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THE ROLE OF SYNBIOTICS IN INCREASING GROWTH AND FEED EFFICIENCY IN CATFISH (*Clarias* sp.)

Peran Sinbiotik dalam Meningkatkan Pertumbuhan dan Efisiensi Pakan pada Ikan Lele (*Clarias* sp.)

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ABSTRACT

Synbiotics are a type of feed additive that has the potential to increase growth rate and feed utilization efficiency by improving the performance of the digestive system in fish. This study aims to analyze the effect of adding synbiotics consisting of Lactobacillus plantarum bacteria and sweet potato flour (Ipomoea batatas) in the ration on the number of lactic acid bacteria (LAB) in the intestine, growth, and feed conversion efficiency in catfish (Clarias sp.). The study was conducted using a Completely Randomized Design (CRD) method with four treatments and three replications. Treatments include: P0 (without the addition of synbiotics), and treatments P1, P2, and P3 which are a combination of L. plantarum with a concentration of 10^8 CFU/mL at a dose of 0.1 mL/g of feed and sweet potato flour at 1%, 2%, and 3%, respectively. A total of 120 catfish with an average length of 8.45±1.67 cm were kept for 30 days in a 30 L aquarium at a density of 10 fish per unit. The results showed that the administration of synbiotics did not have a statistically significant effect on the number of LAB in the digestive tract (P>0.05), although there was an increasing trend compared to the control. However, the addition of synbiotics significantly affected growth performance and feed utilization efficiency (P<0.05). Treatment P3 showed the best results, with an absolute weight of 15.68 g, a specific growth rate of 0.52% per day, and a feed efficiency of 81.18%. Based on these findings, it can be concluded that the use of synbiotics in the form of L. plantarum at a concentration of 10^8 CFU/mL with a dose of 0.1 mL/g of feed combined with sweet potato flour up to 3% is effective in improving growth performance and feed efficiency in catfish.

Keywords: Catfish, Feed Efficiency, Lactic Acid Bacteria, Lactobacillus plantarum, Synbiotic

ABSTRAK

Sinbiotik merupakan salah satu jenis imbuhan pakan yang berpotensi meningkatkan laju pertumbuhan dan efisiensi pemanfaatan pakan melalui perbaikan kinerja sistem pencernaan pada ikan. Penelitian ini bertujuan untuk menganalisis efek penambahan sinbiotik yang terdiri dari bakteri *Lactobacillus plantarum* dan tepung ubi jalar (*Ipomoea batatas*) dalam pakan terhadap jumlah bakteri asam laktat (BAL) di usus, pertumbuhan, serta efisiensi pakan pada ikan lele (*Clarias* sp.). Penelitian dilaksanakan menggunakan metode Rancangan Acak Lengkap (RAL) dengan empat perlakuan dan tiga ulangan. Perlakuan meliputi: P0 (tanpa penambahan sinbiotik), serta perlakuan P1, P2, dan P3 yang merupakan kombinasi *L. plantarum* dengan konsentrasi 10^8 CFU/mL pada dosis 0,1 mL/g pakan dan tepung ubi jalar masing-masing sebesar 1%, 2%, dan 3%. Sebanyak 120 ekor ikan lele dengan panjang rata-rata 8,45±1,67 cm dipelihara selama 30 hari di dalam akuarium berukuran 30 L dengan kepadatan 10 ekor per unit. Hasil penelitian menunjukkan bahwa pemberian sinbiotik tidak memberikan pengaruh yang signifikan secara statistik terhadap jumlah BAL di saluran pencernaan (P>0,05), meskipun terdapat tren peningkatan dibandingkan kontrol. Namun demikian, penambahan sinbiotik berpengaruh nyata terhadap performa pertumbuhan dan efisiensi pemanfaatan pakan (P<0,05). Perlakuan P3 menunjukkan hasil terbaik, dengan bobot mutlak sebesar 15,68 g, laju pertumbuhan spesifik 0,52% per hari, dan efisiensi pakan sebesar 81,18%. Berdasarkan temuan ini, dapat disimpulkan bahwa penggunaan sinbiotik berupa *L. plantarum* pada konsentrasi 10^8 CFU/mL dengan dosis 0,1 mL/g pakan yang dikombinasikan dengan tepung ubi jalar hingga level 3% efektif dalam meningkatkan kinerja pertumbuhan dan efisiensi pakan pada ikan lele.

