 - 0,19	<0,1 (SNI, 2009) <0,2 (Ananda *et al*., 2015)

Discussion

CHF may be utilized as a fish stuff. Experimental results showed that the use of CHF up to 24% was not significantly different from the control treatment (P0) on growth rate. This was thought to be due to the fact that CHF was acceptable as a fish stuff for fish diet. This was evident from the increase in the amount of feed consumption containing CHF. The increased amount of feed consumption is thought to be due to the flavor of coffee that catfish like, causing fish to increase their appetite. According to Nuraisah *et al*. (2013) the increased amount of feed intake due to the palatability of the feed both in terms of aroma and texture that fish like. Feed consumed by fish will be converted into energy. The greater the available energy, the better it can meet maintenance requirements, with the remaining energy being utilized for growth (Afriansyah *et al*. 2023). The amount of feed given will produce growth if the feed can be consumed and digested by catfish. The same results of Nuraisah *et al*. (2013), the use of fermented coffee skin flour up to 20% in feed produces growth that is not significantly different from the control treatment in tilapia. Lovell (1989) explains that, the energy would be used for

maintenance and for growth, so it can be ascertained that would be able to meet of fish maintenance needed. Likewise, in the treatment of P1 (6% CHF), P2 (12% CHF) and P3 (18% CHF) in the feed formulation, it is still able to be digested properly so that it is sufficient for catfish growth. Growth performance showed no significant difference across treatments, it concluded that the use of fermented CHF has the potential to be used as an alternative raw material to substitute bran and soy flour. This can be seen from the results of the study showing that feed containing CHF up to a level of 24% in feed formulations is still acceptable to catfish and for improving growth performmance of striped catfish.

Feed efficiency refers to growth and the amount of feed consumed. Feed efficiency provides an overview of the utilization of feed given so as to increase fish growth (Nuraisah *et al*. 2013). High feed efficiency values indicate it will be absorbed and converted into meat. The use of CHF up to 24% (treatment P4) resulted in feed efficiency that was not different from the control (P0). This is suspected because the fermentation results could reduce crude fiber in CHF from 33.80% to 25.52%, so that the use of CHF up to 24% in feed can still be digested and produce growth in catfish. Crude fiber in the control treatment feed is 6.80%, while crude fiber in feed containing coffee husk ranges 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 RP value, shown the more protein in the body from diet prrotein (Suprayudi *et al*. 2014). 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). As stated by Handayani et al. (2014), high protein retention occurs when the protein content in the diet is efficiently utilized by the fish. Halver (1989) explains if the energy in the diet exceeds of fish requirements, it would be full quickly and may not utilize the protein effectively. Conversely, if the energy in the feed is insufficient for the fish's needs, the energy source from protein allocated for biological functions maintenance.

Based on the study, overall water quality as long as the experiment was optimal and within tolerable range for the fish. Water temperature ranged from 29.5-29.9 ºC, water pH during catfish rearing ranged from 6.0-7.9. Dissolved oxygen content during rearing ranged from 3.97-6.70 $mg.L^{-1}$ and ammonia values during rearing ranged from 0.03-0.19 $mg.L^{-1}$. According to the Indonesian National Standard (2002), a good water temperature for striped catfish rearing ranges from 25-30ºC. According to the Indonesian National Standard (2009) the pH of good water for striped catfish rearing ranges from 6.5-8.5 and ammonia value <0.01 $mg.L^{-1}$. The range of ammonia optimal for fish life is <0.2 $mg.L^{-1}$ (Ananda *et al.* 2015; Tanbiyaskur *et al.* 2024). According to the Indonesian National Standard (2000), for an optimal dissolved oxygen of catfish is 3-8 $mg.L^{-1}$.

CONCLUSION

The inclusion of up to 24% CHF in feed formulations could serve as an alternative feed ingredient without negatively on the growth performance and feed utilization in striped catfish.

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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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2. BUKTI REVIEW

(21 FEBRUARI 2025)

[JoAS] Editor Decision Eksternal Kotak Masuk ×

Journal of Aquaculture Science Universitas Airlangga <joas@psdku.unair.ac.id> 21 Feb 2025, 09.11

kepada saya, Mohamad, Ade, Sefti, Tanbiyaskur

Terjemahkan ke Indonesia

Dear Azmi Afriansyah, Mohamad Amin, Ade Dwi Sasanti, Sefti Heza Dwinanti, Tanbiyaskur Tanbiyaskur,

We hope this message finds you well. We would like to thank you for submitting your manuscript titled "Effects of dietary coffee husk fermented on growth and feed utilization in Striped Catfish Pangasianodon hyphophthalmus" to our journal.

After careful review by our editorial board and peer reviewers, several comments and recommendations have been provided to enhance the quality and suitability of your manuscript for publication. We would like to remind you of the importance of addressing all reviewer comments, adhering to the guidelines outlined in our journal template, and ensuring compliance with language, grammar, and ethical considerations.

Specifically, we kindly request that you:

1. Address all reviewer comments: Please carefully review the feedback provided by the reviewers and make necessary revisions to your manuscript accordingly.
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3. Language and grammar: Pay close attention to language and grammar to ensure clarity and coherence throughout your manuscript. Consider using tools such as Grammarly to assist in improving the overall quality of your writing.
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Should you have any questions or require further clarification on the revision process, please do not hesitate to contact us. We appreciate your cooperation and look forward to receiving your revised manuscript.

Best regards,

Editorial Board Member

REVIEWER 1

Journal of Aquaculture Science

Effects of dietary coffee husk fermented on the growth performance and feed utilization in Striped Catfish (*Pangasianodon hyphophthalmus*)

Article info:

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Revised: xxxxxxx
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E-mail addresses:
*Corresponding author

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ABSTRACT

Coffee husk fermented (CHF) might be utilized as other preference plant protein source. This research focused on evaluating the effects of dietary supplementing CHF for striped catfish on growth and fed application. This study consisted of five grade levels of CHF. The treatments were P0 (without the addition of CHF) P1 (addition of 6% CHF), P2 (addition of 12% CHF), P3 (addition of 18% CHF), P4 (addition of 24% CHF). The results determined that a weight growth of striped catfish in the P0 was 12.58 g ± 1.63, P1 13.68 g ± 0.34, P2 13.24 g ± 1.17, P3 13.31 g ± 0.55 and P4 was 13.34 g ± 0.63, the feed efficiency value in the P0 was 89.10 % ±10.57, P1 95.54 % ±2.16, P2 92.11 % ±7.87, P3 92.15 % ±3.96 and P4 92.23 % ±4.57, the value of protein retention in the P0 was 34.78 % ± 6.68, P1 45.45 % ± 3.99, P2 30.84 % ± 5.24, P3 30.80 % ± 1.61 and P4 31.83 % ± 2.63. The use of CHF up to 24% in the feed formulation was still acceptable to applied and did not negative effect of striped catfish although which results in growth rate, feed efficiency and survival that are not different (P > 0.05).

