Growth Performance, Feed Efficiency and Feed Cost per Gain of Juvenile Redclaw Crayfish *Cherax quadricarinatus* Fed Different Commercial Diets

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ABSTRACT

Aquaculture production is greatly influenced by species growth, feed efficiency, and feed costs. This study aims to evaluate different commercial diets on growth performance, feed efficiency, and feed cost per gain of juveniles redclaw crayfish *Cherax quadricarinatus*. The study used three treatments triplicate, consisting of Diet A (commercial diet with crude protein 40%), Diet B (commercial diet with crude protein 41%), and Diet C (commercial diet with crude protein 41%). The initial crayfish, with sizes of 0,24 ± 0,03 g and 2,1 ± 0,1 cm, were stocked in nine glass tanks (100 cm × 40 cm × 40 cm) with a stocking density of 50 crayfish m^{-2} for 60 days. The crayfish were fed twice daily at 07.00 am and 05.00 pm under a restricted feeding rate of 3% of biomass. The result shows that the final weight, average daily growth, specific growth rate feed conversion ratio, protein retention, and protein efficiency ratio did not differ in each treatment (P>0,05). Besides, the feed cost per gain (FCG) showed that diet B and diet C were better than diet A (P<0,05), with values of IDR 27,679±2,378 kg^{-1} and IDR 26,579±2,624 kg^{-1}, respectively, which means those treatments having better economic value. So, This study concluded that commercial diet C is recommended as feed for redclaw crayfish because it is more economical.

Keywords: commercial diet, feed cost, growth, redclaw crayfish

1. INTRODUCTION

The redclaw crayfish, *Cherax quadricarinatus*, is native to Australia (Queensland) and Asia (Papua) (Papua) (Ghanawi & Saoud, 2012; Muhammadin et al., 2022). This species has good potential to develope in Indonesia, where it was initially popular as ornamental fish but is now becoming popular for consumption. Interest concerning growing crayfish as a food source has grown since 2002 (Mamonto et al., 2023; Webster et al., 2004). However, crayfish production is still deficient for supplying market demand (Sarmin et al., 2020). In addition, this commodity provides technical production advantages such as ease of culture, resistance to stress and disease, and relatively high growth and reproduction (Lengka & Kolopita, 2013; Saoud et al., 2013).

As a novel commodity in aquaculture that has yet to be widely developed, establishing commercial diet is one of the challenges in growing redclaw crayfish. Commercial diets explicitly designed for refclaw crayfish are lacking in the market, even though the feed is the major component of cost production in aquaculture activities (Ansari et al., 2021; Suprayudi et al., 2023) and also has a significant impact on growth, feed efficiency, and waste production (Hardy & Kaushik, 2022). Choosing high-quality feed at an affordable price is critical to ensuring the long-term viability of redclaw crayfish production.

A high-quality diet must provide macro and micronutrients that fish require for energy metabolism, physiological and biochemical activities. According to standard in Indonesia (SNI 7675), the diet for crayfish contains a minimum crude protein of 40% for sizes under 2.5 cm, 36% for sizes 2.5-5 cm, 34% for sizes 6-10 cm, 30% for size over 10 cm, and 35% for broodstock (BSN, 2013). The review results suggested the nutritional requirements for redclaw crayfish were a protein content of 35%, lipid of 6%, and 18-20

ME kg^{-1} feed (Cortes-Jacinto et al., 2005; Saoud et al., 2013). Cortes-jacinto et al. (2004) found that using primary plant-based raw material in the redclaw crayfish diet is preferred over animal-based raw materials. However, commercial crayfish diet has not fully developed like other crustacean species. So far, the only alternative for producing redclaw crayfish is to use commercial diet from other commodities such as shrimp or fish (Saoud et al., 2012).

The optimum diet based on its nutritional content may achieve optimal growth and feed efficiency. Feed efficiency can be improved by reaching the requirement of non-protein energy source, so that protein can be optimal for growth (Fry et al., 2018; Hendriana et al., 2023; Suprayudi et al., 2023; Wahyudi et al., 2023) as reflected in the values of the protein efficiency ratio and feed conversion ratio. Furthermore, commercial diet prices vary widely, ranging from IDR 24,000 to IDR 49,000 per kg of feed with a similar crude protein content. Therefore, selecting commercial diet available in the market is necessary to determine the best diet alternative to support the growth and economic value in redclaw crayfish production. This study aims to evaluate different commercial diets on growth performance, feed efficiency, and feed cost per gain of juvenile redclaw crayfish *Cherax quadricarinatus*.

