Growth Rate And Feed Conversion Of Catfish (Pangasiussp.) Given Mixed Feed With Fermented Mustard Greens And Cabbage Waste Flour

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Abstract: This study aims to determine the growth rate and feed conversion of catfish (*Pangasius sp.*) fed a mixture of powdered and fermented cabbage and mustard greens waste. The catfish used with an initial weight of 3-5 g are stocked in as many as five fish per container box. Feeding is three times a day with a feeding rate of 5% for 56 days of cultivation. This study used a randomized block design (RBD). There were five treatments, and each treatment was repeated three times. The artificial feed was tried with a mixture of fermented mustard greens and cabbage waste flour (FMCWF) with different percentages: Treatment P0 (feed manufacturer MatahariSakti brand), P1 (FMCWF 15%), P2 (FMCWF 30%), P3 (FMCWF 45) %), and P4 (FMCWF 60%). The test parameters are absolute weight growth, feed conversion ratio, and water quality. Based on the ANOVA test (analysis of variances), the results showed that the mixture of fermented mustard greens and cabbage waste flour had a significant effect ($p <0.05$) on the growth rate of catfish. The P2 treatment (FMCWF 30%) produced catfish best growth based on the growth parameters of the absolute weight of 8.11 g and the feed conversion ratio of 1.5.

Keywords: Fermentation, Catfish, Mustard greens and Cabbage Waste, Growth

1. Introduction

Catfish cultivation is a freshwater fish business with great potential. Catfish has many benefits, such as economic value and high nutritional value. The factor that must be considered in cultivation is the feed quality because it can support the success of a fishery cultivation activity. The cost of feed production is estimated at 60-70% (Aliyah et al., 2019). These problems can be overcome by independently procuring feed by utilizing raw material sources that are cheaper but still good.

Vegetable waste is a type of waste that is very abundant because it is widely sold in the market, especially mustard greens and cabbage. This waste can come from sorting the vegetable's damaged parts during harvesting and distribution from farmers to sellers. The utilization of mustard greens and cabbage waste is the right solution to fish farmers' problem to be used as an alternative feed raw material. Also, it can overcome waste problems, especially organic waste. Mustard greens and cabbage waste can substitute soybean flour as a raw material source for fish feed with vegetable protein.

The use of mustard greens and cabbage waste has problems with high fiber and low protein. The fermentation process can be carried out to improve the nutritional quality of mustard greens and cabbage waste using *Rhizopus sp.* It is known as mold-producing enzymes such as protease, pectinase, α-amylase, and lipase. The protease enzyme in *Rhizopus sp.* has a high proteolytic activity to break down complex protein molecules during fermentation (Endrawati&Kusumaningtyas, 2017). Fermentation of mustard greens and cabbage waste flour using *Rhizopus sp.* can increase crude protein from 9.64% to 19.91% and crude fiber from 21.50% to 12.30% (Sitorus, 2019).

This study aims to determine the growth rate of catfish (*Pangasius sp.*) fed a mixture of fermented mustard greens and cabbage waste flour.

2. Materials and Methods

Material

The research was carried out on Binakridastreet, SimpangBarusubdistrict, Binawidya district, Pekanbaru in October 2020 until April 2021. The fish were kept in 15 units of 35 x 24 x 24 cm container, and each container had five fish weighing 3-5 g and 3-5 cm long. Preparation of the cultivation media began with filling the container boxes with water. The water was left for a day and night to adjust its conditions to the environment. After that, the test fish were added in the afternoon and acclimatized for a week using control feed. After a week, the fish were not fed for a day and weighed to equalize the total fish weight to be 18 g/box containers. Fish were fed as much as 5% of the fish biomass three times a day (Syahrizal et al., 2018). Every day the remaining feed was taken to calculate the dry weight of the remaining feed. Water quality was measured every seven days, which includes DO, temperature, and pH. The container box was cleaned, and the water was changed. Fish cultivation was carried out for 56 days.

