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Enrichment of Fermented Lemna in Commercial Feed and Its Effect in Improving the Performance of Common Carp (*Cyprinus carpio*) Infected by *Aeromonas hydrophila* Bacteria

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Abstract

Common carp (*Cyprinus carpio*) is one of the main fishery commodities of aquaculture production in Indonesia, especially West Java. The processing of Lemna through the fermentation process is one of the efforts to improve the quality of alternative feed ingredients that function as prebiotics. The growth of common carp infected with the disease tends to be disturbed, so that the growth rate is inhibited. This study aims to determine the effect of the level of addition of *Lemna minor* flour from the enrichment of BIO-MS probiotics in feed on the growth of common carp infected with *Aeromonas hydrophila* bacteria. The method used in this study was a Complete Randomized Design (CRD) experiment with 5 treatments and 4 replicates. The calculation of the measurement of tested fish samples was carried out 4 times over 30 days. The data was analyzed using the analysis of variance (ANOVA). This study concludes that the addition of Lemna flour enriched with fermented BIOMS probiotics in feed provides an increase in SGR (Specific Growth Rate) value, a decrease in FCR (Feed Conversion Rate) value, and an increase in EP (Feed Efficiency) value of fish that is better than fish fed commercial feed (control +) and lemna without enrichment (control -). Feeding with the addition of fermented Lemna flour can increase the growth of common carp, such as SGR (0.34 ± 0.0599) and EP (68%), as well as reduce the FCR value (1.51 ± 0.3161).

INTRODUCTION

Most people consider the common carp as one of the main sources of meat protein besides poultry meat and other farmed animals. Affordable prices, reasonable taste, and easy cultivation are the reasons why common carp cultivation is widely practiced. Common carp is widely cultivated in ponds, reservoirs, rice fields, and cages in open waters (Winarti *et al*., 2017). Common carp inhabiting its natural habitat tends to have differences in taste and texture of meat that are preferred to common carp that lives by farming. The natural habitat of common carp is the lake ecosystem, and in areas with an altitude of 150-600 meters above sea level. Common

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carp eat all kinds of food, so this fish belongs to the type of omnivorous fish, which is a fish that preys on all kinds of food (Anggriani *et al.*, 2012). Based on the location of its mouth, the common carp is a type of fish that has a habit of eating food at the bottom of the water. Therefore, common carp often stir the bottom of the pond in search of organic bodies (Susanto, 2014). Natural feed from aquatic plants in omnivore fish raised in flooded ponds tends to be more palatable, even though it has a fairly high crude fiber, due to the natural fermentation process. Therefore, to be easier to digest by cultivated common carp, it is necessary to enrich commercial feed with fermented Lemna.

Fish in the stage of seed requires a longer digestion time in digesting artificial feed than natural feed (DKP Jateng, 2020). On the other hand, to produce carp with flesh quality that is in accordance with the requirement of the community, it is necessary to have a feed that can improve the flesh quality in fish and also maintain fish immunity from disease-causing pathogens. Common carp is one of the fish species that is quite susceptible to disease. One of the diseases caused by pathogenic microorganisms is Motile Aeromonas Septicemia or commonly called MAS. MAS disease is a bacterial disease caused by *Aeromonas hydrophila*. The growth of common carp infected with the disease tends to be disturbed, so that the growth rate is inhibited or becomes slow.

Lemna (duckweed) or commonly known as catfish's eye, is a type of aquatic plant that is abundantly available because it is known as a weed that is difficult to control in waters. Lemna can be used as one of the raw materials that can be added to feed as an enrichment application in feed because it contains quite high nutrients, one of which is protein. The protein content of fresh Lemna is 23.47%, and the protein content reaches 10-43% of its dry weight (Asriyanti *et al.*, 2018). The results of the research by Iskandar *et al.* (2021) showed that the nutritional content in Lemna included protein as much as 23.47%, nitrogen free extract (NFE) material as much as 19.02%, and fat as much as 3.99%, crude fiber 29.92% and ash 23.6% in wet weight. However, the high crude fiber content in Lemna, if consumed directly by fish, will be more difficult for the fish's body to digest (Asriyanti *et al.*, 2018). An effort that can be used to reduce the content of crude fiber is through the fermentation process.

