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Formulated Pellet Feed from Cabbage Waste and Fish Meal for Local Catfish (*Clarias batrachus*)

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Abstract

Cabbage waste is household and market industry waste that contains significant nutrients, such as protein, fat, fiber, vitamins, and minerals. This waste has the potential to be utilized as animal feed, for example, for local catfish (*Clarias batrachus*). This study aims to utilize cabbage waste as an alternative feed. The research was conducted from April to June 2024 using a quantitative experimental method and proximate analysis on the feed, with four treatments, three replications, and a positive control. The results showed that treatment 3, with a feed dosage of 12%, was the most effective in influencing all observed parameters. This treatment resulted in a length growth of 14.22 cm, weight growth of 20.59 g, and a feed conversion ratio (FCR) of 1.73, which was better than the other treatments. The proximate analysis results indicated that the feed in treatment 3 contained 32.14% protein, 5.24% fat, and 9.30% carbohydrates.

Keywords: Formulated pellet, fish feed, cabbage waste, local catfish (*Clarias batrachus*)

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Introduction

Local catfish (*Clarias batrachus*) is a type of freshwater fish with high economic value. Catfish farming has rapidly developed because it can be cultivated in limited land and water sources with a high stocking density, easy-to-master farming techniques, and relatively low business capital. Catfish has advantages over other fish species, including fast growth, tolerance to poor water quality, relative resistance to diseases, and the ability to be cultivated in almost any farming container (Manik *et al.*, 2022). Additionally, catfish meat is thicker compared to other freshwater fish such as tilapia, nilem, mujair, and pangasius. Catfish is rich in nutrients, especially protein, which plays a crucial role in growth, tissue repair, and boosting the immune system against diseases. Catfish has a high protein content, ranging from 17.7% to 26.7%, and a fat content of 0.95% to 11.5%. Its growth is influenced by both internal and external factors. One internal factor is the fish's genetics, while an external factor is the feed provided. Catfish require feed with a protein content of 32% to 35% for optimal growth (Rahayu *et al.*, 2019).

Feed is the primary source for supporting the survival and growth of fish. However, feed requirements are also a crucial factor in fish farming, accounting for 60%-70% of the total farming costs (Iswandiary *et al.*, 2021), therefore alternative feed ingredients that are easily accessible and of good quality are needed to reduce production costs and increase profitability (Muntafiah, 2020). The quality of artificial feed is determined by its raw materials, particularly sources of protein, fat, carbohydrates, minerals, and vitamins. The principle of fish feed production is to utilize natural resources that are no longer suitable for human consumption but still contain sufficient protein for fish and are economically affordable (Anis *et al.*, 2019).

The utilization of organic waste has been widely developed, such as the production of eco-enzymes derived from fruit waste (Listiana *et al.*, 2024) or vegetable waste. Vegetable waste like cabbage has great potential in supporting fish growth due to its fairly good

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nutritional content, making it a potential protein source for fish feed production. Cabbage waste contains 15.74% dry matter, 12.49% ash, 23.87% crude protein, 22.62% crude fiber, 1.75% crude fat, and 39.27% nitrogen-free extract. Additionally, cabbage contains other beneficial components (Wulandari & Astuti, 2022).

Cabbage waste is known to have a high water content; therefore, in the production of artificial fish feed, it is necessary to add flour-based ingredients (Suek *et al.,* 2023), such as fish meal. It serves as an ingredient in artificial feed and is rich in protein, making it a good source of protein for the growth of catfish. The nutritional composition of fish meal includes 60% protein, 2.54% crude fiber, 6.56% fat, 31.54% ash, and 7.2% moisture content (Praptiwi & Wahida, 2021). The use of cabbage waste and fish meal as artificial feed is an alternative method of waste processing (Rusad *et al.*, 2016). Through this method, cabbage waste can be utilized more optimally and processed effectively, one of which is by turning it into fish pellets. Moreover, the utilization of cabbage waste and fish meal can be a practical solution for fish farmers to reduce feed costs, which are increasingly expensive in the market. This approach not only addresses the issue of vegetable waste but also helps ease the economic burden caused by the high cost of commercial fish feed (Sugara *et al.*, 2020).