Production of Fermented Mustard Greens and Cabbage Waste Flour

Mustard greens and cabbage waste are obtained from a vegetable seller at the Arengka Morning Market on Soekarno-Hatta Street, Pekanbaru. It is cleanly washed and thinly sliced before it dried in the sun and then crushed into flour. The mustard greens greens and cabbage flour are then fermented with 1: 1 mustard greens flour and cabbage flour. *Rhizopus* sp. with a dose of 3g/kg of the ingredients were mixed (Utami et al. 2012) and stirred until homogeneous. The flour was steamed for 10 minutes, then put in a plastic bag with holes in several sections. Fermentation was carried out for ± 36 hours (Sitorus, 2019). Lastly, the flour was refined and ready to be formulated into the feed.

Production of Mixed Feed of Fermented Mustard greens and Cabbage Waste Flour

The feed was previously formulated according to the protein needs of fish (min. 25%), crude fiber 8% (maximum), crude fat 5% (minimum) (SNI 7548: 2009). Calculation of the nutritional content of feed used the worksheet method (Sary, 2013). The feed ingredients are fermented mustard greens and cabbage waste flour, soy flour and fish flour, wheat flour, vitamin and mineral mix, and fish oil. The test feed preparation began with mixing all the formulated ingredients until they were homogeneous. In the mixing process, warm water was added to make it easier for the dough to clump. The homogeneous lump of feed dough was molded and dried under direct sunlight. The composition and nutritional content of the test feed ingredients can be seen in Table 1.

Table 1. The composition and Nutritional Content of Test Feed

Ingredients	**Treatment (%SF: FMCWF)**				
	P0	P1	P2	P3	P4
	%B	%B	%B	%B	%B
FMCWF	Manufactrured Feed PF- 1000	15	30	45	60
Soy Flour		45	30	15	0
Wheat Flour		5	5	5	5
Fish Flour		32	32	32	32
Fish Oil		2	2	2	2
Vitamin dan Mineral Mix		1	1	1	1
Total	100	100	100	100	100
Crude Protein (%)	33*	38,38	35,69	32	30,29
Crude Fiber (%)	5*	4,72	5,81	6,91	8
Crude Fat (%)	6*	11,53	8,99	8	3,93

Information: FMCWF: Fermented mustard greens and cabbage waste flour, SF: Soy flour, %B: Percentage of used ingredients (%).*(Aliyah et al., 2019).

Methods

This study used an experimental method with a randomized block design (RBD). There were five treatments, each of which was repeated three times. The treatment given was a modification of Sitorus' research (2019). The treatments given were:

P0 (MatahariSakti manufactured feed),
P1 (15% of FMCWF),
P2 (30% of FMCWF),
P3 (45% of FMCWF), and
P4 (60% of FMCWF).

Data Collection

The data collected was under the observation parameters: absolute weight growth, feed conversion ratio, and water quality.

Absolute Weight Growth

The weight of the test fish was weighed every seven days using an analytical balance. According to Septimesy et al. (2016), the formula for calculating absolute weight growth is as follows:

$$\Delta W = W_t - W_0$$

Information:

ΔW= Absolute Weight Growth (g)
W_0 = Fish average weight at the start of cultivation (g)
W_t= Fish average weight on the time of t of the cultivation (g)

Feed Conversion Ratio

According to Phaseari and Darmawan (2018), the formula for calculating fish feed conversion is:

$$FCR = \frac{F}{(Wt + D) - W0}$$

Information:

FCR = Feed Conversion Ratio
F = Total of given feed (g)
Wt = Fish biomass at the end of the study (g)
D = Dead fish biomass (g)
W0 = Fish biomass at the start of the study (g)

Water Quality

Measurements were made every seven days before water change within 56 days of cultivation. A thermometer was used to measure temperature, a pH meter to measure the degree of acidity (pH), and a DO meter to measure DO.

Data Analysis

Data from the research results of absolute weight growth and feed conversion ratio were analyzed using the SPSS version 25 application program. Collected quantitative data were tested for normality and homogeneity first, thenanalyzed using ANOVA (Analysis of Variances). If the test results between treatments are significantly different, where F count is greater than F table, then the Duncan Multiple Range Test (DMRT) will be carried out at a significance level of 5%. Water quality data were analyzed descriptively using SNI 7471.2: 2009.

3. Results and Discussion

Results

Absolute Weight Growth

Absolute weight growth is the difference between the fish's average weight at the end and the beginning of the study. The weight gain of catfish increases with increasing cultivation time. Following is the weight gain of catfish for 56 days of cultivation (Figure 1).