Kata Kunci: Bakteri Asam Laktat, Efisiensi Pakan, Ikan Lele, *Lactobacillus plantarum*, Sinbiotik

INTRODUCTION

Catfish (*Clarias* sp.) is a freshwater aquaculture commodity with high economic value and good adaptability, making it widely cultivated in Indonesia. The development of catfish farming toward semi-intensive systems with high stocking densities often leads to problems such as deteriorating water quality, which can increase disease incidence and reduce growth rates. Meanwhile, the demand for commercial feed is increasing, so efforts by farmers to process local ingredients as substitutes for commercial feed have not significantly increased production.

As a more sustainable alternative, feed supplementation such as synbiotics plays a role in improving growth performance, health status, and feed efficiency in fish by modulating the microbiota community of their digestive tract (Okey et al., 2018). Synbiotics are a combination of probiotics, which are beneficial live microorganisms, and prebiotics, which are substrates selectively metabolized by these microorganisms, synergistically providing a positive impact on host health (Yilmaz et al., 2022). Probiotics, including lactic acid bacteria such as *Lactobacillus plantarum*, can improve the balance of the host's intestinal microflora, leading to better nutrient absorption, faster growth, and greater disease resistance (Anggraeni et al., 2020). Prebiotics, such as non-digestible oligosaccharides, serve as a food source for beneficial bacteria in the gut.

Sweet potatoes are a source of prebiotics that have been studied for their benefits in fish (Inayati & Putra, 2015; Baleta et al., 2022). Sweet potatoes are a rich source of carbohydrates and contain provitamin A, vitamin B, vitamin C, minerals, and small amounts of fat and protein. Furthermore, sweet potatoes also contain oligosaccharides, which act as prebiotics for probiotic microorganisms. These oligosaccharides can stimulate the growth and activity of beneficial microbes, particularly the Bifidobacterium group, in the digestive tract, thus contributing to improved host health (Silalahi, 2006). Sweet potato extract also contains fructo-oligosaccharides (FOS) and raffinose, and has been shown to enhance immune responses and improve gut microbiota composition by enriching *Bifidobacterium* sp. and *Lactobacillus* sp. populations (Suri, 2017). According to research by Putra & Romdhonah (2019), LAB from the Bacillus species as probiotics and sweet potato as a prebiotic in catfish showed several positive effects related to digestive performance and growth. Information related to the use of synbiotics *L. plantarum* and sweet potato flour is still very limited in catfish so this research is necessary. The combination of *L. plantarum* and sweet potato flour is expected to work synergistically to improve digestive health and catfish performance. This study aims to analyze the effect of adding different doses of sweet potato flour as a prebiotic component combined with *L. plantarum* at a concentration of 10^8 CFU/mL with a dose of 0.1 mL/g of feed on the population of lactic acid bacteria in the catfish intestine, production performance in the form of growth and feed efficiency.

METHODS

Time and Place

This research was conducted from October to December 2023, covering preparation of tools and materials, fish maintenance, and data processing. The research was conducted in the Fish Nutrition Laboratory, Faculty of Fisheries and Marine Sciences, and the Biology Laboratory, Center for Environmental and Natural Resource Studies, Mulawarman University, Samarinda, East Kalimantan.

Tools and Materials

The equipment used included 12 aquariums (30 L each), an aerator, a digital scale, a dehydrator, a blender, and standard laboratory equipment for bacterial culture and water quality analysis (pH meter, DO meter, spectrophotometer). The materials used included catfish fingerlings (8.45±1.67 cm), commercial feed, yellow sweet potatoes, a pure culture of *Lactobacillus plantarum* bacteria (10^8 CFU/mL), De Man Rogosa Sharpe Agar (MRSA) and De Man Rogosa Sharpe Broth (MRSB) media, egg white, distilled water, and reagents for water quality testing.

Research Procedures

1. Preparation of Test Animals and Rearing Containers

The catfish fry were acclimatized for approximately 10 days in a 1-meter-diameter plastic container half-filled with water. Commercial feed with a protein content of approximately 35% was fed twice daily until satiated (ad libitum), once in the morning and evening. The water used was sourced from the local water company (PDAM), which had undergone a five-day sedimentation process and was aerated beforehand. The aquarium used as the rearing container was thoroughly washed, dried, and then filled with 30 liters of water. After aeration, the aquarium was ready for use in rearing the test fish.

2. Preparation of *L. plantarum* Bacteria

Lactobacillus plantarum isolates were obtained from the Biology Laboratory, Center for Environmental and Natural Resource Studies, Mulawarman University. The bacterial culture was inoculated onto MRSB media and incubated for 24 hours at 36°C. After incubation, the bacterial cells were separated by centrifugation for 15 minutes at 3000 rpm. The resulting sediment was then washed and resuspended in PBS solution. A 0.1 mL bacterial suspension contained approximately 10^8 CFU/mL, according to standard colony count methods (Gupta et al., 2014).