Although several studies have examined the use of vegetable waste as feed ingredients, few have specifically investigated the utilization of cabbage waste combined with fish meal as a formulated feed for local catfish (*Clarias batrachus*), particularly regarding optimal dosage levels and their effects on growth performance. This gap indicates the need for experimental evaluation of cabbage waste–based feed formulations. Therefore, this study aims to analyze the effects of various dosage levels of pellet feed formulated from cabbage waste and fish meal on the growth and survival of *Clarias batrachus*, as well as to determine the most effective feed formulation in enhancing catfish growth. The results of this research are expected to contribute to sustainable aquaculture practices by promoting low-cost feed innovations and reducing vegetable waste in the environment.

Methods

Time and Place

This research was conducted from April to June 2024 in Way Dadi Urban Village, Bandar Lampung City, and the proximate analysis was carried out at the Laboratory of the Center for Standardization and Industrial Service (BSPJI) Bandar Lampung.

Tools and Materials

The tools used in this study included a simple rectangular fish pond (Length: 60 cm, Width: 40 cm, Height: 40 cm), an analytical balance, a pH meter, a ruler, and a camera. The materials used in this research included 14 day old local catfish fingerlings, cabbage waste, fish meal, tapioca flour, fine rice bran, and EM-4 aquaculture probiotics.

Research Design

This study employed a quantitative experimental method using a completely randomized design (CRD) consisting of four treatments and three replications, along with one positive control with different feed dosage levels (4%, 8%, 12%, and 16% of the fish body weight per week). The rearing process lasted 35 days, with a stocking density of 25 fish per intervention pond.

Research Procedure

a. Production of Feed Using Cabbage Waste

The production of alternative feed utilizing cabbage waste and fish meal was carried out by preparing 5 kilograms of feed using the 4-square method, which calculates the formulation of ingredients needed for alternative feed production. Feed formulation with 35% protein using the 4-square method which can be seen in Figure 1 while the molding process can be seen in Figure 2.

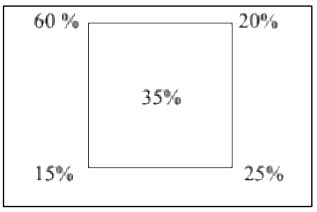

Figure 1. 4-square method for feed formulation

Figure 2. The Molding Process of the Fermented Alternative Feed

The results obtained from the 4-square method in feed production with a protein content of 35% showed a formulation calculation of the ingredients needed for alternative feed production, indicating that the highest protein source comes from fish meal, with a protein content of 60% of the total ingredients, while cabbage waste and rice bran each contain 15% protein. For producing 5 kilograms of feed, the ingredient formulation consists of 2.8 kilograms of fish meal, 2.2 kilograms of cabbage waste, and rice bran.

In the feed preparation stage, cabbage waste is first ground for fermentation. The fermentation process is conducted by mixing the cabbage waste with an EM-4 aquaculture solution, then fermenting it for two days to enhance the nutritional value and digestibility of the material. The main raw materials used in the feed formulation include cabbage waste, fish meal, fine rice bran, EM-4 aquaculture solution, and vitamins. The procedure for catfish feed production involves several stages. First, a container is prepared to mix the vitamins with the EM-4 solution, which is then left to stand for two hours to ensure thorough blending. Next, the cabbage waste and fish meal are mixed until homogeneous, achieving a smooth and elastic texture. Then, fine rice bran is added according to the required proportion, followed by vitamin supplementation. A binder made from cooked tapioca flour is then prepared and incorporated into the feed mixture. After that, the EM-4 solution enriched with vitamins is added again, and the mixture is stirred evenly before being fermented for four days. After fermentation, the mixture is molded into pellets and then dried to improve its durability and buoyancy. Finally, the dried pellets are stored in airtight containers to maintain their quality and nutritional stability (Bouk *et al.*, 2022).

b. Test Parameters

1) Length Growth

L=Lt – Lo

Description :

L : Absolute length growth (cm)

Lt : Final seed length at the end of the study (cm)

Lo : Initial seed length at the beginning of the study (cm)

2) Weight Growth

W= Wt – Wo

Description :

W : Absolute weight growth (g)

Wt : Final seed weight at the end of the study (g)

Wo : Initial seed weight at the beginning of the study (g)

3) Feed convertion ratio (FCR)

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

Description :

FCR : *feed convertion ratio*

Wt : Average final weight at the end of the study

Wo : Average initial weight

F : Total feed consumed during the study

Data Analysis

The data analysis test used in this study is the Analysis of Variance (ANOVA) test using the SPSS 25 program with One-Way ANOVA. If there is a significant difference between treatments, a follow-up test will be conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

Results and Discussion

Catfish Length Growth

The results of the study on catfish length growth showed varying outcomes across different treatments, with the highest average length growth observed in the positive control (K+) at 14.83 cm (Table 1). This significant increase in growth in the K+ group was due to the use of commercial feed, which contains adequate nutrients to support catfish growth, including 35% protein, 5% fat, 8% fiber, and added vitamins. Catfish are able to efficiently utilize the nutrients in commercial feed, with protein being the main energy source essential for their growth (Nugraha, 2020).