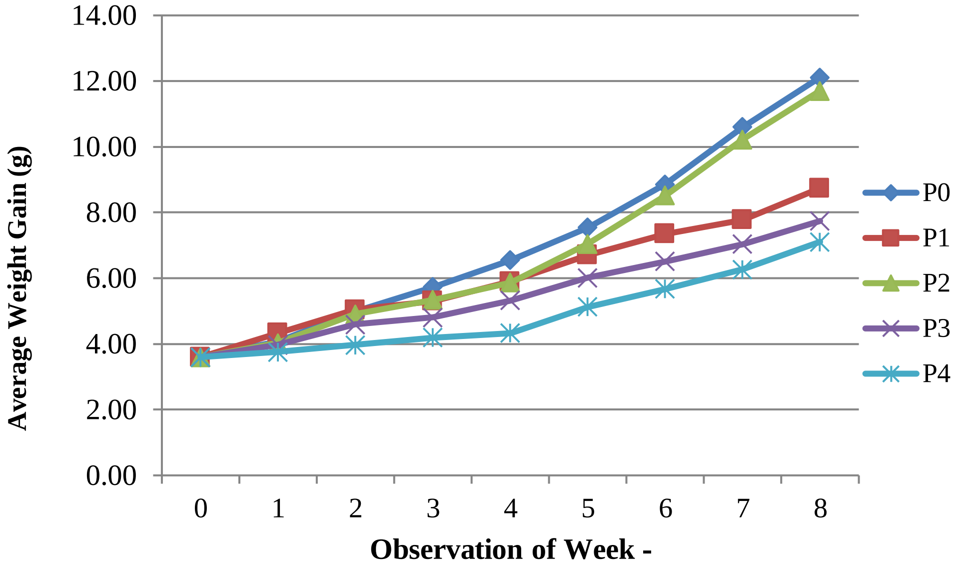

Figure 1. Average Weight Gain of Catfish

In Figure 1, it can be seen that the first week to the third week of the average weight gain is slow, ranging from 0-2 g. The weight gain of catfish tended to be faster at week 4 to week 8, but the results differed in each treatment except P0 and P2 treatments. The absolute weight growth of catfish is presented in Table 2.

Table 2. Catfish Absolute Weight Growth

Treatment of Fermented Mustard greens and Cabbage Waste Flour (FMCWF)	Parameter
	Absolute Weight Grow (g)
P0 (Manufactured Feed)	8,52±0,99 **c**
P1 (15% FMCWF)	5,14±0,48 **b**
P2 (30% FMCWF)	8,11±0,42 **c**
P3 (45% FMCWF)	4,14±0,25 **ab**
P4 (60% FMCWF)	3,51±0,38 **a**

Analysis of variances (ANOVA) test results on the growth of catfish's absolute weight found that the treatment of fermented mustard greens and cabbage waste flour (FMCWF) with different percentages significantly affected the absolute weight growth of catfish. The treatment that produced the ighest absolute weight growth was control treatment 8.52 ± 0.99 g. Based on the DMRT test, the control treatment was not significantly different from the P2 treatment (30% FMCWF) 8.11 ± 0.42 g.

Feed Conversion Ratio

During cultivation, catfish used different amounts of feed. The feed conversion ratio shows the ratio between the biomass of fish produced and the total fish feed. Data regarding the catfish feed conversion ratio during the study is presented in Table 3.

Table 3. Catfish Feed Conversion Ratio

Treatment of Fermented Mustard greens and Cabbage Waste Flour (FMCWF)	Parameter
	Feed Conversion Ratio
P0 (Manufactured Feed)	1,84±0,03 **b**
P1 (15% FMCWF)	2,11±0,03 **c**
P2 (30% FMCWF)	1,58± 0,04 **a**
P3 (45% FMCWF)	2,57± 0,14 **d**
P4 (60% FMCWF)	2,64± 0,18 **d**

Based on the analysis of variances (ANOVA), the conversion ratio of catfish feed, it was found that the treatment of fermented mustard greens and cabbage waste flour (FMCWF) with different percentages had a significant effect on the conversion ratio of catfish feed. Treatment with 30% FMCWF resulted in the best feed conversion ratio of 1.58 ± 0.04.