Keyword: feed, striped catfish, coffee husk fermented, growth

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Show the best results on each observed parameter

INTRODUCTION

Striped catfish is a valuable freshwater species with high economic importance, playing a significant role in boosting aquaculture production thus it included among the most widely cultivated species (Hoque *et al*. 2021). The value of catfish production from 2019-2023 has risen by an average of 4.17% each year (Ministry of Fisheries and Marine Affairs, 2024). Globally, catfish has also ranked as the ninth massive freshwater fish production around the globe (FAO, 2022). Increasing catfish production based on the high demand of the world society for animal protein sources in human nutritional needs which continues to grow as the world's population grows. An attempt to fulfill this demand has encouraged the development of catfish culture such as the application of intensive farming systems. On the other hand, the problem in the application of intensive farming systems will also improve the nutritional needs as well as feed as one of the aspects in the successfully of aquaculture (Zannat *et al*. 2023). Diet is an essential component in the growth rate and survival of fish. Furthermore, nearly 60% of the total production cost is devoted to feed (Daniel, 2018). Currently, protein as the main nutrient component in the diet is still highly dependent on fishmeal and soybean flour, which have relatively more expensive prices (Putri *et al*. 2012; Ahmad *et al*. 2020). Attempts to reduce feed costs are by using alternative feed ingredients. These ingredients generally are derived from materials that are not utilized by humans but have nutritional content for fish stuff. One of these alternative feed ingredients is coffee husk, which is the waste from processing coffee fruit (Afriansyah *et al*. 2023; Nuraisah *et al*. 2013).

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Commented [I3]: Add protein needs to striped catfish feed. And can adding coffee husk meet the protein needs of striped catfish?

Can coffee skin-derived plant protein be a viable substitute for animal protein in striped catfish feed, and what is the nutritional analysis and impact on fish growth and health?

The utilization of coffee husk as a fish feed ingredient was grounded by the potential of coffee plantations in South Sumatra, which has a land area of 254.374 hectares with coffee production of 147.090 tons per year (Directorate General of Plantations, 2015). Coffee husk is a by-product of coffee bean which if not handled further will cause pollution and has not been utilized properly yet (Diniyah *et al*. 2013). Coffee bean processing produces 65% coffee beans and 35% husk waste, thus providing considerable potential to be utilized (Iriondo-Dehond *et al*. 2020). Coffee husk containing micronutrient and macronutrient essential for diet. (Bondesson, 2015; Esquivel & Jiménez, 2012). Besides, there are also phytochemical compounds of the polyphenol class that act as antioxidants that help improve the health status of fish (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). Murib *et al.* (2016) explained that the protein content of coffee husk was around 11.18%, while the results of proximate tests at the Fish Nutrition Laboratory of IPB University obtained the nutritional value of coffee husk, which were protein of 9.03%, fat of 1.6%, BETN of 41.34% and crude fiber of 34.96%. The high crude fiber is a weakness in the use of coffee husk. This weakness can be overcome through prior processing, namely the fermentation process (Nuraisah, 2013; Fitria *et al.* 2020; Siddik *et al.* 2024; Yafetto *et al.* 2023).

A fermentation is a biological processing, which utilizes microorganisms which produce enzymes to make changes to complex molecules such as proteins, carbohydrates and fats into simpler and easily digestible molecules (Nuraisah, 2013). These natural microorganisms in EM4 used for fermentation are divided into four main groups: photosynthetic bacteria, fermentation fungi, lactic acid bacteria and Actinomycetes sp, all of which contribute to the breakdown of lignocellulosic bonds, namely releasing lignin and cellulose that proteolytic microbes will produce protease enzymes which function to break down proteins into amino acids (Winedar *et al*., 2006; Al Barru *et al*., 2022). 2022). The implemented of this study for look forward the influences of CHF in striped catfish. The benefit of this research was expected to provide information on the utilization of CHF into feed stuff.

MATERIALS AND METHODS

Preparation of coffee husk fermented

The coffee husk derived from the local plantation of Buay Rawan Disctrict, South Sumatra, Indonesia. The coffee husk was sun-dried for approximately 7 hours and then ground using a disk mill. Fermentation of coffee husk flour was carried out in refer to Warasto *et al*. (2013) by first making a fermentation solution by mixing commercial probiotics brand EM_4 into water in a ratio of 1:100. Then, 150 grams of sugar was added as a carbon source. Next, the coffee husk flour was mixed evenly with the fermentation solution. The mixing ratio is 3 ml of fermentation solution for 10 grams of coffee husk flour. The results of the mixing were then put in a plastic bag and stored at room temperature for seven days.

Experimental diets

The diet used in this study consisted of 5 types of diet, namely: P0 (0% CHF), P1 (6% CHF), P2 (12% CHF), P3 (18% CHF), P4 (24% CHF) which were arranged in a feed formulation with a protein content of 30%. (Table 1). Association of Official Analytical Chemists (AOAC, 2012) used for analysis of proximate.

Experimental design

Striped catfish acquired from local farm of Indralaya, Ogan Ilir Regency. they were kept in a hapa 2×2×1 m^3 for one week to adapt to the research environment. Then, the hapa used in this study was 50×50×50 cm^3. It

Commented [I4]: Please provide similar studies investigating the use of coffee husks as a feed supplement in aquaculture, particularly for fish nutritional needs.

Commented [I5]: What are the negative impacts of high crude fiber levels in fish feed on aquatic animal health and performance?

Commented [I7]: Please provide literature references to support the doses used.

