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Effectiveness of various commercial feeds on the growth performance of common carp (*Cyprinus carpio*) in floating net cages in Cirata Reservoir, West Java

Muhammad Agus Suprayudi[1], *Julie* Ekasari[1], *Muhammad* Fakhri Muslim[1] and *Talita* Shofa Adestia[1*]

[1]Departement of Aquaculture, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, West Java 16680, Indonesia

Abstract. This study aims to compare the growth performance of common carp (*Cyprinus carpio*) reared in floating net cages (FNC) in Cirata Reservoir, West Java, with different commercial feeds. This study utilized four different commercial feeds, namely: commercial feed A (protein content: 28.10%), treatment B (protein content: 28.80%), treatment C (protein content: 28.90%), and treatment D (protein content: 29.12%). The average weight of the fish used at the beginning of stocking was 23 g. The FNC plot used was 3 × 3 × 3 m in size. The frequency of feeding was three times a day (08:00, 12:00, 17:00) with feeding at satiation for 100 days of rearing period. The results showed that treatment D (29.12%) provided the best final biomass performance, as well as the highest average weight, specific growth rate, and feed cost per gain and feed conversion value, compared to the other three treatments. Based on the research results obtained, it can be concluded that the highest growth performance was achieved in commercial feed treatment D, which had a protein content of 29.12%.

1 Introduction

The common carp (*Cyprinus carpio* L., 1758) is one of the aquaculture commodities that has been cultivated for a long time in Indonesia. It is considered a popular commodity across various provinces, such as West Java, North Sumatra, South Sulawesi, and North Sulawesi [8]. Among these regions, West Java has become a central hub for carp aquaculture, with Cirata Reservoir being one of the prominent cultivation sites. Feed expenses represent the largest proportion of the total production cost in aquaculture operations, accounting for approximately 85% to 98% of overall production expenses [1]. Commercial feeds, driven by the rising demand for higher fish production outputs [2]. For example, in Cirata Reservoir alone, the annual demand for commercial fish feed has reached 149,321 tons.

An ideal commercial fish feed must have a balanced and optimal composition that includes essential nutrients such as proteins, fats, ash, crude fiber, moisture content, vitamins, and minerals [3]. A feed with an appropriate nutritional formulation can significantly enhance fish growth performance. The more digestible the nutrients are for the fish, the more efficient the feed becomes in promoting growth and health. However, feed efficiency is also influenced by the balance of nutrients—when the composition exceeds the fish's actual

* Corresponding talitashofa@apps.ipb.ac.id

nutritional needs, the surplus cannot be digested and is ultimately wasted, thus lowering overall efficiency [4]. According to the Indonesian National Standard (SNI) 01-4266-2006, during the grow-out phase, common carp (*Cyprinus carpio*) require feed that contains at least 25% protein and a minimum of 5% fat, with a maximum of 12% ash, a maximum moisture content of 12%, and a maximum crude fiber content of 8%.

The availability of various types of commercial fish feed in the market—differing in both quality and price—makes the selection of appropriate feed a critical decision in aquaculture operations. Practical considerations and economic factors play a decisive role in determining the feasibility and continued use of commercial fish feeds [5]. A good commercial feed is characterized by a nutritionally balanced formulation that aligns with the dietary needs of the fish, while also being economically viable—meaning it is affordable for fish farmers and fits within their purchasing capacity [6]. With many types of commercial feed available on the market, it becomes essential to evaluate their effectiveness. To ensure the efficient use of feed in supporting aquaculture production, it is necessary to conduct thorough evaluations of both the biological performance and economic outcomes within the targeted aquaculture business units, such as floating net cages.

2 Materials and Method

2.1 Test materials

The materials used in this research included four units of floating net cages measuring 3 meters × 3 meters × 3 meters each. Four types of commercial sinking feed with similar protein levels (ranging from 27.90% to 29.12%), each with a pellet size of 3 mm. Additional supporting materials included a quarantine pond, a feed storage warehouse, and daily records for monitoring feed quantity. The net cages were equipped with repair materials and tools, as net inspections and stitching repairs were carried out prior to the rearing period.