Water Quality

An important factor affecting environmental conditions during fish rearing is water quality to affect the fish metabolic process. The data from the measurement of water quality are presented in Table 4.

Table 4. Water Quality

Treatment of Fermented Mustard greens and Cabbage Waste Flour (FMCWF)	Parameter		
	Temperature (^{0}C)	**pH**	**DO (mg/l)**
P0 (Manufactured Feed)	27-31	5,93-6,91	4,3-5
P1 (15%)	27-30	5,56-6,60	4,1-4,9
P2 (30%)	27-31	5,92-6,94	4,3-5
P3 (45%)	27-31	5,18-6,12	4,2-4,7
P4 (60%)	27-31	5,13-5,98	4,1-4,6

The temperature obtained during the study ranged from 27-310C. This temperature is in the optimal range to support growth according to Kordi K. and M. Ghufran H. (2013) and is under SNI 7471.2: 2009.

In pH parameters, the pH range obtained during the study was 5.13-6.94. The pH range obtained is quite good, still acceptable for catfish, is at the limit value according to Kordi K. and M. Ghufran H. (2013), and is under SNI 7471.2: 2009. In the dissolved oxygen (DO) parameter, the DO obtained ranged from 4.1 to 5 mg / l. Overall, the DO value during the study was classified as an optimal condition to support growth according to Kordi K. and M. Ghufran H. (2013) and is under SNI 7471.2: 2009.

Discussions

The growth of catfish (*Pangasius* sp.) can be determined through the study's parameters. The administration of fermented mustard greens and cabbage waste flour has been shown to have a significant effect ($p < 0.05$) on the parameters of absolute weight growth and feed conversion ratio. In general, the water quality used for cultivation still supports the growth and development of catfish.

Absolute Weight Growth

In Figure 1, the growth of catfish from week 1 to week 3 has not increased. The reason is that catfish carry out an adaptation process to the environment and feed. Feed adaptation is influenced by the organs used to collect feed. The size of the fish's mouth opening determines the amount of feed it consumes because fish only consume food whose size matches its mouth opening (Yustina, 2019). Although researchers have made small feed sizes, it is suspected that at week 1 to 3, the size of the feed does not match the size of the fish's mouth opening. However, in week 4, the results showed significant weight growth because the test fish could survive and adapt to feed and environmental conditions. The level of adaptation of the fish to the environment and the feed they are given will get better with the length of cultivation. The growth that occurs every week means that the feed given is digested and absorbed by the test fish properly so that fish growth can occur (Rambo et al., 2018).

P4 treatment resulted in the lowest increase in absolute weight of 3.51 ± 0.38 g. One of the factors that influence fish growth is related to the nutritional content of the feed. Based on Table 1, the higher the mixing of FMCWF in the feed will increase the crude fiber to become an obstacle in catfish's digestion process.

Feed that has high crude fiber can inhibit the digestive process. It is because the feed is held longer in the intestine and has an impact on satiety so that it affects the appetite of fish, the amount of feed consumption, and the absorption of feed nutrients, resulting in a decrease in feed efficiency for weight growth in P4 treatment due to lack of energy generated for the growth of the body's structural tissues. According to Yuniati et al. (2018), fish feed with a high fiber content causes growth to be stunted because the utilization of feed nutrition is disrupted.

Crude fiber consists of polysaccharides composed of hundreds to thousands of monosaccharides, so digestive enzymes are needed to simplify polysaccharides into monosaccharides to be used as energy. However, catfish do not have crude fiber digestive enzymes in the form of cellulase enzymes. The only enzymes found are protease and amylase enzymes, so crude fiber digestion is not optimal (Oktavianto et al., 2014). Crude fiber has strong *lignohemicellulose* bonds so that it is difficult to break down by digestive enzymes. Dietary nutrients can be carried by crude fiber, not digested, and comes out with feces (Kardana et al., 2012).

The digestive tract's physiological conditions play an essential role in converting feed nutrients into raw materials for the growth biosynthesis process. The intestinal length of omnivorous fish ranges from 0.8 to 5 times shorter in body length than herbivorous fish, which is 2-21 times its body length (Haraningtias et al., 2018). Catfish belongs to omnivorous fish with a short intestine, a long process of digestion of feed when it contains high crude fiber so that the digestive tract needed is also long. The digestive tract of catfish does not support the digestion of feed containing high fiber.

