The effect of use of tofu dregs fermented on feed efficiency and growth of African cat fish (Clarias gariepinus)

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Abstract. The aims of research were to investigate the effect of tofu dregs fermented utilization on feed efficiency and growth of African catfish (Clarias gariepinus). This research consists of two experimental stages. Preliminary experiments were performed to determine the optimal bioactivator dosage to ferment the tofu dregs. The result showed that optimal bioactivator used to ferment tofu dregs was 60 ml kg⁻¹. The main experiment was carried out for 45 days using triplicate set up of fifteen rectangular plastic tanks. Twenty five fingerling African catfish with a mean total body length of 10 ± 0.1 cm were stocking in the plastic tanks. The experimental fishes were fed twice daily at satiation. Five fish feed (Diet K was the control diet, Diet A contained 10 percent, Diet B contained 20 percent, Diet C contained 30 percent, and Diet D contained 40 percent tofu dregs fermented, respectively) were used in feeding the fish. Growth performances and diet nutrient utilization were analysed using the specific growth rate (SGR) and feed efficiency (FE). Data obtained from the experiment were subjected to one-way analysis of variance. Duncan’s multiple Range Test was performed using to determine differences between treatment at significance rate of P < 0.05. In conclusion, the results showed that the utilization of tofu dregs fermented had significant effect on feed efficiency and growth of African catfish. Further, the present experiment showed that tofu dregs fermented could be utilized in diets up to 40 percent.

1. Introduction

Intensif fish farming has been recently develop in Indonesia. Several effort have been conducted to support fish farming industry. Computer program to fish diseases control using Case-Based Reasoning has been created by [1]. Furthermore, software to determine nutrition requirement base on species and age of fish using expert system has been developed by [2]. Also, software to determine feed fish price based on feed formulation with local raw materials using fuzzy logic implementation has been developed by [3].

The success of fish farming depends on availability of fish feed, both in sufficient quantity and good quality. In fish farming, feed accounts more than 50 percent of the production cost [4]. The increase of feedstuff price is creating some problems. The increase of production cost is one of the most important problem that resulted in an decrease in benefit of fish farmers. Therefore, it is important to produce artificial feed using local raw materials. Fish meal is one of the most important ingredients artificial feed, however is a limited and high price resource. Consequently, a reduced use
of fish meal represents a challenge for sustainable fish farming production [5]. The high price of fish meal have stimulated to search an alternative material can to substitute fish meal reduce fish feeding cost and halieutics resources pressure [6].

Dregs of tofu can be used as an alternative source of protein. The nutrient content of tofu dregs was 23.55% protein, 5.54% fat, carbohydrate 26.92%, ash 17.03%, coarse 16.53%, and water 10.43% [7]. The dregs of tofu was a waste of tofu manufacture, still containing high protein with amino acid lysin and methionine, and calcium [8]. The high protein content of tofu dregs could be used as fish feed. With biotechnology of fermentation, dregs of tofu fermented could substitute fish meal which was still dependent on imports. However, the high content of crude fiber become a limiting factor for use in fish feed. Therefore, the tofu dregs should be treated by fermentation biotechnology to increased its digestibility.

Several studies conducted to substitute fish meal with other plant protein sources such as soybean or cotton seed meals in African catfish and Vundu catfish [9]. Azolla in Oreochromis niloticus [10] and animal protein sources such as earthworm in Heterobranchus longifilis [11], Heteroclarias fingerlings [6], Clarias gariepinus [12], snail, termite, tadpole [13], rice bran, tofu waste, fish meal in the Oithona sp. [14], defatted biomass of the microalga Desmodesmus in Atlantic Salmon [15], earthworm meal and the maggot meal in Clarias gariepinus [16] fingerlings and other alternative plant sources in Oreochromis niloticus [17]. In general, these studies showed that total replacement of fish meal leads to the decrease of feed intake, feed efficiency and growth performances.

The purpose of this study were to investigate the effect of using dregs of tofu fermented on feed efficiency and growth of catfish (Clarias gariepinus). This research also aims to determine the dosage of dregs of tofu fermented that can be used as feed ingredients of African catfish.

2. Materials and methods

2.1. Preliminary experiment
Preliminary experiment was conducted to determine the optimal dosage of bioactivators to ferment dregs of tofu. Bioactivators were obtained from the fermented process of 1 kg banana fruit, 1 pineapple fruit, 1 ounce onion, 1 kg tempe (soybean fermented), 2 kg sugar, and 8 liter of boiled water for ten (10) days. Bioactivators was dominated by Rhizopus oryzae. The result of biocativator was used to ferment the tofu dregs with different dosages, i.e 0, 60, 80, and 100 ml kg\(^{-1}\) of tofu dregs. Dregs of tofu was fermented for 5 days. Further, the results optimal dosage of fermentation was applied to ferment the tofu dregs.