Commented [I6]: What percentage reduction in crude fiber content can be achieved through fermentation of coffee husk?

was installed in a 4×4×1 m^3 concrete pond. A total of 300 catfish were distributed into 15 hapa with 3 replicates using a completely randomized design (CRD). Fish rearing was conducted for 6 weeks and during rearing, treatment feeding was applied at satiation 3 times daily at 08.00 a.m, 12.00 a.m and 16.00 p.m.

Absolute weight growth

Absolute weight growth determined based on (Effendie, 1997):

$$W = Wt - Wo$$

Specific growth rate

Specific growth rate calculated based on (Afriansyah *et al.* 2023):

$$SGR = \left(\sqrt[t]{\frac{Wt}{Wo}} - 1\right) \times 100$$

Feed efficiency

Feed efficiency calculated based on NRC (1993), namely:

$$FE = \frac{(Wt + Wd) - Wo}{F} \times 100$$

Survival rate

The survival rate calculated refers to (Mulchlisin *et al*., 2016).

$$SR = \frac{Nt}{No} \times 100$$

Protein R

The protein retention determined refers to (Zehra and Khan, 2016).

$$PR = \frac{F - I \times 100}{P}$$

Water quality measurement

The water quality has a significant influence on fish survival and growth. Water quality parameter monitoring was carried out to examine water environment. The parameters observed were water pH, dissolved oxygen, ammonia and temperature.

Data analysis

Data analysis determined by analysis of variance (ANOVA), and treatments that exhibited significant differences were further examined using Duncan test with a 95% confidence interval through the SPSS 22.0 software

Table 1. Diet formulation of five grade levels CHF

Ingredients (%)	Treatments of diet				
	P0	P1	P2	P3	P4
Coffee husk fermented	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
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).

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Commented [I15]: Discuss the implications of the proximate feed analysis, which revealed minimal differences in protein content among treatments, yet a significant increase in crude fiber content with escalating coffee husk doses. Elaborate on how these findings relate to growth performance and feed efficiency in the treated groups.

RESULTS AND DISCUSSIONS

Results

Growth Performance and Feed Utilization

The results indicated that an adition of CHF no effect significantly different impact on specific growth rate, an absolute weight growth and survival rate of striped catfish ($P > 0.05$). While CHF in the diet did not result in a significantly different affect on feed intake and feed efficiency ($P > 0.05$), the addition of 6% CHF in the diet significantly for protein retention ($P < 0.05$) compared to the other treatments. On the other hand, P2, P3, and P4 treatments not significant difference from P0 ($P > 0.05$). All data regarding growth performance and feed utilization are listed in Table 2.

Water Quality

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

Tabel 2. Growth and feed utilization after rearing

Parameter	Treatments of diet				
	P0	P1	P2	P3	P4
Wo (g)	5,31±0,34[a]	5,33±0,09[a]	5,48±018[a]	6,17±0,19[a]	5,43±0,13[a]
Wt (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[a]	45,45±3,25[b]	30,84±4,28[a]	30,80±1,31[a]	31,49±2,25[a]
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 catfish

Parameter	Results of measurement	Optimal range
Temperature (°C)	29,5 - 29,9	27 - 30 (SNI, 2002)
pH	6,0 - 7,9	6,5 - 8,5 (SNI, 2009)
Dissolved oxygen ($mg.L^{-1}$)	3,97 - 6,66	>3 (SNI, 2009)
Ammonia ($mg.L^{-1}$)	0,03 - 0,19	<0,1 (SNI, 2009) <0,2 (Ananda *et al*., 2015)

Discussion

CHF may be utilized as a fish stuff. Experimental results showed that the use of CHF up to 24% was not significantly different from the control treatment (P0) on growth rate. This was thought to be due to the fact that CHF was acceptable as a fish stuff for fish diet. This was evident from the increase in the amount of feed consumption containing CHF. The increased amount of feed consumption is thought to be due to the flavor of coffee that catfish like, causing fish to increase their appetite. According to Nuraisah *et al*. (2013) the increased amount of feed intake due to the palatability of the feed both in terms of aroma and texture that fish like. Feed consumed by fish will be converted into energy. The greater the available energy, the better it can meet maintenance requirements, with the remaining energy being utilized for growth (Afriansyah *et al*. 2023). The amount of feed given will produce growth if the feed can be consumed and digested by catfish. The same results of Nuraisah *et al*. (2013), the use of fermented coffee skin flour up to 20% in feed produces growth that is not significantly different from the control treatment in tilapia. Lovell (1989) explains that, the energy would be used for maintenance and for growth, so it can be ascertained that would be able to meet of fish

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maintenance needed. Likewise, in the treatment of P1 (6% CHF), P2 (12% CHF) and P3 (18% CHF) in the feed formulation, it is still able to be digested properly so that it is sufficient for catfish growth. Growth performance showed no significant difference across treatments, it concluded that the use of fermented CHF has the potential to be used as an alternative raw material to substitute bran and soy flour. This can be seen from the results of the study showing that feed containing CHF up to a level of 24% in feed formulations is still acceptable to catfish and for improving growth performmance of striped catfish.

Feed efficiency refers to growth and the amount of feed consumed. Feed efficiency provides an overview of the utilization of feed given so as to increase fish growth (Nuraisah *et al*. 2013). High feed efficiency values indicate it will be absorbed and converted into meat. The use of CHF up to 24% (treatment P4) resulted in feed efficiency that was not different from the control (P0). This is suspected because the fermentation results could reduce crude fiber in CHF from 33.80% to 25.52%, so that the use of CHF up to 24% in feed can still be digested and produce growth in catfish. Crude fiber in the control treatment feed is 6.80%, while crude fiber in feed containing coffee husk ranges 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 RP value, shown the more protein in the body from diet prrotein (Suprayudi *et al*. 2014). 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). As stated by Handayani et al. (2014), high protein retention occurs when the protein content in the diet is efficiently utilized by the fish. Halver (1989) explains if the energy in the diet exceeds of fish requirements, it would be full quickly and may not utilize the protein effectively. Conversely, if the energy in the feed is insufficient for the fish's needs, the energy source from protein allocated for biological functions maintenance.