2.2 Experimental design

This research was conducted at the Denox floating net cage in the Cirata Reservoir, West Java, as shown in Figure 1. The Denox floating net cages used in this study are aquaculture facilities that have been operationally implemented at the research site. The floating net cages used consisted of 4 compartments, with supporting facilities including a quarantine pond and a feed warehouse, as presented in Figure 1. This study employed a quasi-experimental design [14], using four treatment feeds with relatively similar protein levels and one replication, as follows:

Treatment A: Commercial feed A with a protein content of 28.10%
Treatment B: Commercial feed B with a protein content of 28.80%
Treatment C: Commercial feed C with a protein content of 27.90%
Treatment D: Commercial feed D with a protein content of 29.12%

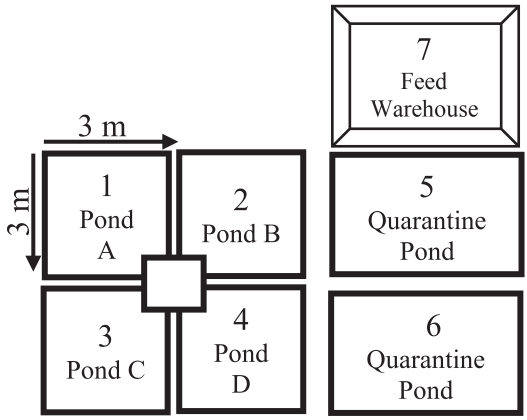

Fig. 1. FNC layout in Cirata Reservoir.

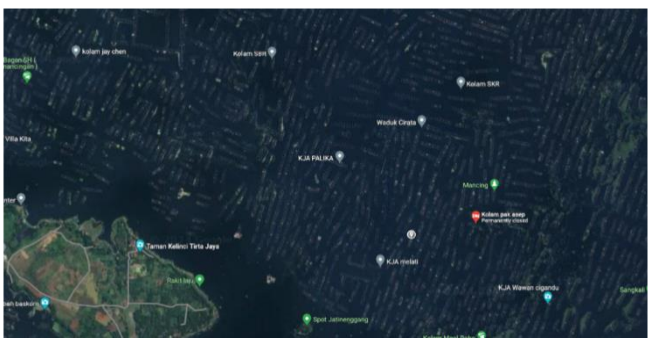

Fig. 2. Location map of Denox floating net cages.

2.3 Fish maintenance and feed experiment

The test fish were reared in four floating net cage compartments, each measuring 3 m × 3 m × 3 m. The nets of the floating cages were inspected prior to the rearing period; if any damage was found, repairs were made to the damaged sections using stitching methods. The test fish in this study were common carp (*Cyprinus carpio*) with an average weight of 23.61 g and a stocking density of 211 fish/m³ (4.98 kg/m³). The rearing period lasted for 100 days.

Feed was administered using the *at satiation* method, with a feeding frequency of three times a day at 08:00–09:00, 12:00–13:00, and 16:00–17:00. The feed used was a commercial sinking feed with a pellet size of 3 mm. The amount of feed was recorded daily. The proximate composition of the test feeds is presented in Table 1.

Table 1. Feed proximate analysis.

Component	Feed Brand			
	A	B	C	D
Moisture (%)	10.87	9.80	10.12	9.76
Crude Fiber (%)	4.70	5.06	5.10	5.23
Protein (%)	28.10	28.80	28.90	29.12
Ash (%)	7.13	9.24	9.45	9.22

Fat (%)	7.04	6.90	6.89	6.99
NFE(%)*	42.16	40.21	39.54	39.68
GE (kcal kg^{-1})**	4447	4334	4324	4338

* Nitrogen Free Extract (NFE) = 100% – (moisture + protein + fat + ash + fiber)
** Gross Energy Composition (GE) was calculated based on protein = 5.64 kcal/g protein, fat = 9.44 kcal/g fat, and carbohydrate/NFE = 4.11 kcal/g carbohydrate [7].

2.4 Analysis

Evaluating growth performance in aquatic species typically involves assessing parameters that track changes throughout their life cycle [8]. Emphasis is often placed on early growth stages to better understand feed efficiency and overall development. This principle informed the choice of growth indicators in this study, which included Survival Rate (SR), Specific Growth Rate (SGR), Feed Intake (FI) [9], Feed Conversion Ratio (FCR) [10], Protein Efficiency Ratio (PER) [11], and Feed Cost Gain (FCG).