In treatments P3 (12%), P4 (16%), and P2 (8%), the results did not show significant differences. This is likely because the nutritional needs of the fish were sufficiently met by the alternative feed, which contained 32.14% protein, 5.24% fat, and 9.30% carbohydrates. The adequate protein content in the alternative feed was derived from fish meal, rice bran, and cabbage waste. The protein requirement for catfish growth ranges from 32% to 35%. Protein with high biological value leads to greater body growth compared to protein with lower biological value. Sufficient nutritional content in the alternative feed is a contributing factor to the length growth of catfish. In addition to protein, fish also require carbohydrates for growth. Carbohydrates serve as an energy source for fish to carry out daily activities and metabolic processes. Furthermore, to support the length growth of catfish, minerals in the feed are essential for maintaining the health of bones, teeth, and scales. Cabbage waste contains minerals, one of which is calcium (Ca), which plays an important role in supporting optimal bone growth in fish. Calcium is an essential mineral for bone formation and maintenance, contributing to the integrity and strength of the fish's skeletal structure (Sajid et al., 2024). Moreover, vitamins are also needed in the bone growth process—particularly vitamin C, which functions in the formation of collagen, the main structural component of bones. The vitamin C and mineral content in the alternative feed was sourced from cabbage waste (Manik & Arleston, 2021).

Table 1. Length Growth Test Results

Treatment	Average Length (cm)
P1 (4% Feed)	$12{,}12^{a}$
P2 (8% Feed)	$13{,}23^{b}$
P3 (12% Feed)	$14{,}22^{c}$
P4 (16% Feed)	$13{,}77^{bc}$
K+ (12% Feed)	$14{,}83^{d}$

Values followed by different superscript letters are significantly different ($p<0.05$).

Table 2. Weight Growth Test Results

Treatment	Average Weight (g)
P1 (4% Feed)	13.43[a]
P2 (8% Feed)	15.7[b]
P3 (12% Feed)	20.59[c]
P4 (16% Feed)	21.78[d]
K+ (12% Feed)	24.75[e]

Values followed by different superscript letters are significantly different ($p<0.05$).

Catfish Weight Growth

The growth of catfish is influenced by the quality of feed, the amount of feed, and the feeding rate consumed. This factor plays a crucial role in determining the growth rate of fish and serves as a basis for setting the appropriate protein level in the feed (Santika *et al.*, 2021). Weight gain in treatments P4 (16%) and P3 (12%) showed an increase in the final fish weight at the end of the study (Table 2), indicating that the nutritional content in the feed was adequate, with 32,14% protein, 5,24% fat, and 9,30% carbohydrates. Fish weight gain is affected by the amount of protein provided, as approximately 50% of the calories required by fish come from protein, which functions to build muscle, cells, and body tissues-especially in juvenile fish (Manik & Arleston, 2021).

Protein is a key component essential for growth and health, serving as a building block for new tissues formed within the body of fish (Nurilmala *et al.*, 2020). Catfish require a protein content of around 32%–35% to support their nutritional needs. In this study, treatment groups P4 and P3 received 16% and 12% protein in their feed, respectively, with a feeding frequency of twice daily, this amount is considered sufficient to meet the nutritional requirements of catfish. In addition to protein, carbohydrates and fats also play important roles in fish growth. Carbohydrates serve as the main energy source for fish to carry out their daily activities and metabolic processes. Meeting energy needs is a top priority. If carbohydrate intake is insufficient and the fat content in the feed or body reserves is also inadequate, then protein will be used as an alternative energy source. As a result, protein will deviate from its primary function as a building nutrient (Masriah & Alpiani, 2019), if this condition continues over time, a deficiency in both energy and protein can negatively affect fish growth. Fish that do not receive an adequate amount of fat in their diet may experience stunted growth, and in severe cases, may stop growing altogether and eventually die. A lack of fat in the feed can also lead to dry and unhealthy skin (Khalil *et al*., 2022). Carnivorous fish generally have a relatively low carbohydrate requirement, only about 10–20%, due to limitations in their digestive systems. Nevertheless, carbohydrates are still necessary in formulated feeds as a primary energy source and to help conserve protein use (Puteri *et al.*, 2020).