Based on the study, overall water quality as long as the experiment was optimal and within tolerable range for the fish. Water temperature ranged from 29.5-29.9 ºC, water pH during catfish rearing ranged from 6.0-7.9. Dissolved oxygen content during rearing ranged from 3.97-6.70 $mg.L^{-1}$ and ammonia values during rearing ranged from 0.03-0.19 $mg.L^{-1}$. According to the Indonesian National Standard (2002), a good water temperature for striped catfish rearing ranges from 25-30ºC. According to the Indonesian National Standard (2009) the pH of good water for striped catfish rearing ranges from 6.5-8.5 and ammonia value <0.01 $mg.L^{-1}$. The range of ammonia optimal for fish life is <0.2 $mg.L^{-1}$ (Ananda *et al.* 2015; Tanbiyaskur *et al.* 2024). According to the Indonesian National Standard (2000), for an optimal dissolved oxygen of catfish is 3-8 $mg.L^{-1}$.

CONCLUSION

The inclusion of up to 24% CHF in feed formulations could serve as an alternative feed ingredient without negatively on the growth performance and feed utilization in striped catfish.

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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.

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Commented [l21]: What evidence can be provided to demonstrate that P1, P2, and P3 are sufficiently digestible?

Commented [l22]: Please provide additional data on the reduction of crude fiber content in coffee husk

Furthermore, please incorporate similar studies or relevant research findings to support and validate your results, providing a more comprehensive understanding of the topic.

Commented [l25]: Please clarify the rationale behind selecting this particular dose as the optimal dose, given that the data indicates P1 yields the highest values for growth, feed efficiency, and protein retention, albeit without significant differences from other treatments.

Commented [l23]: The protein retention value in P1 is higher compared to other treatments, is there a relationship with the crude fiber value in coffee husk?

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CONFLICT OF INTEREST

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

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REVIEWER 2

Journal of Aquaculture Science

Effects of dietary coffee husk fermented on the growth performance and feed utilization in Striped Catfish (*Pangasianodon hyphophthalmus*)

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ABSTRACT

Coffee husk fermented (CHF) might be utilized as other preference plant protein source. This research focused on evaluating the effects of dietary supplementing CHF for striped catfish on growth and fed application. This study consisted of five grade levels of CHF. The treatments were P0 (without the addition of CHF) P1 (addition of 6% CHF), P2 (addition of 12% CHF), P3 (addition of 18% CHF), P4 (addition of 24% CHF). The results determined that a weight growth of striped catfish in the P0 was 12.58 g ± 1.63, P1 13.68 g ± 0.34, P2 13.24 g ± 1.17, P3 13.31 g ± 0.55 and P4 was 13.34 g ± 0.63, the feed efficiency value in the P0 was 89.10 % ±10.57, P1 95.54 % ±2.16, P2 92.11 % ±7.87, P3 92.15 % ±3.96 and P4 92.23 % ±4.57, the value of protein retention in the P0 was 34.78 % ± 6.68, P1 45.45 % ± 3.99, P2 30.84 % ± 5.24, P3 30.80 % ± 1.61 and P4 31.83 % ± 2.63. The use of CHF up to 24% in the feed formulation was still acceptable to applied and did not negative effect of striped catfish although which results in growth rate, feed efficiency and survival that are not different (P > 0.05).

Keyword: feed, striped catfish, coffee husk fermented, growth

INTRODUCTION

Striped catfish is a valuable freshwater species with high economic importance, playing a significant role in boosting aquaculture production thus it included among the most widely cultivated species (Hoque *et al*. 2021). The value of catfish production from 2019-2023 has risen by an average of 4.17% each year (Ministry of Fisheries and Marine Affairs, 2024). Globally, catfish has also ranked as the ninth massive freshwater fish production around the globe (FAO, 2022). Increasing catfish production based on the high demand of the world society for animal protein sources in human nutritional needs which continues to grow as the world's population grows. An attempt to fulfill this demand has encouraged the development of catfish culture such as the application of intensive farming systems. On the other hand, the problem in the application of intensive farming systems will also improve the nutritional needs as well as feed as one of the aspects in the successfully of aquaculture (Zannat *et al*. 2023). Diet is an essential component in the growth rate and survival of fish. Furthermore, nearly 60% of the total production cost is devoted to feed (Daniel, 2018). Currently, protein as the main nutrient component in the diet is still highly dependent on fishmeal and soybean flour, which have relatively more expensive prices (Putri *et al*. 2012; Ahmad *et al*. 2020). Attempts to reduce feed costs are by using alternative feed ingredients. These ingredients generally are derived from materials that are not utilized by humans but have nutritional content for fish stuff. One of these alternative feed ingredients is coffee husk, which is the

waste from processing coffee fruit (Afriansyah *et al*. 2023; Nuraisah *et al*. 2013).

The utilization of coffee husk as a fish feed ingredient was grounded by the potential of coffee plantations in South Sumatra, which has a land area of 254.374 hectares with coffee production of 147.090 tons per year (Directorate General of Plantations, 2015). Coffee husk is a by-product of coffee bean which if not handled further will cause pollution and has not been utilized properly yet (Diniyah *et al*. 2013). Coffee bean processing produces 65% coffee beans and 35% husk waste, thus providing considerable potential to be utilized (Iriondo-Dehond *et al*. 2020). Coffee husk containing micronutrient and macronutrient essential for diet. (Bondesson, 2015; Esquivel & Jiménez, 2012). Besides, there are also phytochemical compounds of the polyphenol class that act as antioxidants that help improve the health status of fish (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). Murib *et al*. (2016) explained that the protein content of coffee husk was around 11.18%, while the results of proximate tests at the Fish Nutrition Laboratory of IPB University obtained the nutritional value of coffee husk, which were protein of 9.03%, fat of 1.6%, BETN of 41.34% and crude fiber of 34.96%. The high crude fiber is a weakness in the use of coffee husk. This weakness can be overcome through prior processing, namely the fermentation process (Nuraisah, 2013; Fitria *et al.* 2020; Siddik *et al.* 2024; Yafetto *et al.* 2023).

A fermentation is a biological processing, which utilizes microorganisms which produce enzymes to make changes to complex molecules such as proteins, carbohydrates and fats into simpler and easily digestible molecules (Nuraisah, 2013). These natural microorganisms in EM4 used for fermentation are divided into four main groups: photosynthetic bacteria, fermentation fungi, lactic acid bacteria and Actinomycetes sp, all of which contribute to the breakdown of lignocellulosic bonds, namely releasing lignin and cellulose that proteolytic microbes will produce protease enzymes which function to break down proteins into amino acids (Winedar *et al*., 2006; Al Barru *et al*., 2022). 2022). The implemented of this study for look forward the influences of CHF in striped catfish. The benefit of this research was expected to provide information on the utilization of CHF into feed stuff.