Treatment P4 had low-fat content (Table 1). If there is excess energy from the body's maintenance, metabolism, and activity processes, that energy can be used for the growth process. The need for adequate oil and fat in feed, protein can be used for growth. Low-fat content in feed causes the energy source to come only from protein so that the weight growth of catfish becomes slower because energy is used up for fish movement and metabolism activities compared to increasing the growth of the structural tissue of the fish body (Phaseari&Darmawan, 2018)

In the FMCWF treatment, P2 treatment had the highest absolute weight gain of 8.11 ± 0.42. It shows that giving FMCWF 30% / kg of feed is the suitable composition of feed because the results of mixing FMCWF with other feed raw materials produce feed whose nutritional content meets SNI 7548: 2009 and is almost the same as manufactured feed (Table 1), so the use of FMCWF in the manufacture of feed can reduce the use of soy flour and the feed composition in treatment P2 can be used as an alternative feed. The addition of the correct composition of FMCWF can undoubtedly increase the weight optimally so that it helps speed up the maintenance period and speed up the rearing period of catfish.

The feed nutritional content is a limiting factor in the fish growth process influenced by feed composition, feed preferences, feeding time, feed size, and fish mouth opening (Yustina et al., 2019). The high growth in P2 treatment is because the nutrients in the feed can produce total energy that can support growth. Treatment P2 contains crude fiber, which can still be tolerated in the fish digestive system so that crude fiber does not hinder the digestion process of the feed nutritional content. Catfish can only digest feed with low crude fiber content and high protein (Rambo et al., 2018).

The pancreas produces lipase and protease enzymes to digest fat and protein from the feed to be absorbed by enterocyte cells in the intestine. Proteases degrade proteins into peptides and then further broken down into amino acids, whereas lipases simplify fat molecules. Fat is used as a source of energy so that most of the amino acid content of the protein in P2 feed is thought to be fully utilized for the growth of the fish's body structural tissue, resulting in a more optimal body weight growth.

Feed Conversion Ratio

Treatment P4 had the highest feed conversion compared to other treatments. In the P4 treatment, the mixture of fermented ingredients inhibits the absorption of nutrients in the intestine because the crude fiber content reached 8%, which is the maximum digestibility limit for crude fiber of catfish feed (SNI 7548: 2009) (Table 3.3). Feed with high crude fiber results in the utilization of feed by fish which is not optimal as evidenced by the number of feces produced.

Besides, the preference factor of catfish towards feed showed that catfish did not like P4 treatment, as evidenced by the less feed consumption during cultivation which only reached 138.26 g, while in P2 treatment 191.95 g. Feed preferences are related to the size, shape, aroma, taste, and color of the feed (Pamungkas, 2013). At the beginning of the study, it was found that the test fish did not eat much food. The reason is thought to be due to the feed size, which is not suitable for the mouth size of the catfish. But the longer the cultivation, the size of the fish's mouth is getting bigger and can consume the feed. The fishy taste and aroma are usually preferred by catfish as evidenced by the high consumption of P0 and P2 treatment, which smells fishy, the more the addition of fermented mustard greens and cabbage waste flour, it is assumed that the taste and aroma of the feed-in P4 treatment are more dominant so that catfish less favor it.

Feed consumption is also influenced by the fish preference for feed (buoyancy and destructive power). Treatment P4 has faster buoyancy (> 5 minutes), and the feed is destroyed more quickly (> 12 hours). According to Harianto et al. (2016), the addition of excessive fermentation material results in higher feed moisture levels, faster absorption of water, and larger feed pores so that the feed is easily destroyed. Of course, if the feed is easily destroyed, if it sinks to the bottom, it will be difficult to find the fish and not be consumed by the fish, which affects the feed conversion ratio. The high feed conversion ratio certainly affects the weight and absolute length of the fish. It is proven that P4 treatment has a smaller absolute weight and length than all treatments because much feed is wasted. Good feed remains intact in water for at least 3 hours and can last more than 15 minutes for catfish feed (Fahrizal&Ratna, 2020).