Table 3. Feed Convertion Ratio (FCR) Test Results

Treatment	Average FCR
P1 (4% Feed)	1.32[a]
P2 (8% Feed)	1.82[b]
P3 (12% Feed)	1.73[b]
P4 (16% Feed)	2.83[c]
K+ (12% Feed)	1.26[a]

Values followed by different superscript letters are significantly different ($p<0.05$).

Table 4. Results of Water Acidity (pH) Observations

Treatment	Acidity (PH)
P1 (4%)	7.0^{a}
P2 (8%)	6.83^{b}
P3 (12%)	6.80^{b}
P4 (16%)	6.69^{c}
K+	6.90^{ab}

Values followed by different superscript letters are significantly different ($p<0.05$).

Table 5. Proximate analysis results of feed

No.	Parameter	Unit	Test Result
1	Protein	%	32.14
2	Fat	%	5.25
3	Carbohydrate	%	9.30
4	Water content	%	10.37
5	Ash content	%	11.15
6	Fiber	%	3.21

Values followed by different superscript letters are significantly different ($p<0.05$).

Feed Conversion Ratio (FCR)

Feed efficiency is the inverse of Feed Conversion Ratio (FCR). A lower FCR value indicates better feed utilization efficiency (EPP), while a higher FCR means poorer feed efficiency. The FCR value reflects how much of the consumed feed is converted into fish body growth (Santika *et al.,* 2021). Based on the research results, the lowest FCR among alternative feeds was observed in K+ at 1,26 with commercial feed used in the study, followed by P1 at 1,32, P3 at 1,73, P2 at 1,82, and the highest FCR was shown by P4 at 2,83 (Table 3). The high FCR value in P4 was caused by the largest amount of feed given, which was not optimally utilized by the catfish. As a result, only a small portion of the feed was actually consumed to support growth. This happened because the feeding dose exceeded the fish's needs, while the fish had already reached their optimal consumption level. Overfeeding caused not all the feed to be eaten by the fish. The leftover feed produced ammonia, which made the feed deteriorate quickly and polluted the pond. Consequently, water quality declined, the fish's appetite decreased, and fish growth became uneven (Sonavel *et al.,* 2020).

Acidity (PH)

Based on Table 4, the average pH observation results ranged from 6,7 to 7, indicating that the water pH in the maintenance ponds is still within the normal range. According to the Indonesian National Standard (SNI), the suitable pH for catfish ponds is between 6,5 and 8,5. A pH below 6,5 tends to be too acidic, which can inhibit fish growth, cause stress, and increase the risk of infection. If the pH is above 8,5, it is considered alkaline, which can disrupt the metabolism and physiological functions of catfish. pH is one of the most important factors affecting the growth and survival of fish. If the pH does not meet the fish's requirements, it can hinder growth and even cause death (Pradhana *et al.,* 2021).

Proximate Analysis Results

Based on the laboratory test results which can be seen in Table 5, the alternative feed contains nutrients that meet the requirements of local catfish (*Clarias batrachus*). According to the SNI 9043-4:2022 (Standar Nasional Indonesia), catfish require 30%–35% protein in their feed. This indicates that the combination of cabbage waste and fishmeal can be probably developed for feed alternative which can support the growth of local catfish.

Conclusion

The utilization of cabbage waste and fish meal for local catfish (*Clarias batrachus*) farming in Way Dadi Urban Village, Bandar Lampung City, has a significant impact on research parameters such as length growth, weight gain, and feed conversion ratio (FCR). The most effective treatment in enhancing catfish growth was obtained with a feed protein content of 32.14%, corresponding to Treatment 3 with a 12% feeding dosage, which resulted in an average length growth of 14.22 cm, weight gain of 20.59 g, and an FCR value of 1.73. These findings indicate a statistically significant improvement compared to other treatments. Future research development can focus on using cabbage waste and fish meal for the farming of other fish species such as tilapia, pangasius, gourami, and others. Additionally, the use of environmentally friendly alternative protein sources should be considered, such as maggots, salted fish waste, meat meal, and other similar materials.

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