Fermentation is an enrichment technology using microorganisms to decompose complex compounds and form simple compounds that are more abundant than unfermented materials (Warasto *et al.*, 2013). Fermentation lowers crude fiber by remodeling long polymer chains from proteins to amino acids, fats to essential fatty acids, and carbohydrates to simple sugar acids, so that the feed is easily absorbed and digested by the fish's body (Nardi *et al.*, 2013). Lemna that is fermented in the form of flour will be easier for fish to digest and is also easy to mix in feed. The addition of fermented Lemna flour to fish feed can enrich the nutritional content of fish feed, so that it will have a good impact on fish.

METHODOLOGY

Ethical Approval

The research was monitored by the head of the aquaculture laboratory and approved ethically by the Faculty of Fisheries and Marine Science.

Place and Time

This research was carried out with an experimental method in February-April 2024 at the Aquaculture Laboratory, Faculty of Fisheries and Marine Sciences, Padjadjaran University, for maintenance and the Laboratory of Ruminant Livestock Nutrition and Animal Food Chemistry, Faculty of Animal Husbandry, Padjadjaran University, to conduct a proximate test.

Research Materials

The materials used in this study were 200 tested fish of a carp species (*Cyprinus carpio*) with a length of 8-11 cm, HiProVite 781-1 commercial feed, quail manure fertilizer, *Lemna minor*, BIO-MS probiotics,

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and molasses. Meanwhile, the tools used during the study were grinders, feed printing tools, 120 mesh sieves, ovens, measuring cups, pipettes, scales, zip locks, plastic bases, aquariums, and fiber tubs.

Research Design

The research design used was a Complete Random Design (RAL) on 5 treatments. Each treatment was repeated 4 times, so that the number of rearing aquariums was 20. Each aquarium contained 10 common carp that were infected with *Aeromonas hydrophila* bacteria. The following were the percentages of the treatment given:

Treatment A (Control +): Commercial feed; Treatment B (Control -): Commercial feed with non fermented Lemna flour (NFLF) added as much as 15%); Treatment C: Commercial feed with the addition of 15% fermented Lemna flour (FLF); Treatment D: Commercial feed with the addition of 20% fermented Lemna flour; and Treatment E: Commercial feed with the addition of 25% fermented Lemna flour.

Work Procedure

Lemna Flour Enrichment

Lemna was cultivated in 2-pond media measuring 200 cm × 100 cm × 50 cm. Lemna cultivation was carried out by using quail manure fertilizer as much as 30 kg for two ponds at a water level of ±15 cm. Lemna was harvested and dried within 5-7 days. Then, it was followed by the flocculation and fermentation process by mixing BIOM-S probiotics and molasses with a ratio between BIO-M-S probiotics and molasses, respectively, of 1 (ml): 1 (ml) in 100 ml of water. Let it sit for ± 3 hours, then the solution and the Lemna that has been milled were mixed in the ratio between the solution and Lemna, respectively of 3 (ml): 10 (g). Then store the Lemna flour that was being fermented for 3 days at a temperature of 28-30°C.

Test Feed

The production of tested feed began with the re-frying of HiProVite 781-1 commercial feed. The feed used was in the form of HiProvite 781-1 commercial feed, using a grinder and continued with sifting using a 120 mesh sieve. Furthermore, the fermented Lemna was mixed with commercial feed that has become flour, with the percentage of fermented Lemna flour according to the treatment to be tested. After mixing, the feed was shaped using a feed shaping tool with a screen size of 1.5 mm. Then the feed was kept in the oven at 65°C for 3 hours. The fish were fed 2 times a day at 08.00 WIB and 16.00 WIB. The amount of feed given was calculated from 5% of the total weight of fish biomass. The tested fish were reared for 30 days.

Data Collection Techniques

Specific Growth Rate (SGR)

Specific growth rate calculations refer to Mulqan *et al*. (2017), that is:

$$SGR = \frac{[\ln(Wt) - \ln(W0)]}{T} \times 100\%$$

Information:

SGR = Specific growth rate (% per day)
W0 = Average weight of seeds at the beginning of the study (g)
Wt = Average weight of seeds at the end of the day (g)
T = Maintenance duration (days)

Feed Conversion Ratio (FCR)

According to Effendi (1997), Feed Conversion Ratio (FCR) can be calculated using the following formula:

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

Information:

FCR = Feed conversion rate
Wo = Weight of the test animal at the beginning of the study (g)
Wt = Weight of the test animal at the end of the study (g)
D = Weight of dead fish (g)
F = Weight of feed given (g)

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Feed Efficiency (FE)

The calculation is based on the formula according to Zonneveld *et al.* (1991):

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

Information:

FE = Feed efficiency
Wo = Weight of the test animal at the beginning of the study (g)
Wt = Weight of the test animal at the end of the study (g)
D = Weight of dead fish (g)
F = Weight of feed given (g)

Data Analysis

Data analysis used ANOVA and a post-hoc test to determine the effect of feed for fish growth.