2.2. Main experiment
The experiment was carried out for forty five (45) days using triplicate set up of fifteen (15) rectangular plastic tanks (A1, A2, A3, B1, B2, B3, C1, C2, C3, D1, D2, D3, E1, E2, and E3) with a total water volume of 245 L. Five fish feed (Diet K, Diet A, Diet B, Diet C, and Diet D) were used in feeding the fish. Diet K was the control diet, Diet A contained 10 percent, Diet B contained 20 percent, Diet C contained 30 percent, and Diet D contained 40 percent dregs of tofu fermented, respectively. Table 1 shows the composition of five experimental diets in grams per kilogram (g kg\(^{-1}\)). While, table 2 shows the nutrient proximate analysis content of each experimental diets.
Table 1. Composition of experimental diets in grams per kilogram.

| Ingredients          | Diet (g kg⁻¹) | K (Control) | A (10%) | B (20%) | C (30%) | D (40%) |
|----------------------|---------------|-------------|---------|---------|---------|---------|
| Fish meal            |               | 750         | 650     | 550     | 450     | 350     |
| Strach               |               | 50          | 50      | 50      | 50      | 50      |
| Dregs of tofu        |               | 0           | 100     | 200     | 300     | 400     |
| Rice Bran            |               | 100         | 100     | 100     | 100     | 100     |
| Fish oil             |               | 3           | 3       | 3       | 3       | 3       |
| Vitamine premix      |               | 2           | 2       | 2       | 2       | 2       |
| Minerale premix      |               | 50          | 50      | 50      | 50      | 50      |
| Total                |               | 1000        | 1000    | 1000    | 1000    | 1000    |

Table 2. Nutrient proximate analysis content of each experimental diets.

| Nutrient Content     | K (Control) | A (10%) | Diet B (20%) | C (30%) | D (40%) |
|----------------------|-------------|---------|--------------|---------|---------|
| Crude Protein (%)    | 21.51       | 25.30   | 22.82        | 32.87   | 37.45   |
| Crude Lipid (%)      | 6.94        | 8.37    | 9.85         | 12.06   | 14.54   |
| Crude Fiber (%)      | 3.01        | 3.21    | 4.25         | 5.05    | 6.93    |

2.3. Rearing of African catfish

Twenty five (25) fingerling African catfish with a mean total body length of 10 ± 0.1 cm were stocking in the plastic tanks. Prior to the start of experiment, the experimental fishes were starved for 48 hours before introducing the experimental diets. The experimental fishes were fed twice daily at satiation. Water of tanks were changed every 10 days at 30% of the volume of tanks. The experimental fishes were reared for 45 days.

2.4. Chemical analysis

Protein was assessed by the Kjeldahl method, the crude lipid with extraction method, ash by heating sample at temperature 600°C, crude fiber used method of dissolving sample with acid, strong base and heating [18]. Water content and crude fiber of feed was determined by the gravimetric method following the method described by [19]. Total nitrogen was determined by nitrogen analyzer (LECO, FP-428; system 601-700-500, Perkin Elmer Coop., Norwalk, CT, USA), and crude protein was calculated as a N x 6.25. Crude fat content was determined by a sample extraction method using chloroform and methanol in a 2:1 ratio and then determined according to the method described by Folch [18].

2.5. Growth performance and feed efficiency

Growth performances and diet nutrient utilization were analysed using the specific growth rate (SGR) and feed efficiency (FE). These parameters were calculated using the following formulae [20, 21]:

\[
\text{SGR} = \frac{(\ln W_t - \ln W_0)}{T} \times 100
\]

\[
\text{FE} = \frac{(B_t + B_d) - B_0}{F} \times 100\%
\]

FE = feed efficiency (%)

Bt = fish biomass at the end of experiment (g)

Bo = fish biomass at the beginning of experiment (g)

Bd = biomass of died fish during experiment (g)

F = the amount of feed consumed during experiment (g)
2.6. Statistical analysis
Data obtained from the experiment were subjected to one-way analysis of variance. Duncan’s multiple Range Test was performed using to determine differences between treatment at significance rate of P < 0.05. All statistics were carried out using Statistical Analysis Program (SPSS ver.16).

3. Results and discussion

3.1. Preliminary experiment results
The preliminary experiment results of the tofu dregs fermented nutrient content with different doses of bioactivators were presented in Table 3.

| Bioactivator dose (ml kg⁻¹) | Crude Protein (%) | Crude Lipid (%) | Crude fiber (%) | Materials extract non-nitrogen (%) |
|-----------------------------|-------------------|----------------|----------------|-----------------------------------|
| 0                           | 22.40             | 8.76           | 25.40          | 43.09                             |
| 60                          | 23.55             | 20.61          | 36.84          | 18.39                             |
| 80                          | 20.70             | 21.6           | 38.84          | 18.75                             |
| 100                         | 20.72             | 19.57          | 42.95          | 16.15                             |