Treatment P2 had the lowest feed conversion value compared to other treatments. The amount of feed consumption is closely related to the protein and energy content in the feed. The good feed has a low feed conversion value. Therefore, the smaller the feed conversion ratio's value, the maximum bodyweight is produced (Yustina et al., 2019; Diana &Ernawati, 2014).

According to Syahrizal et al. (2018), the greater the feed conversion ratio value, the more feed is needed to produce 1 kg of cultivated fish meat. For example, in P2 treatment with a feed conversion ratio value of 1.58, so to produce 1 kg of catfish bodyweight, it takes 1.58 kg of fish feed. P2 treatment is more profitable in catfish cultivation because the amount of feed needed is less but produces optimal body weight.

The provision of feed containing a mixture of fermented ingredients with the right composition facilitates the digestion and absorption process in the intestine. The efficiency of feed utilization is optimal to reduce the feed conversion ratio value (Samuel Sitorus, 2019). Besides, fish preference (level of preference) affects the digestion process of feed so that it is closely related to the feed conversion ratio. Feed preference in P2 treatment is classified as good as evidenced by the high level of food consumption P2 191.95 g. The feed conversion ratio is also closely related to the efficient use of nutrients (protein, fat, minerals, and vitamins) broken down to be converted into energy and growth biosynthesis. The addition of FMCWF 30%/kg of feed is the correct percentage because the value of feed efficiency and feed conversion ratio is relatively good compared to other treatments. Besides, the consumption of feed is high because catfish like the feed given.

Water Quality

Water quality parameters were analyzed descriptively using water quality criteria according to Kordi K. and M. Ghufran H. (2013) and SNI 7471.2: 2009. The temperature obtained during the study ranged from 27-310C, in the optimal range to support growth according to Kordi K. and M. Ghufran H. (2013), and is under SNI 7471.2: 2009. The temperature in this study is ideal because if it is too hot, it will affect the DO value. The increase in temperature is directly proportional to the rise in the fish metabolic rate so that fish respiration increases and dissolved oxygen levels decrease drastically. It results in fish experiencing tolerant or intolerant reactions (illness to death) due to permanent gill damage (Wangni et al., 2019). In this study, the ideal temperature is because the research location is shaded by buildings so that sun exposure does not hit the water directly. Sunlight hits the water at 12.00-16.00 WIB, so it doesn't cause the water temperature to change drastically. Besides, there is a protector in the form of waring used to reduce sun exposure.

In pH parameters, the pH range obtained during the study was 5.13-6.94. The pH range obtained is quite good and still acceptable for catfish and is at the limit value according to Kordi K. and M. Ghufran H. (2013) and is under SNI 7471.2: 2009. The pH of the water affects the rate of growth and development of the fish's body. Low pH results in a decrease in DO levels. Oxygen levels are dissolved so that fish respiration activity increases and appetite decreases. As a result, fish growth will be stunted, and the fish are susceptible to bacterial infection to die. And vice versa if there is an alkaline atmosphere (Wangni et al., 2019).

In the dissolved oxygen (DO) parameter, the DO obtained ranged from 4.1 to 5 mg/l. Overall DO in each treatment is optimal to support growth according to Kordi K. and M. Ghufran H. (2013) and is under SNI 7471.2: 2009. Fish need oxygen to produce energy from the feed they consume for activities, reproduction, growth, and many more. Therefore, oxygen availability in the environment determines the circle of fish activity, feed conversion ratio, and oxygen-dependent growth rate (Kordi K. & M. Ghufran H., 2013). The DO obtained is good enough but not yet in the optimal DO range. The DO is not optimal because, in this study, an aerator was not used to help provide oxygen in the water.

4. Conclusions

This study shows that the provision of fermented mustard greens and cabbage waste flour as a mixture of feed ingredients to replace soybean flour has a very significant effect ($p < 0.05$) based on the Analysis of Variance (ANOVA) test on the growth of catfish on parameters of absolute weight growth and feed conversion ratio. Treatment P2 (30% FMCWF) produced catfish's best growth based on the parameters of absolute weight growth of 8.11 g, absolute length growth of 1.41 cm, relative growth of 225.2%, and feed conversion ratio of 1.58.

The treatment in this study can be used as a solution for catfish cultivators in overcoming the problem of high feed procurement costs by making alternative feeds to produce maximum catfish growth and almost the same as manufactured feed.

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