MATERIALS AND METHODS

Preparation of coffee husk fermented

The coffee husk derived from the local plantation of Buay Rawan Disctrict, South Sumatra, Indonesia. The coffee husk was sun-dried for approximately 7 hours and then ground using a disk mill. Fermentation of coffee husk flour was carried out in refer to Warasto *et al*. (2013) by first making a fermentation solution by mixing commercial probiotics brand EM_4 into water in a ratio of 1:100. Then, 150 grams of sugar was added as a carbon source. Next, the coffee husk flour was mixed evenly with the fermentation solution. The mixing ratio is 3 ml of fermentation solution for 10 grams of coffee husk flour. The results of the mixing were then put in a plastic bag and stored at room temperature for seven days.

Experimental diets

The diet used in this study consisted of 5 types of diet, namely: P0 (0% CHF), P1 (6% CHF), P2 (12% CHF), P3 (18% CHF), P4 (24% CHF) which were arranged in a feed formulation with a protein content of 30%. (Table 1). Association of Official Analytical Chemists (AOAC, 2012) used for analysis of proximate.

Experimental design

Striped catfish acquired from local farm of Indralaya, Ogan Ilir Regency, they were kept in a hapa 2×2×1 m^3 for one week to

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adapt to the research environment. Then, the hapa used in this study was 50×50×50 cm^3. It was installed in a 4×4×1 m^3 concrete pond. A total of 300 catfish were distributed into 15 hapa with 3 replicates using a completely randomized design (CRD). Fish rearing was conducted for 6 weeks and during rearing, treatment feeding was applied at satiation 3 times daily at 08.00 a.m, 12.00 a.m and 16.00 p.m.

Absolute weight growth

Absolute weight growth determined based on (Effendie, 1997):

$$W = Wt - Wo$$

Specific growth rate

Specific growth rate calculated based on (Afriansyah *et al.* 2023):

$$SGR = \left(\sqrt[t]{\frac{Wt}{Wo}} - 1\right) \times 100$$

Feed efficiency

Feed efficiency calculated based on NRC (1993), namely:

$$FE = \frac{(Wt + Wd) - Wo}{F} \times 100$$

Survival rate

The survival rate calculated refers to (Mulchlisin *et al*., 2016).

Protein R $SR = \frac{Nt}{No} \times 100$

The protein retention determined refers to (Zehra and Khan, 2016).

$$PR = \frac{F-I \times 100}{P}$$

Water quality measurement

The water quality has a significant influence on fish survival and growth. Water quality parameter monitoring was carried out to examine water environment. The parameters observed were water pH, dissolved oxygen, ammonia and temperature.

Data analysis

Data analysis determined by analysis of variance (ANOVA), and treatments that exhibited significant differences were further examined using Duncan test with a 95% confidence interval through the SPSS 22.0 software

Table 1. Diet formulation of five grade levels CHF

Ingredients (%)	Treatments of diet				
	P0	**P1**	**P2**	**P3**	**P4**
Coffee husk fermented	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
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).

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RESULTS AND DISCUSSIONS

Results

Growth Performance and Feed Utilization

The results indicated that an addition of CHF no effect significantly different impact on specific growth rate, an absolute weight growth and survival rate of striped catfish ($P > 0.05$). While CHF in the diet did not result in a significantly different affect on feed intake and feed efficiency ($P > 0.05$), the addition of 6% CHF in the diet significantly for protein retention ($P < 0.05$) compared to the other treatments. On the other hand, P2, P3, and P4 treatments not significant difference from P0 ($P > 0.05$). All data regarding growth performance and feed utilization are listed in Table 2.

Water Quality

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

Tabel 2. Growth and feed utilization after rearing

Parameter	Treatments of diet				
	P0	P1	P2	P3	P4
Wo (g)	5,31±0,34[a]	5,33±0,09[a]	5,48±018[a]	6,17±0,19[a]	5,43±0,13[a]
Wt (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[a]	45,45±3,25[b]	30,84±4,28[a]	30,80±1,31[a]	31,49±2,25[a]
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 catfish

Parameter	Results of measurement	Optimal range
Temperature (ºC)	29,5 - 29,9	27 - 30 (SNI, 2002)
pH	6,0 - 7,9	6,5 - 8,5 (SNI, 2009)
Dissolved oxygen (mg.L^{-1})	3,97 - 6,66	>3 (SNI, 2009)
Ammonia (mg.L^{-1})	0,03 - 0,19	<0,1 (SNI, 2009) <0,2 (Ananda *et al*., 2015)

Discussion

CHF may be utilized as a fish stuff. Experimental results showed that the use of CHF up to 24% was not significantly different from the control treatment (P0) on growth rate. This was thought to be due to the fact that CHF was acceptable as a fish stuff for fish diet. This was evident from the increase in the amount of feed consumption containing CHF. The increased amount of feed consumption is thought to be due to the flavor of coffee that catfish like, causing fish to increase their appetite. According to Nuraisah *et al*. (2013) the increased amount of feed intake due to the palatability of the feed both in terms of aroma and texture that fish like. Feed consumed by fish will be converted into energy. The greater the available energy, the better it can meet maintenance requirements, with the remaining energy being utilized for growth (Afriansyah *et al*. 2023). The amount of feed given will produce growth if the feed can be consumed and digested by catfish. The same results of Nuraisah *et al*. (2013), the use of fermented coffee skin flour up to 20% in feed produces growth that is not significantly different from the control treatment in tilapia. Lovell (1989) explains that, the energy would be used for

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maintenance and for growth, so it can be ascertained that would be able to meet of fish maintenance needed. Likewise, in the treatment of P1 (6% CHF), P2 (12% CHF) and P3 (18% CHF) in the feed formulation, it is still able to be digested properly so that it is sufficient for catfish growth. Growth performance showed no significant difference across treatments, it concluded that the use of fermented CHF has the potential to be used as an alternative raw material to substitute bran and soy flour. This can be seen from the results of the study showing that feed containing CHF up to a level of 24% in feed formulations is still acceptable to catfish and for improving growth performmance of striped catfish.