Proximate analysis was conducted following the Association of Official Analytical Chemists (AOAC) standard procedures. This analysis was performed on both the experimental feed and the test fish at the beginning and end of the rearing period. The proximate components analyzed included crude protein, moisture content, crude fiber, crude fat, ash content, and nitrogen-free extract (NFE). Protein content was determined using the Kjeldahl method, which involves three main steps: digestion, distillation, and titration. Fat content was assessed using two methods—Folch method for wet fat content and Soxhlet extraction for dry fat content. Moisture content was measured by drying samples in an oven at 110°C, while ash content was determined by incinerating samples in a muffle furnace at 600°C. Crude fiber was analyzed through a process involving strong acid and alkali digestion followed by heating. The nitrogen-free extract (NFE) was calculated by subtracting the sum of other proximate components from 100%.

Water quality monitoring included daily measurements of temperature, dissolved oxygen (DO), and pH at 06:00, 12:00, and 17:00. In addition, total ammonia nitrogen (TAN), nitrite, and nitrate levels were assessed three times during the culture period—on days 7, 40, and 90. The collected data were tabulated using Microsoft Excel 365 and analyzed descriptively, following the approach used in previous research [12].

3 Result and discussion

Water quality is a crucial factor in aquaculture, significantly influencing fish health, growth rates, and feed efficiency. Throughout the 100-day rearing period, several key water quality parameters were monitored regularly on days 7, 40, and 90 across all four treatment groups (A, B, C, and D). The results indicate consistent and suitable environmental conditions for common carp (*Cyprinus carpio*). The water quality is shown on Table 2.

Table 2. Water quality in floating net cage.

Parameter	**Net Cage**			
	A	**B**	**C**	**D**
DO (mg L^{-1})	2.7-5.9	2.7-5.9	2.7-5.9	2.7-5.9
Temperature (°C)	26.9–30.8	26.9–30.8	26.9–30.8	26.9–30.8
pH	6.72–7.79	6.72–7.79	6.72–7.79	6.72–7.79

TAN*	0.12	0.10	0.11	0.08
Nitrite (mg L^{-1})	0.02	0.02	0.02	0.02
Nitrate (mg L^{-1})	0.04	0.2	0.4	0.3

*Total Ammonia Nitrogen

The dissolved oxygen levels ranged from 2.7 to 5.9 mg L^{-1} across all treatments, showing no variation between groups. These DO concentrations are generally within the acceptable range for common carp culture. However, the lower end of 2.7 mg L^{-1} approaches the minimum threshold at which fish may experience stress. Ideally, DO levels should be maintained above 3 mg L^{-1} to support optimal metabolic activity and growth.

Water temperature remained stable across all treatments, ranging between 26.9°C and 30.8°C. This temperature range is considered optimal for carp culture as it promotes healthy feed intake and metabolic functions. The absence of sudden temperature fluctuations ensured a stable environment conducive to consistent fish growth. The pH values observed ranged from 6.72 to 7.79, indicating a slightly acidic to neutral environment, which is appropriate for common carp. The minimal fluctuations in pH suggest effective buffering capacity in the water and low accumulation of organic waste, contributing to a healthy aquatic environment.

TAN concentrations varied slightly among treatments, with values ranging from 0.08 mg L^{-1} in treatment D to 0.12 mg L^{-1} in treatment A. All values remained well below the commonly accepted safe limit of 0.5 mg L^{-1} for carp, indicating that ammonia toxicity was unlikely during the study. The small differences in TAN may reflect variations in feed utilization efficiency or waste production. Nitrite levels were consistent across all treatments, measured at 0.02 mg L^{-1}. This low concentration is considered safe, as elevated nitrite can interfere with oxygen transport in fish, causing conditions such as brown blood disease. No adverse effects were reported, indicating that nitrite levels were well controlled. Nitrate concentrations ranged from 0.04 mg L^{-1} in treatment A to 0.4 mg L^{-1} in treatment C. While nitrate is less toxic compared to ammonia and nitrite, it serves as an important indicator of the nitrogen cycle and overall water quality stability. The slightly higher nitrate level in treatment C may indicate more efficient nitrification processes or differences in organic matter decomposition linked to feed breakdown.

All water quality parameters remained within safe and acceptable ranges for common carp culture throughout the duration of the experiment. The uniformity of these parameters across treatments suggests that any observed differences in fish growth performance and feed efficiency are likely due to the feed treatments themselves rather than variations in environmental conditions.

Feed plays a crucial role in supporting fish growth, and its rates can vary significantly between fish species due to differences in individual nutritional requirements. In aquaculture, the success of fish growth largely depends on how well the feed meets these nutritional needs. Fish growth is also influenced by factors such as sex, environmental conditions, larval development, and overall health status [13].