RESULTS AND DISCUSSIONS

Nutritional Value of Fermented Lemna

Increasing nutrients in feed can be done through the fermentation process because the protein content contained in feed ingredients will be broken down into simpler compounds or amino acids, so that the feed will be easier for fish to digest. In addition, during the fermentation process, there will be a decrease in pH so that the shelf life of feed will increase and the growth of putrefactive bacteria will be inhibited (Utami, 2023).

Table 1. The Results of Complete Proximate Analysis Test at the Laboratory of Ruminant Livestock Nutrition and Animal Feed Chemistry, Faculty of Animal Husbandry, Padjadjaran University 2024.

Sample	Water %	Ash %	Protein %	Fiber %	Fat %	NFE%	Kcal Energy/kg
Feed B	8.75	20.12	31.18	4.09	5.5	39.11	4021
Feed C	6.81	10.44	32.28	4.60	6.06	46.63	4113
Feed D	6.43	10.86	32.48	4.38	6.44	45.84	4168
Feed E	5.50	12.15	32.76	4.16	5.24	45.69	4070

Note: B= 15% NFLF Addition, C= 15% FLF Addition, D= 20% FLF Addition, E= 25% Addition, NFLF= Non-Fermented Lemna Flour, FLF= Fermented Lemna Flour.

Table 2. Nutrient Content of Lemna Flour and Lemna Flour Pellet Mix from Enrichment Through the Fermentation Process.

Parameter	Material			Changes in Nutritional Value
	Lemna Flour*	Fermented Lemna Flour Pellet Mix 25%**	SNI 01-4266-2006***	
Water (%)	11.20	5.50	Max. 12	-5.70
Ash (%)	13.15	12.15	Max. 13	-1
Protein (%)	25.24	32.76	Min. 30	+7.52
Fiber (%)	11.93	4.16	Max. 6	-7.77
Fat (%)	1.31	5.24	Min. 5	+3.93
Nitrogen Free Extract (%)	48.37	46.69	-	-1.68
Gross Energy (Kcal/kg)	3631	4070	-	+439

Note: *Utami (2023), **Results of Proximate Analysis of Treatment E at the Laboratory of Ruminant Livestock Nutrition and Animal Food Chemistry, Faculty of Animal Husbandry, Padjadjaran University 2024, ***Quality Requirements for Stadia Common carp Feed Seeds in Intensive Cultivation (SNI 01-4266-2006).

Based on the results of laboratory tests of *Lemna minor* flour fermented using BIOM-S and molasses with microorganism content in the form of *Lactobacillus* sp., *Saccharomyces* sp., and *Bacillus* sp. incubated for 3 days, it was known that the fermentation process carried out caused the changes in the nutritional content of Lemna in the form of increased levels of protein, fat, and energy, as well as a decrease in

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water content, ash, crude fiber, and carbohydrates (Table 1). The highest protein value was found in treatment E with a difference in protein increase of +7.52% when compared to unfermented Lemna flour. In addition, the nutrient content in the E treatment feed was by SNI 01-4266-2006, which is in accordance with the feed quality requirements for common carp in the seed stadia (Table 2).

According to Wang *et al*. (2008), the increase in protein after fermentation was caused by the presence of *Bacillus* sp. which is classified as a saccharolytic bacterium, which is a bacterium that was able to decompose disaccharides or polysaccharides into simpler molecular groups. Next, *Bacillus* sp. will break down proteins into amino acids. These amino acids are then used by bacteria to multiply themselves, so that they can increase feed protein and reduce crude fiber, so that they can increase protein and carbohydrates in feed (Anggriani *et al*., 2012). The change in nutrient content was suspected to be due to an overhaul of the substrate during fermentation, where the organic matter in Lemna was decomposed by microorganisms found in probiotics.

According to Sandra *et al*. (2020), the microorganism of *Lactobacillus* sp. contained in the bio-biotic BIO-M-S could produce cellulase enzymes that could break down coarse fibers. The activity of *Lactobacillus* sp. bacteria is producing lactic acid from sugars and carbohydrates produced by photosynthetic bacteria and yeast. *Lactobacillus* sp. bacteria have a role in balancing microbes contained in the digestive tract so that it will increase fish digestibility by converting carbohydrates into lactic acid which can lower pH, thereby stimulating the production of endogenous enzymes to increase nutrient absorption, feed consumption, growth and inhibit pathogenic organisms (Armin *et al*., 2024).