Feed efficiency refers to growth and the amount of feed consumed. Feed efficiency provides an overview of the utilization of feed given so as to increase fish growth (Nuraisah *et al*. 2013). High feed efficiency values indicate it will be absorbed and converted into meat. The use of CHF up to 24% (treatment P4) resulted in feed efficiency that was not different from the control (P0). This is suspected because the fermentation results could reduce crude fiber in CHF from 33.80% to 25.52%, so that the use of CHF up to 24% in feed can still be digested and produce growth in catfish. Crude fiber in the control treatment feed is 6.80%, while crude fiber in feed containing coffee husk ranges 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 RP value, shown the more protein in the body from diet protein (Suprayudi *et al*. 2014). 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). As stated by Handayani et al. (2014), high protein retention occurs when the protein content in the diet is efficiently utilized by the fish. Halver (1989) explains if the energy in the diet exceeds of fish requirements, it would be full quickly and may not utilize the protein effectively. Conversely, if the energy in the feed is insufficient for the fish's needs, the energy source from protein allocated for biological functions maintenance.

Based on the study, overall water quality as long as the experiment was optimal and within tolerable range for the fish. Water temperature ranged from 29.5-29.9 ºC, water pH during catfish rearing ranged from 6.0-7.9. Dissolved oxygen content during rearing ranged from 3.97-6.70 $mg.L^{-1}$ and ammonia values during rearing ranged from 0.03-0.19 $mg.L^{-1}$. According to the Indonesian National Standard (2002), a good water temperature for striped catfish rearing ranges from 25-30ºC. According to the Indonesian National Standard (2009) the pH of good water for striped catfish rearing ranges from 6.5-8.5 and ammonia value <0.01 $mg.L^{-1}$. The range of ammonia optimal for fish life is <0.2 $mg.L^{-1}$ (Ananda *et al.* 2015; Tanbiyaskur *et al.* 2024). According to the Indonesian National Standard (2000), for an optimal dissolved oxygen of catfish is 3-8 $mg.L^{-1}$.

CONCLUSION

The inclusion of up to 24% CHF in feed formulations could serve as an alternative feed ingredient without negatively on the growth performance and feed utilization in striped catfish.

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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.

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CONFLICT OF INTEREST

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

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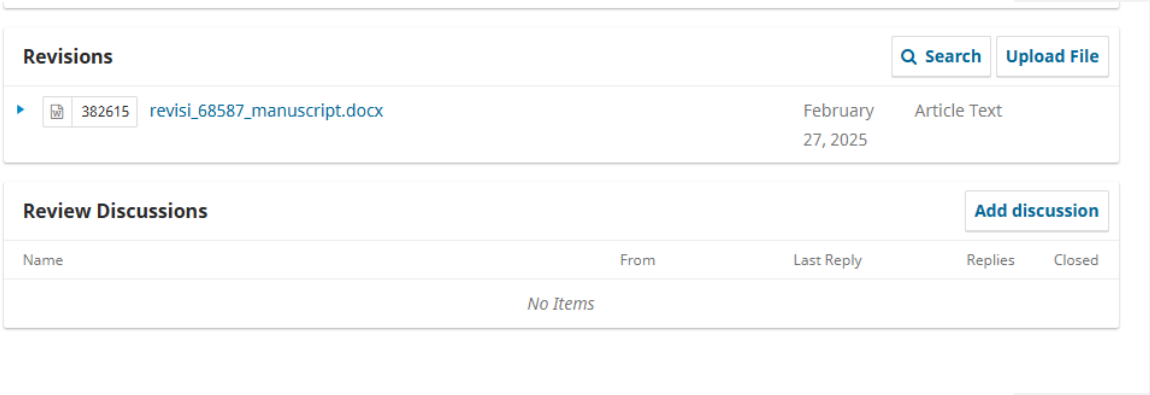
3. **BUKTI UPLOAD HASIL REVISI ARTIKEL (27 FEBRUARI 2025)**



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Effects of dietary coffee husk fermented on the growth performance and feed utilization in Striped Catfish (*Pangasianodon hyphophthalmus*)

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ABSTRACT

Coffee husk fermented (CHF) might be utilized as other preference plant protein source. This research focused on evaluating the effects of dietary supplementing CHF for striped catfish on growth and fed application. This study consisted of five grade levels of CHF. The treatments were P0 (without the addition of CHF) P1 (addition of 6% CHF), P2 (addition of 12% CHF), P3 (addition of 18% CHF), P4 (addition of 24% CHF). The results determined that dietary CHF inclusion had no significantly different effect on specific growth rate and feed efficiency (P>0.05). P1 (CHF 6%) is the best dose by producing PR that was different in comparison the control (P0) and other CHF treatments (P<0.05). Survival rate during rearing there was no significant effect recorded among all treatments.The use of CHF up to 24% in the feed formulation was still acceptable to applied and did not negative effect of striped catfish although which results in growth rate, feed efficiency and survival that are not different (P > 0.05).

Keyword: feed, striped catfish, coffee husk fermented, growth

INTRODUCTION

Striped catfish is a valuable freshwater species with high economic importance and the most widely cultivated species around the globe (Hoque *et al*. 2021). The value of catfish production from 2019-2023 has risen by an average of 4.17% each year (Ministry of Fisheries and Marine Affairs, 2024). Globally, catfish has also ranked as the ninth massive freshwater fish production around the globe (FAO, 2022). Increasing catfish production based on the high demand of the world society for animal protein sources in human nutritional needs which continues to grow as the world's population grows. An attempt to fulfill this demand has encouraged the development of catfish culture such as the application of intensive farming systems. On the other hand, the problem in the application of intensive farming systems will also improve the nutritional needs as well as feed as one of the aspects in the successfully of aquaculture (Zannat *et al*. 2023). Diet is an essential component in the growth rate and survival of fish. Furthermore, nearly 60% of the total production cost is devoted to feed (Daniel, 2018). Currently, protein as the main nutrient component in the diet is still highly dependent on fishmeal and soybean flour, which have relatively more expensive prices (Putri *et al*. 2012; Ahmad *et al*. 2020). Attempts to reduce feed costs are by using alternative feed ingredients. These ingredients generally are derived from materials that are not utilized by humans but have nutritional content for fish stuff. One of these alternative feed ingredients is coffee husk, which is the waste from processing coffee fruit (Afriansyah *et al*. 2023; Nuraisah *et al*. 2013).