3. Sweet Potato Flour Preparation

The yellow sweet potatoes (*Ipomoea batatas*) used were obtained from traders in Samarinda City. The sweet potatoes were cleaned, peeled, and sliced into thin slices approximately 0.1 cm thick. The slices were dried in an oven at 40–50°C for approximately 4 hours. The dried sweet potatoes were ground using a flouring machine and sieved to produce a fine flour.

4. Experimental Design

This research was conducted as an experimental study using a Completely Randomized Design (CRD) consisting of four treatments and three replications for 30 days. The treatments tested, based on the research by Putra & Romdhonah (2019), were as follows:

P0: Control feed (commercial pellets).
P1: *L. plantarum* 10^8 CFU/mL + feed with 1% sweet potato flour.
P2: *L. plantarum* 10^8 CFU/mL + feed with 2% sweet potato flour.
P3: *L. plantarum* 10^8 CFU/mL + feed with 3% sweet potato flour.

5. Preparation of Test Feed

Commercial feed was ground and mixed with sweet potato flour according to the treatment dosage and approximately 30% water. Then, it was molded into pellets and dried at 40-50°C for 3 hours. 100 g of test feed was prepared for each replication. A 10 mL *L. plantarum* culture was added to 2% egg white. The *L. plantarum* and egg white mixture was then homogenized using a vortex mixer. The mixture was then sprayed with 0.1 mL/g of feed, stirred thoroughly, and stored in a refrigerator to maintain bacterial viability before use.

6. Maintenance of the Test Fish

The previously acclimatized catfish fry were measured for their initial length and weight, then placed in aquariums at a stocking density of 10 per aquarium. The fish were then raised for 30 days, fed twice daily at satiation (until full) according to the test diet.

7. Water Quality Maintenance

Water quality was maintained by siphoning waste from the aquarium daily, monitoring the aeration volume, and replacing the water with fresh water according to the amount removed during siphoning.

Data Collection

In this study, the following parameters were collected:

1. Total Lactic Acid Bacteria (LAB) in the intestine, analyzed using the Total Plate Count (TPC) method on MRS Agar media and calculated using the following formula based on SNI (2897: 2008):

$$\text{Number of bacteria} = \text{Number of colonies} \times \frac{1}{\text{Dilution factor}}$$

2. Absolute Weight Growth, calculated using the formula by Gabriel et al. (2019):

$$W = Wt - Wo$$

Where:
W = Absolute weight growth (g)
Wt = Fish weight at the end of the study (g)
Wo = Fish weight at the beginning of the study (g)

3. Specific Growth Rate (SGR, %/day), calculated using the formula by Gabriel et al. (2019):

$$SGR = \frac{\ln Wt - \ln Wo}{t} \times 100\%$$

Where:
SGR = Specific growth rate (%/day)
Wo = Fish weight at the beginning of the study (g)
Wt = Fish weight at the end of the study (g)
t = Maintenance period (days).

4. Feed Utilization Efficiency (FUE) was calculated using the formula according to Tacon (1987) in Chilmawati et al. (2018).

$$FUE = \frac{(Wt + D) - Wo}{F} \times 100\%$$

Where:
FUE = Feed utilization efficiency (%)
F = Weight of feed given (g)
Wt = Fish weight at the end of the study (g)
D = Weight of dead fish (g)
W_0 = Fish weight at the beginning of the study

5. Water quality parameters observed included temperature, pH, dissolved oxygen, and total ammonia nitrogen. Temperature measurements were taken in the morning and evening, while pH and dissolved oxygen were measured once daily. Total ammonia nitrogen was measured at the beginning and end of the fish rearing period.

Data Analysis

The data analyzed included total LAB, absolute weight growth, specific growth rate, and feed efficiency. Data homogeneity was tested using the Bartlett test, followed by analysis of variance (ANOVA). If a significant effect was found, the test was continued with the Duncan test at the 95% confidence level. Water quality parameter data were analyzed descriptively and presented in tabular form.

RESULTS

The addition of the synbiotic *L. plantarum* and sweet potato flour to catfish feed showed a significant effect ($p<0.05$) on production performance parameters, but no significant effect on total lactic acid bacteria (LAB) in the intestine. Treatment with the addition of 3% sweet potato flour (P3) consistently provided the best results for all growth and feed efficiency metrics.