Saccharomyces sp. used in feed could also act as an immunostimulant and prevent disease attacks caused by bacteria, viruses, and other disease-causing pathogens because it contains essential ingredients such as β1,3 glucans (Apriyan *et al*., 2021). Chemical compositions can be used to improve livestock health, such as probiotics and immunostimulants contained in *Saccharomyces* sp., consisting of 50-52% crude protein, 30-37% carbohydrates, and 7-8% minerals, as well as vitamins, especially B vitamins (Ahmadi *et al*., 2012). *Saccharomyces* sp. can increase the activity of peptidase, protease, and amylase enzymes in the digestive tract of fish, it will make it easier for feed to be absorbed in fish digestion and increasing fish growth (Razak *et al*., 2017). Feed containing *Saccharomyces* sp. will affect the use of feed that becomes more efficient due to increased protein digestibility (Rachmawati *et al*., 2020).

Specific Growth Rate (SGR)

The SGR value or specific growth rate in fish has a strong relationship with the growth of the absolute weight of the fish, so that the increase in the SGR value indicates that the increase in fish weight in a unit time occurs optimally. In the calculation of SGR, the most appropriate stage is at the seed stage. This was because when the fish were at the seed stage, the curve would be exponential, whereas in the adult stage, the curve would be linear (Lugert *et al*., 2016).

Table 3. Specific Growth Rate (SGR).

Treatment	SGR
A (Control +)	0.18 ± 0.0260[a]
B (Control - : 15% NFLF Addition)	0.17 ± 0.0236[a]
C (15% TLF Addition)	0.28 ± 0.0087[b]
D (20% TLF Addition)	0.31 ± 0.0090[c]
E (25% TLF Addition)	0.34 ± 0.0599[d]

Note: NFLF= Non-Fermented Lemna Flour, FLF= Fermented Lemna Flour, Values followed by

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different lowercase letters indicate a significant difference at the 95% confidence level (F count > F table).

Table 2 shows that treatment B was the treatment with the lowest SGR of 0.17 ± 0.0236 per day, while treatment E was the treatment with the highest value of 0.34 ± 0.0599 per day. Based on ANOVA statistical analysis with a confidence level of 95%, it is known that F counts > F table, meaning that the treatment with the addition of fermented Lemna flour has a significantly different effect on the SGR value of common carp. The results of the Duncan test showed that there was a real difference between the treatments. Treatment E, which used the addition of 25% fermented Lemna flour, produced the highest SGR value, while treatment B, which was a negative control, produced the lowest SGR value.

The SGR value in this study was quite low compared to the SGR value that it should be. Research by Nurkartika (2023) showed the SGR value of common carp given 15% fermented Lemna flour as feed, resulting in an SGR value of 2.13 ± 0.0048. Meanwhile, the administration of 15% non-fermented Lemna flour resulted in an SGR value of 1.69 ± 0.0057 per day. Meanwhile, this study produced an SGR value that ranged from 0.17-0.34, which was still very far compared to the previous study. Low SGR values in fish can occur due to other factors that cause weight gain in fish to be inhibited.

Factors that could affect the SGR value could be in the form of internal and external factors of fish, including fish strains, pathogens, stress, and feed quality. Feed in treatment E, namely the addition of fermented Lemna flour by 25%, produced better nutritional content results than other treatments based on the results of proximate tests. The low SGR value was due to the presence of virulent *A. hydrophila* bacterial infection, so it could cause stress in fish, which would ultimately affect the nutrient absorption response in fish. Fish that were stressed tended to experience a decrease in appetite, where the needs of the fish were not met, so that, cellularly, the fish became less able to repair damaged cells properly.

The content of flavonoids which were antioxidant substances that function as an antidote to free radicals so that it was good for increasing immunity in fish, but it was also an anti-nutrient substance contained in Lemna which caused the absorption of nutrients related to fish growth to be inhibited since the absorption of nutrients would focus on repairing damaged cells caused by the presence of *A. hydrophila* bacterial infection. Flavonoids act as immunomodulators, antioxidants, and also anti-inflammatories, so that they are able to stimulate the body to produce leukocytes that function as nonspecific immunity. In addition, Lemna also contains saponins, which are anti-nutrient substances that can cause stress, so that they affect the physiological activity of fish (Iskandar *et al*., 2021). Even according to Zhang *et al*. (2023), overall, there was a content of saponins (23.25 mg/g), flavonoids (0.83 mg/g), and alkaloids (6.40 mg/g) in dry weight.