The utilization of coffee husk as a fish feed ingredient was grounded by the potential of coffee plantations in South Sumatra, which has a land area of 254.374 hectares with coffee production of 147.090 tons per year (Directorate General of Plantations, 2015). Coffee husk is a by-product of coffee bean

which if not handled further will cause pollution and has not been utilized properly yet (Diniyah *et al*. 2013). Coffee bean processing produces 65% coffee beans and 35% husk waste, thus providing considerable potential to be utilized (Iriondo-Dehond *et al*. 2020). Coffee husk containing micronutrient and macronutrient essential for diet. (Bondesson, 2015; Esquivel & Jiménez, 2012). Besides, there are also phytochemical compounds of the polyphenol class that act as antioxidants that help improve the health status of fish (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). Based on the results of proximate tests at the Fish Nutrition Laboratory of IPB University obtained the nutritional value of coffee husk, which were protein of 9.03%, fat of 1.6%, BETN of 41.34% and crude fiber of 34.96%. The high crude fiber is a weakness in the use of coffee husk. High crude fiber content makes feed more difficult to digest by fish, 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 prior processing, namely the fermentation process (Nuraisah *et al.* 2013; Fitria *et al.* 2020; Siddik *et al.* 2024; Yafetto *et al.* 2023).

A fermentation is a biological processing, which utilizes microorganisms which produce enzymes to make changes to complex molecules such as proteins, carbohydrates and fats into simpler and easily digestible molecules, CHF fermentation using the role of several microbes could reduce crude fiber of 23.1%. (Nuraisah *et al*, 2013). These natural microorganisms in EM_4 used for fermentation are divided into four main groups: photosynthetic bacteria, fermentation fungi, lactic acid bacteria and *Actinomycetes* sp, all of which contribute to the breakdown of lignocellulosic bonds, namely releasing lignin and cellulose that proteolytic microbes will produce protease enzymes which function to break down proteins into amino acids (Winedar *et al*., 2006; Al Barru *et al*., 2022). 2022). The implemented of this study for look forward the influences of CHF in striped catfish. The benefit of this research was expected to provide information on the utilization of CHF into feed stuff.

MATERIALS AND METHODS

Preparation of coffee husk fermented

The coffee husk derived from the local plantation of Buay Rawan Disctrict, South Sumatra, Indonesia. The coffee husk was sun-dried for approximately 7 hours and then ground using a disk mill. Fermentation of coffee husk flour was carried out in refer to Warasto *et al*. (2013) by first making a fermentation solution by mixing commercial probiotics brand EM_4 into water in a ratio of 1:100. Then, 150 grams of sugar was added as a carbon source. Next, the coffee husk flour was mixed evenly with the fermentation solution. The mixing ratio is 3 ml of fermentation solution for 10 grams of coffee husk flour. The results of the mixing were then put in a plastic bag and stored at room temperature for seven days.

Experimental diets

The diet used in this study consisted of 5 types of diet, namely: P0 (0% CHF), P1 (6% CHF), P2 (12% CHF), P3 (18% CHF), P4 (24% CHF), all dosages treatments refers to previous report according to Fitria *et al.* (2020) and Afriansyah *et al.* (2023) which were arranged in a feed formulation with a protein content of 30%. (Table 1). Association of Official Analytical Chemists (AOAC, 2012) used for analysis of proximate.

Experimental design

Striped catfish acquired from local farm of Indralaya, Ogan Ilir Regency, South Sumatra Province. they were kept in a hapa $2\times2\times1$ m^3 for one week to adapt to the research environment. Then, the hapa used in this study

was 50×50×50 cm^3. It was installed in a 4×4×1 m^3 concrete pond. A total of 300 fish (5.54 ± 0.38 g) were distributed into 15 hapa with 3 replicates using a completely randomized design (CRD). Fish rearing was conducted for 6 weeks and during rearing, treatment feeding was applied at satiation 3 times daily at 08.00 a.m, 12.00 a.m and 16.00 p.m.

Absolute weight growth

Absolute weight growth determined based on (Effendie, 1997):

$$W = Wt - Wo$$

Specific growth rate

Specific growth rate calculated based on (Afriansyah *et al.* 2023):

$$SGR = \left(\sqrt[t]{\frac{Wt}{Wo}} - 1\right) \times 100$$

Feed efficiency

Feed efficiency calculated based on (de verdal *et al*. 2018) namely:

$$FE = \frac{(Wt + Wd) - Wo}{F} \times 100$$

Survival rate

The survival rate calculated refers to (Mulchlisin *et al*., 2016).

$$SR = \frac{Nt}{No} \times 100$$

Protein Retention

The protein retention determined refers to (Zehra and Khan, 2016).

$$PR = \frac{F - I \times 100}{P}$$

Water quality measurement

The water quality has a significant influence on fish survival and growth. Water quality parameter monitoring was carried out to examine water environment. The parameters observed were water pH, dissolved oxygen, ammonia and temperature.

Data analysis

Data analysis determined by analysis of variance (ANOVA), and treatments that exhibited significant differences were further examined using Duncan test with a 95% confidence interval through the SPSS 22.0 software

Table 1. Diet formulation of five grade levels CHF

Ingredients (%)	Treatments of diet				
	P0	**P1**	**P2**	**P3**	**P4**
Coffee husk fermented	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
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).

RESULTS AND DISCUSSIONS

Results

Growth Performance and Feed Utilization

The results indicated that an addition of CHF no effect significantly different impact on specific growth rate, an absolute weight growth and survival rate of striped catfish ($P > 0.05$). While CHF in the diet did not result in a significantly different affect on feed intake and feed efficiency ($P > 0.05$), the addition of 6% CHF in the diet significantly for protein retention ($P < 0.05$) compared to the other treatments. On the other hand, P2, P3, and P4 treatments not significant difference from P0 ($P > 0.05$). All data regarding growth performance and feed utilization are listed in Table 2.