Lactic Acid Bacteria (LAB) Count

The LAB count in the catfish intestines averaged 2.2×10^3 CFU/mL at the beginning of the study and increased after 30 days, both in the control and synbiotic-treated groups. Based on Figure 1, feeding with the addition of the synbiotic showed a trend toward an increase in the LAB count in the fish intestines compared to the control group. The highest average LAB count was recorded in treatment P1 (3.4×10^4 CFU/mL), followed by P2 at 2.8×10^4 CFU/mL, and P3 at 2.8×10^4 CFU/mL. The control showed the lowest count at 1.3×10^4 CFU/mL.

Analysis of variance showed that the addition of synbiotics had no significant effect on the intestinal LAB count of catfish ($P > 0.05$). Duncan's t test further indicated a significant difference between treatments P0 and P1 ($P < 0.05$), while treatments P2 and P3 showed no significant differences compared to P0 and P1.

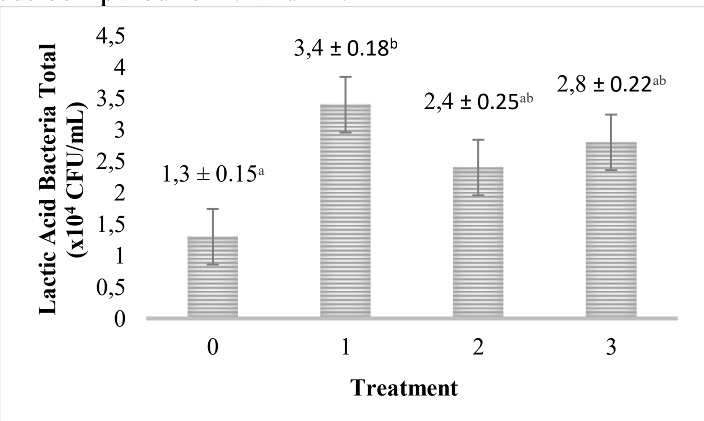

Figure 1. Average Total Lactic Acid Bacteria Count in the Gut of Catfish

Absolute Weight Growth and Specific Growth Rate (SGR)

In this study, production in the form of growth and feed utilization efficiency of catfish are shown in Table 1. The highest absolute weight gain was achieved by treatment P3 at 15.68 g, followed by P2 (14.79 g), P1 (14.19 g), and the lowest by P0 (13.93 g). Similar results were also shown for the specific growth rate (SGR) parameter, where treatment P3 showed the highest value at 0.52%/day, followed by P2, P1, and P0 at 0.49, 0.47, and 0.46%/day, respectively.

Analysis of variance showed that the addition of synbiotics to catfish feed for 30 days of culture significantly affected absolute weight gain and specific growth rate ($P<0.05$). Duncan's further test showed that the absolute weight gain and specific growth rate of catfish in P3 were significantly different from those in P2, P1, and P0.

Feed Utilization Efficiency (FUE)

Table 1 shows a similar pattern as the previous parameter for catfish feed utilization efficiency throughout the study. P0, or the control, showed the lowest feed utilization efficiency at 72.89%, while P3 showed the highest at 81.14%. Analysis of variance results indicated that the addition of synbiotics to the feed significantly affected the level of fish feed utilization efficiency ($P < 0.05$). Duncan's further test showed that the feed utilization efficiency in the P3 treatment was significantly different compared to P0 and P1, but not significantly different compared to P2.

Table 1. Average Weight Growth and Specific Growth Rate of Catfish

Parameter	Treatment			
	P0	P1	P2	P3
Initial weight (g)	13.27^{b}	13.41^{b}	13.08^{b}	11.34^{a}
Final weight (g)	27.20^{a}	27.60^{ab}	27.88^{b}	27.03^{a}
Absolute weight growth (g)	13.93^{a}	14.19^{a}	14.80^{b}	15.69^{c}
Total feed consumption (g)	19.12^{a}	19.00^{a}	19.02^{a}	19.32^{a}
Specific growth rate (%/hari)	0.46^{a}	0.47^{a}	0.49^{b}	0.52^{c}
Feed utilization efficiency (%)	72.89^{a}	74.71^{ab}	77.84^{bc}	81.19^{c}

Note: Mean values followed by the same letter in the same row indicate no significant difference ($P>0.05$).

Water Quality Parameters

During 30 days of cultivation, water quality parameters in all treatments were within the optimal range for catfish growth (Table 2). The average temperature was 27.33–27.67°C, pH 6.42–6.61, dissolved oxygen 4.90–5.28 mg/L, and ammonia levels 0.88–1.02 mg/L, all within safe limits.