Efficient protein absorption from feed contributes significantly to growth by providing amino acids necessary for repairing damaged muscle cells, thereby supporting tissue development rather than being diverted for energy use [14]. Proteins also serve as the primary building blocks of muscles, ligaments, tendons, and internal organs [15]. The growth performance of common carp reared for 100 days in the Cirata Reservoir, West Java, and fed with different commercial feeds is presented in Table 3.

Table 3. The growth performance of common carp reared for 100 days in the Cirata Reservoir, West Java.

Parameter	**Feed Brand**			
	A	**B**	**C**	**D**
SR (%)	83	95	83	87
FI (kg)	123.5	156.4	157.3	160.6
B0 (kg)	15	15	15	15
Bt (kg)	70	100	99	104
ADG (g)	133.53	165.33	188.46	187.50
FCR	2.09	1.84	1.87	1.80
SGR (%)	3.67	5.67	5.69	5.93
PER	1.58	1.89	1.85	1.90
FCG (Rp)	22,188	19,320	19,943	18,947

*(SR) Survival Rate, (FI) Feed Intake, (B0) Initial Biomass, (Bt) Final Biomass, (ADG) Average Daily Gain, (FCR) Feed Conversion Ratio, (SGR) Specific Growth Rate, (PER) Protein Efficiency Ratio, (FCG) Feed Cost Gain

Table 3 presents the growth performance of common carp (*Cyprinus carpio*) reared for 100 days in the Cirata Reservoir, West Java, under four different commercial feed treatments (A–D). Although all feeds had comparable crude protein levels (approximately 28–29%), notable differences were observed in growth parameters, indicating that factors beyond crude protein content—such as feed formulation, digestibility, and palatability—play a significant role in influencing fish performance.

Survival Rate (SR) ranged from 83% in Treatments A and C to 95% in Treatment B, suggesting relatively consistent fish health across treatments, with Treatment B demonstrating the highest survivability. Feed Intake (FI) was highest in Treatment D (160.6 kg), slightly above the other groups, potentially reflecting better feed palatability or higher appetite due to improved feed quality. Despite all treatments starting with the same initial biomass (15 kg), final biomass (Bt) varied significantly, with Treatment D achieving the highest at 104 kg and Treatment A the lowest at 70 kg, demonstrating superior overall growth in Treatment D.

Although the crude protein contents of the experimental feeds were relatively similar (28.10 – 29.12%), significant differences in growth performance and feed utilization were observed among treatments. This indicates that fish growth was not determined solely by total protein level, but rather by overall feed quality, including protein source, digestibility, amino acid balance, fiber content, and processing characteristics. Previous studies have consistently reported that diets with comparable crude protein levels can results in different growth and feed efficiency due to variations in protein origin and nutrient availability [15].

Average Daily Gain (ADG) values were also highest in Treatments C and D, at 188.46 g and 187.50 g respectively, indicating more efficient nutrient conversion into body mass. In terms of feed efficiency, Treatment D recorded the lowest Feed Conversion Ratio (FCR) at 1.80, meaning less feed was required to produce each kilogram of fish, while Treatment A showed the least efficient conversion with an FCR of 2.09. Similarly, Specific Growth Rate (SGR) was highest in Treatments D (5.93%) and C (5.69%), further highlighting their superior daily growth performance.

Protein Efficiency Ratio (PER), which reflects the efficiency of protein utilization, was again highest in Treatment D (1.90), suggesting better assimilation of dietary protein into fish biomass. This may be attributed to differences in protein sources used in the feeds, such as varying proportions of fish meal, soybean meal, or other plant – or animal – based ingredients, which influence amino acids profiles and digestibility. Diets with better-balanced essential amino acids and lower anti-nutritional factors have been shown to enhance protein retention and growth efficiency in common carp. Furthermore, Feed Cost per Gain (FCG)—a critical economic indicator—was lowest in Treatment D at Rp 18,947, making it the most cost-effective option despite its slightly higher feed intake. Collectively, these results suggest that Treatment D provided the best combination of biological performance and economic return, underscoring the importance of overall feed quality in aquaculture production.

4 Conclusion

Although the commercial feeds used had similar protein levels, growth performance varied significantly. The best growth and feed utilization were achieved with Treatment D (protein 29.12%), which showed the lowest FCR (1.80) and the most economical feed cost per gain (Rp 18,947 or $1.13). This suggests that not only protein percentage but overall feed quality and composition significantly influence production outcomes.

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