Water Quality

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

Tabel 2. Growth and feed utilization after rearing

Parameter	Treatments of diet				
	P0	P1	P2	P3	P4
Wo (g)	5,31±0,34[a]	5,33±0,09[a]	5,48±018[a]	6,17±0,19[a]	5,43±0,13[a]
Wt (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[a]	45,45±3,25[b]	30,84±4,28[a]	30,80±1,31[a]	31,49±2,25[a]
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 catfish

Parameter	Results of measurement	Optimal range
Temperature (°C)	29,5 - 29,9	27 - 30 (SNI, 2002)
pH	6,0 - 7,9	6,5 - 8,5 (SNI, 2009)
Dissolved oxygen ($mg.L^{-1}$)	3,97 - 6,66	>3 (SNI, 2009)
Ammonia ($mg.L^{-1}$)	0,03 - 0,19	<0,1 (SNI, 2009) <0,2 (Ananda *et al*., 2015)

Discussion

CHF may be utilized as a fish stuff. Experimental results showed that the use of CHF up to 24% was not significantly different from the control treatment (P0) on growth rate. This was thought to be due to the fact that CHF was acceptable as a fish stuff for fish diet. This was evident from the increase in the amount of feed consumption containing in all CHF treatmnets. The increased amount of feed consumption is thought to be due to the flavor of coffee that catfish like, causing fish to increase their appetite. Despite the lack of available research, it is suspected that the feed utilization increase is due to the aroma that arises from CHF which is derived from the maillard reaction, this reaction causes a distinctive coffee aroma from the roasting process, so induced the formation of aroma precursors (Cardoso *et al.* 2023; Tarigan *et al.* 2022). According to Nuraisah *et al*. (2013) the increased amount of feed intake due to the palatability of the feed both in terms of aroma and texture that fish like. Feed consumed by fish will be converted into energy. The greater the available energy, the better it can meet maintenance requirements, with the remaining energy being utilized for growth (Afriansyah *et al*. 2023). The amount of feed given will produce growth if the feed can be consumed and digested by catfish. The same results of Nuraisah *et al*. (2013), the use of fermented

coffee skin flour up to 20% in feed produces growth that is not significantly different from the control treatment in tilapia. The energy would be used for maintenance and for growth, so it can be ascertained that would be able to meet of fish maintenance needed (Suprayudi *et al.* 2017). Growth performance showed no significant difference across treatments, it concluded that the use of fermented CHF has the potential to be used as an alternative raw material to substitute bran and soy flour. This can be seen from the results of the study showing that feed containing CHF up to a level of 24% in feed formulations is still acceptable to catfish and for improving growth perforrmance of striped catfish. Afriansyah *et al*. (2023) reported the use of 4% coffee skin flour had a positive effect on growth performance and antioxidants. The use of CHF up to 24% had a positive impact on tilapia fillet quality (Fitria *et al*. 2020).

Feed efficiency refers to growth and the amount of feed consumed. Feed efficiency provides an overview of the utilization of feed given so as to increase fish growth (Nuraisah *et al*. 2013). High feed efficiency values indicate it will be absorbed and converted into meat. The use of CHF up to 24% (treatment P4) resulted in feed efficiency that was not different from the control (P0). This is suspected because the fermentation results could reduce crude fiber in CHF from 33.80% to 23.1% (Nuaisah *et al.* 2013) so that the use of CHF up to 24% in feed can still be digested and produce growth in catfish. the decrease in crude fiber was suspected of the role of microbes that acted in degrading cellulose in CHF. (Nuraisah *et al.* 2013). Crude fiber in the control treatment feed is 6.80%, while crude fiber in feed containing coffee husk ranges 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 prrotein (Suprayudi *et al*. 2014). In previous studies utilizing CHF supplementation the highest protein retention at a dose of 4% CHF for tilapia diet (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). As stated by Handayani et al. (2014), high protein retention occurs when the protein content in the diet is efficiently utilized by the fish. Suprayudi *et al.* (2017) explains if the energy in the diet exceeds of fish requirements, it would be full quickly and may not utilize the protein effectively. Conversely, if the energy in the feed is insufficient for the fish's needs, the energy source from protein allocated for biological functions maintenance.

Based on the study, overall water quality as long as the experiment was optimal and within tolerable range for the fish. Water temperature ranged from 29.5-29.9 ºC, water pH during catfish rearing ranged from 6.0-7.9. Dissolved oxygen content during rearing ranged from 3.97-6.70 $mg.L^{-1}$ and ammonia values during rearing ranged from 0.03-0.19 $mg.L^{-1}$. According to the Indonesian National Standard (2002), a good water temperature for striped catfish rearing ranges from 25-30ºC. According to the Indonesian National Standard (2009) the pH of good water for striped catfish rearing ranges from 6.5-8.5 and ammonia value <0.01 $mg.L^{-1}$. The range of ammonia optimal for fish life is <0.2 $mg.L^{-1}$ (Ananda *et al.* 2015; Tanbiyaskur *et al.* 2024). According to the Indonesian National Standard (2000), for an optimal dissolved oxygen of catfish is 3-8 $mg.L^{-1}$.

CONCLUSION

The inclusion of up to 24% CHF in feed formulations could serve as an alternative feed ingredient without negatively on the growth performance and feed utilization in striped catfish.

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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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4. BUKTI ACCEPTED ARTIKEL

(03 MARET 2025)

[JoAS] Editor Decision Eksternal Kotak Masuk ×

Journal of Aquaculture Science Universitas Airlangga <joas@psdku.unair.ac.id> Sen, 3 Mar, 08.18

kepada saya, Mohamad, Ade, Sefti, Tanbiyaskur

Terjemahkan ke Indonesia

Azmi Afriansyah, Mohamad Amin, Ade Dwi Sasanti, Sefti Heza Dwinanti, Tanbiyaskur Tanbiyaskur:

We have reached a decision regarding your submission to Journal of Aquaculture Science, "Effects of dietary coffee husk fermented on growth and feed utilization in Striped Catfish Pangasianodon hyphophthalmus".

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Authors:

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5. BUKTI ARTIKEL PUBLISHED ONLINED

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Prof. Dr. Rossita Shapawi rossita@ums.edu.my lewat ibox.unair.ac.id Jum, 25 Apr, 16.59

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There is new activity in the discussion titled "Production process next steps for authors of accepted manuscripts" regarding the submission "Effects of dietary coffee husk fermented on growth and feed utilization in Striped Catfish Pangasianodon hyphophthalmus".

Link: https://e-journal.unair.ac.id/JoAS/authorDashboard/submission/68587

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Journal of Aquaculture Science

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

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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

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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

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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

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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

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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^{o}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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