Based on the data Table 3 showed that the protein content dregs of tofu fermented with bioactivator at dose of 60 ml kg⁻¹ was highest as amount as 23.55%. While, the protein content of dregs of tofu fermented with doses of 80 ml kg⁻¹ and 100 ml kg⁻¹ was lower than the dose of 60 ml kg⁻¹. In fish feed manufactured, the protein plays important role for the growth performance of fish. Therefore, the dose of bioactivator used to ferment the dregs of tofu in this experiment was 60 ml kg⁻¹. However, to improve the nutritional quality of tofu dregs could be done by biofermentation using Saccharomyces cerevisiae [22]. Saccharomyces cerevisiae could increased the digestibility of fibrous feed and could play as a probiotic in poultry. Fermented feed products could significantly increased carcass growth and quality, as well as lower serum duck cholesterol [23]. Fermentation can also break cellulose, hemicellulose, and its polymers become simple sugars or derivatives and can increase the nutrients of the origin because microbes are catabolic as well as can synthesize vitamins such as riboflavin, vitamin B12 and pro vitamin.

Further, based on the results of proximate analyts showed an increase in nutrient content in tofu dregs after fermented that compared before fermentation. It proved that with fermentation can improve the nutritional quality of a material. In addition, fermentation also improves the digestibility level of a proven ingredient with crude fiber that decreases after fermentation. Protein is the main fraction of lipids and carbohydrates, which shows usability as energy reserves and metabolic substrates [24]. In addition, lipids are a great source of energy and as energy reserves that provide essential fatty acids needed for the maintenance and robustness of cellular membranes and also provide the formation of steroids and hormone molting [25].

3.2. Main experiment results
Based on proximate analysis on the experimental diets at table 2 indicated that in diet D content the highest protein and lipid. It showed that dregs of tofu fermented can increase the nutritional value of its supplemented diet. This proved that higher supplementation dregs of tofu demonstrated the content of protein and lipid simultaneously more high than the other experimental diet. The differences nutrient content of experimental diet caused differences in specific growth rate and feed efficiency. Growth performance of African catfish and feed efficiency with different experimental diets is shown in table 4.
Table 4. Specific growth rate (g/day) and feed efficiency (%) from different experimental diets.

| Variable                   | Diet   |
|----------------------------|--------|
|                            | K (Control) | A (10%) | B (20%) | C (30%) | D (40%) |
| Spesific Growth Rate (g/day) | 2.37   | 2.27   | 2.30   | 2.54   | 2.76   |
| Feed Efficiency (%)        | 61.84  | 35.83  | 53.62  | 63.09  | 64.60  |

The results showed that, growth performance (SGR) of African catfish tend increased (P < 0.05) with increasing of dregs of tofu fermented replacement from 10% to 40%. However, the highest value of SGR were obtained by fish fed 40% dregs of tofu fermented (diet D), while the lower value of SGR were obtained by fish fed 10% dregs of tofu fermented (diet A). These results indicated that the high content of protein and lipid of diet D are more suitable for fish diets. These results are in agreement with those obtained by [26] who found that supplementing diets with 5% tofu fermented by probiotic inoculants increased significantly on final body weight, liver weight gains, and feed efficiency. Also, using of 10-30% soybean distillery by-product fermented by Saccharomyces cerevisiae culture in diets to increase performance of male Bali duckling aged 6-12 weeks, but inhibit abdominal-fat and serum cholesterol contents of the duck [27].

From the presented results in table 4, the highest value of feed efficiency were obtained by fish fed diet containing 40% dregs of tofu fermented (diet D), while the lower value of SGR were obtained by fish fed diet containing 10% dregs of tofu fermented (diet A). In addition value, the feed efficiency increased significantly (P < 0.05) with increasing of dregs of tofu fermented replacement from 10% to 40%. However, 40% dregs of tofu fermented (diet D) resulted in the significant higher of feed efficiency. These results are in agreement with those obtained by [28] who revealed that use of dregs of tofu fermented with S. cerevisiae cultures as a real probiotic inoculant could improved the feed efficiency due to increased enzymatic activity and digestive activity. Also, that increased of protein consumption could increased carcass weight, carcass percentage, and breast meat percentage [29]. Fermentation technology could improved the quality of feed ingredients, especially crude fiber and high anti-nutrients. Fermentation could improved the digestibility of feed ingredients through activity of enzymes produced by microbes [30]. Increased digestibility of feed will increase feed intake so as to improve feed efficiency.

4. Conclusion

The results of research showed that the utilization of tofu dregs fermented had significant effect on feed efficiency and growth of African catfish (Clarias gariepinus). Further, the present experiment showed that tofu dregs fermented could be utilized in African catfish diets up to 40% instead of dietary ingredient without any adverse effects on fish growth performances and feed efficiency.

Acknowledgement

We thank the Education and Cultural Office, Province of Central Java, Indonesia for funding the experiment. The authors would like to acknowledge the support of the teacher and student of SMA Margasari, Tegal, Province of Central Java, Indonesia.

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