Feed Conversion Ratio (FCR)

The Feed Conversion Ratio (FCR) in the aquaculture system is one of the important indicators to determine the effectiveness of feed management. FCR states the ratio of the amount of feed needed to produce 1 kg of cultured fish (Effendi, 2004). The smaller the FCR value, the more effective the feed is in increasing the biomass weight of fish, and vice versa. If the feed conversion ratio value is high, it means that the feed is not well used by the fish (Rad *et al*., 2003).

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Table 4. Feed Conversion Ratio (FCR).

Treatment	FCR
A (Control +)	2.66 ± 0.03923[bc]
B (Control - : 15% NFLF Addition)	2.83 ± 0.2593[c]
C (15% FLF Addition)	1.76 ± 0.0435[a]
D (20% FLF Addition)	1.68 ± 0.0934[a]
E (25% FLF Addition)	1.51 ± 0.3161[a]

Note: NFLF= Non-Fermented Lemna Flour, FLF= Fermented Lemna Flour, Values followed by different lowercase letters indicate a significant difference at the 95% confidence level (F count > F table).

Table 3 shows the improvement in FCR values of common carp fry observed during the study. Treatment B (15% non-fermented Lemna flour) had the highest FCR value of 2.83 ± 0.2593, while treatment E (25% fermented Lemna flour) showed the lowest FCR value of 1.51 ± 0.3161. The lower the FCR value, the better because the feed given is more converted into fish flesh, The results of this study showed that the addition of fermented Lemna flour could reduce the FCR value as evidenced by the drastic decrease from treatment B (non-fermented Lemna flour 15%) to treatment C (fermented Lemna flour 15%). ANOVA statistical analysis with a confidence level of 95% produced an F value calculated > F table, which meant that the treatment could have an influence on lowering the FCR value.

Different FCR values have a relationship with the level of digestibility of fish to the given feed. The FCR value in treatment A (control) was 2.66 ± 0.3923, while treatment B (15% non-fermented Lemna flour) had the highest FCR value, namely, 2.83 ± 0.2593. This showed that feed with the addition of non-fermented Lemna was increasingly difficult to digest or convert into fish biomass weight compared to other treatments. There was only a slight difference in FCR values between C (15% fermented Lemna flour), D (20% fermented Lemna flour), and E (25% fermented Lemna flour) treatments (Table 3). This proved that there was a significant difference due to the administration of fermented Lemna flour, so that the addition of fermented Lemna flour was superior to the control and the addition of non-fermented Lemna flour.

The low FCR value indicates the optimal ability of fish to digest and absorb the feed given during maintenance, so that it is able to optimally convert feed into meat (Mardhiana *et al.*, 2017). Based on this, treatment E with the addition of 25% fermented Lemna flour was the optimal dose because it produced an FCR value of 1.51 ± 0.3161. This showed that feeding using E treatment (Lemna flour fermentation 25%) during the study could be optimally utilized in the flesh. In this condition, it greatly affected the increase in body weight of common carp fry. Barrow (1992) stated that the value of the feed conversion ratio was influenced by feed protein, feed protein that was in accordance with the nutritional needs of fish, resulting in more efficient feeding. This showed that the application of fermented Lemna minor in the feed mixture given could be used well by common carp. A low conversion ratio value could occur since the feed used was good for fish farming production, while the larger the value of the feed conversion ratio, the lower the quality of the feed provided. Djarijah (2005) stated that better feed quality would lead to smaller feed conversion values, and vice versa.

Feed efficiency depends on the species (feeding habits and size or stadia), water quality (oxygen, temperature, pH, and ammonia), type of feed (quantity and quality), and also the health condition of the fish (Effendi, 2004). The use of feed in this study which contained *Lemna minor* fermentation in treatment C (fermented Lemna flour 15%), treatment D (fermented Lemna flour 20%), and treatment E (fermented Lemna flour 25%) which was a

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vegetable material with a lower content of protein, crude fiber and high carbohydrates, this allowed common carp fry to make good use of the feed because it is in accordance with the habits of the fish. This was also supported by antioxidants and other ingredients that function as immunostimulants that causing fish immunity to increase and the nutrient absorption process to be superior compared to treatments A and B. In addition, water quality during the study was always maintained to meet SNI 8296.4-2016 so that it could support the proper use of feed.