Table 2. Average Water Quality Results During the Study

Treatment	Water Quality			
	Temperature (˚C)	pH	DO (mg/L)	Ammonia (mg/L)
P0	27.60	6.56	5.18	0.91
P1	27.33	6.42	5.28	0.95
P2	27.33	6.54	5.03	0.88
P3	27.67	6.61	4.90	1.02

DISCUSSION

The results of this study indicate that the addition of synbiotics significantly improved growth performance and feed utilization efficiency, with treatment P3 (3% sweet potato flour) providing the most optimal results. Although statistically the addition of synbiotics had no significant effect on the total number of lactic acid bacteria (LAB), there was a tendency for an increase in the LAB population in the treatment group compared to the control. This indicates that sweet potato flour as a prebiotic is able to provide the substrate needed by gut microbes to reproduce. As mentioned by Rachman (1989) in Setyawan et al. (2014), LAB density will increase if the microbes receive sufficient nutrition. In this study, a dose of 1% sweet potato flour was able to increase the number of LAB in the fish intestine higher than other treatments. This is suspected to be due to competition for sweet potato utilization by microbes in the fish intestine that are not included in the lactic acid bacteria such as Bifidobacterium, Akkermansia, Bacteroidetes. This is in line with the research of Liu et al. (2020), although this study was conducted in human (in vitro) and mouse (in vivo) models, these findings suggest that sweet potato fiber has the potential to modulate the microbiota broadly, not just lactic acid bacteria.

The increase in absolute weight, specific growth rate, and feed efficiency in the P3 treatment was likely due to the synergistic effect between the probiotic *L. plantarum* and the prebiotic sweet potato flour. *L. plantarum* bacteria are known to produce the enzyme phytase, which functions to break down phytic acid, a type of anti-nutrient contained in fish feed (Amin et al., 2018). Phytase-producing bacteria can improve feed digestibility, ultimately supporting optimal fish growth (Anggraeni et al., 2020). Furthermore, sweet potato flour contains oligosaccharides, a type of carbohydrate that cannot be hydrolyzed in the fish digestive tract but is very beneficial for supporting the growth of probiotic bacteria (Utami et al., 2010; Haydersah et al., 2012).

Interestingly, although the LAB population was higher in the P1 treatment, growth in the P3 treatment was greater. This indicates that it is not only the quantity (number) of lactic acid bacteria in the intestine that determines growth and feed efficiency, but also the balance of microflora and physical factors of the feed play an important role. The 3% sweet potato flour dose in P3 not only serves as a nutritional source for LAB but also likely improves the texture of the feed, making it softer and more easily broken down. This is very appropriate for the feeding characteristics of catfish (*Clarias* sp.), which are known as voracious feeders and actively suck up food from the bottom of the water (Effendi, 1997; Zakaria et al., 2020). However, LAB efficacy is highly dependent on the fish species, dosage, administration method, and aquaculture conditions, so it does not always work optimally for carnivorous fish (Ringo et al., 2020), and catfish are omnivorous fish with carnivorous tendencies. This more easily consumed and digested feed contributes significantly to increased digestive efficiency and growth of catfish. This increase in feed efficiency is in line with improved digestive processes, where the oligosaccharide content of sweet potatoes reaching the intestines acts as a substrate for microflora (Silalahi et al., 2021), thus supporting better nutrient absorption.

All observed differences in growth performance are confirmed to be due to the feed treatment, as water quality parameters throughout the study were within the range that supports catfish growth. Water temperatures, ranging from 27.33°C to 27.67°C, fall within the ideal range of 25°C-30°C mentioned by Mujalifah (2018), where appropriate temperatures can increase the fish's metabolic rate and nutrient absorption. Similarly, the water pH (6.42-6.61) is still within safe limits according to Sartika et al. (2022). Although the dissolved oxygen (DO) content showed the lowest value at P3 (4.90 mg/L), this figure is still above the critical threshold and within the catfish's tolerance limits. Ammonia levels also vary between 0.88 mg/L to 1.02 mg/L, which is still far below the safe limit of 5.70 mg/L according to Hastuti and Subandiyono (2015), so it is not a growth inhibiting factor.

CONCLUSION

Supplementing catfish feed with a synbiotic combination of *Lactobacillus plantarum* bacteria and sweet potato flour significantly increased absolute weight gain, specific growth rate, and feed utilization efficiency. A 3% concentration of sweet potato flour provided the most optimal production performance. Therefore, its application can be recommended for intensive catfish farming to improve growth and feed utilization efficiency.

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