Meanwhile, in treatment A (control) and B (15% non-fermented Lemna flour), the utilization of feed did not occur properly. This occurred because after the challenge test, the health condition of the fish was in a poor state, which even caused stress in the fish. Feed in treatment A (control) was not given any additions, so that there was no increase in nutrient content in the fish feed. Treatment B (non-fermented Lemna flour) produced lower feed quality than treatment A (control) due to the addition of non-fermented Lemna flour, which contained high crude fiber. So even though the feed contained antioxidant compounds such as flavonoids, carotenoids, and phenolics, fish had difficulty digesting the feed, which caused these antioxidant compounds to not be used properly by fish. This was what deteriorated the stress level in fish, so that the fish's appetite decreased and the FCR value increased.

Feed Efficiency (FE)

Feed Efficiency or FE is an alternative parameter other than FCR that can be used to determine the level of feed efficiency in increasing aquaculture productivity. The FE parameter explains how much feeding efficiency the fish uses to increase the growth percentage, while the FCR explains how much of the fish biomass is produced from the feeding. The value of good efficiency can reduce the production cost of the feed used and can have a good impact on the environment.

Table 5. Feed Efficiency (FE).

Treatment	%FE
A (Control +)	38% ± 0.0556a
B (Control - : 15% NFLF Addition)	36% ± 0.0329a
C (15% FLF Addition)	57% ± 0.0143b
D (20% FLF Addition)	60% ± 0.0331c
E (25% FLF Addition)	68% ± 0.1270d

Note: NFLF= Non-Fermented Lemna Flour, FLF= Fermented Lemna Flour, Values followed by different lowercase letters indicate a significant difference at the 95% confidence level (F count > F table).

Based on Table 4 shows the results of feed efficiency values from common carp fry observed during the study. Treatment B (15% non-fermented Lemna flour) had the lowest feed efficiency value of 36% ± 0.0329, while treatment E (25% fermented Lemna flour) showed the highest feed efficiency value of 68% ± 0.01270. ANOVA statistical analysis with a confidence level of 95% produced an F value calculated > F table, meaning that the treatment could have an influence on increasing the feed efficiency value. The addition of fermented Lemna flour of 15% (treatment C), 20% (treatment D), and 25% (treatment D) resulted in an FE value of 57% ± 0.0143; 60% ± 0.0331; and 68% ± 0.01270, so it can be concluded that the addition of fermented Lemna flour can further increase the FE value compared to no addition of fermented Lemna flour or the addition of non-fermented Lemna flour.

According to Puspita *et al.* (2015), the value of reasonable feed efficiency was more than 50%. Feed efficiency is closely related to the digestibility of fish of the feed given.

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According to Yanti *et al*. (2013), the digestibility of fish to a feed is influenced by several factors, namely the chemical properties of water, water temperature, type of feed, size and age of fish, feed nutrient content, frequency of feeding, and the number and type of digestive enzymes contained in the digestive tract of feed. Based on this, the treatments C (15% fermented Lemna flour), D (20% fermented Lemna flour), and E (25% fermented Lemna flour) were the most optimal treatments in feed utilization efficiency, this was because the feed efficiency value was more than 50%.

The feed efficiency value was inversely proportional to the FCR value. However, similar to the FCR value, the low FE value in treatment A (control) and B (non-fermented Lemna flour) was due to the post-challenge test by infecting fish using *A. hydrophila* bacteria made the health condition of the fish deteriorate which was followed by the appearance of stress symptoms in the fish, such as decreased appetite in the fish. Feed in treatment A (control) and treatment B (non-fermented Lemna flour) resulted in lower feed quality compared to treatment C (15% fermented Lemna flour), D (20% fermented Lemna flour), and E (25% fermented Lemna flour). Although in treatment B, the feed contained antioxidant compounds, the fish could not digest them properly, which caused stress in the fish to increase and caused fish appetite to decrease. So the EP value also decreased.

CONCLUSION

Based on the results of the research that has been carried out, the following conclusions can be stated that the addition of fermented Lemna flour (*Lemna minor*) with various percentages in the feed has a real effect on *the* Specific Growth Rate (SGR), Feed Conversion Rate (FCR), and Feed Efficiency (EP) of fish infected with *Aeromonas hydrophila* bacteria with respective values of 0.34 ± 0.0599; 1.51 ± 0.3161; and 68% ± 0.01270.

The best dose of fermented Lemna flour (*Lemna minor*) in improving growth in carp (*Cyprinus carpio*) is 25% (treatment E).

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTION

Kiki Haetami, Jeni Ghina Syifa, Iskandar, and Roffi Grandiosa Herman contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

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