2. MATERIALS AND METHODS

2.1.1 Experimental Design and Diet Preparation

This study used an experimental design with a Completely Randomized Design (CRD) consisting of three treatments and three replications. The treatments are three iso-nitrogenous commercial diets: A, B, and C. Commercial diet A, priced at IDR 48,960 kg^{-1}, was obtained from an agent in Depok City; commercial diet B, priced at IDR 26,730 kg^{-1}, was obtained from an agent in Tangerang Regency, while commercial diet C, priced at IDR 24,999 kg^{-1}, was obtained from an agent in Tulungagung Regency. The proximate composition of the diet and the feed price are shown in Table 1.

2.1.2 Redclaw Crayfish Maintenance

The juvenile crayfish sizes 0.24 ± 0.03 g and 2.1 ± 0.1 cm were obtained from Tasik Lobster Business Unit (Taster), Tasikmalaya, Indonesia. The crayfish were distributed to nine glass aquariums measuring 1 m × 0.4 m × 0.4 m and 20 cm water level. The crayfish fed the treatment diet twice daily at 07.00 am and 5.00 pm for 60 days with a density of 50 tails per m^{-2}. Feeding is based on a feeding rate (FR) of 3% crayfish biomass. Weight, length, and survival rates were measured at the experiment's initial and final and regularly monitored every two weeks. Water quality is maintained by siphoning waste every two days. During maintenance, water quality is regularly evaluated twice daily with the result for temperature 24.0-28.4 °C, pH 8.0-9.3, dissolved oxygen 5.6-13.4 mg L^{-1}, and total ammonia nitrogen 0.00 - 0.24 mg L^{-1}.

2.1.3 Proximate analysis

Proximate analysis was done on test diet in the Fish Nutrition Laboratory, Department of Aquaculture, IPB University, according to the Association of Official Analytical Chemists method (AOAC, 2012). Water content was analyzed in an oven at 105-110°C for 12 hours. Protein analysis using the Kjeldahl method. Low acid and base dissolution were used to conduct crude fiber analysis. Ash content was determined using a furnace set to 600°C. The Soxhlet method is used to analyze the lipid content of diet. The Folch method determines whole body and liver lipid content (Watanabe, 1998) were analyzed at PT. Saraswanti Indo Genetech, Bogor.

2.1.4 Parameters

The research parameters, such as absolute length gain (ΔL), average daily growth (ADG), specific growth rate (SGR), feed intake (FI), feed conversion ratio (FCR), protein efficiency ratio (PER), protein retention (PR), survival rate (SR), and feed cost per gain (FCG), were meticulously evaluated. These parameters were calculated with the following formulas:

$$\Delta L \text{ (cm)} = \text{final lengh (cm)} - \text{initial leng (cm)}$$

$$ADG \text{ (g day}^{-1}\text{)} = \frac{\text{final weight (g)} - \text{initial weight (g)}}{\text{period (day)}}$$

$$\text{SGR (\% hari}^{-1}\text{)} = \frac{\text{bobot rata-rata akhir (g)} - \text{bobot rata-rata awal (g)}}{\text{waktu (hari)}} \times 100$$

$$\text{FCR} = \frac{\text{feed intake (g)}}{\text{final biomass(g)} - \text{initial biomass (g)}}$$

$$\text{PER (\%)} = \frac{\text{final biomass (g)} - \text{initial biomass(g)}}{\text{protein intake (g)}} \times 100$$

$$\text{PR (\%)} = \left[\frac{\text{final protein body content (g)} - \text{initial protein body content (g)}}{\text{protein intake (g)}}\right] \times 100$$

$$\text{SR (\%)} = \frac{\text{final amount of crayfish}}{\text{initinal amount of crayfish}} \times 100$$

Feed Cost per Gain (IDR kg^{-1} crayfish) = feed price (IDR kg^{-1}) × feed conversion ratio

2.1.5 Data Analysis

The data were tabulated using Microsoft Excel 2010 and analyzed using IBM SPSS Statistics software version 26. The distributed normal and homogenous data were analyzed using One-way ANOVA with a 95% confidence level. If there was a difference, the data were further tested using the Duncan Multiple Range Test (DMRT). Meanwhile, the data that did not show a normal and homogeneous distribution were analyzed using the Kruskal-Wallis test.

3. RESULT

3.1.1 Growth Performance

The results of growth performance are shown in Table 2. The Kruskal Wallis test found no significant difference ($p < 0.05$) between commercial diet treatments A, B, and C regarding ΔL, ADG, SGR, and SR parameters. The FI parameters also showed no significant difference ($p>0.05$) between treatments based on One-Way ANOVA analysis at a 95% confidence level.

3.1.2 **Feed Efficiency and Feed Cost per Gain**

The result of protein retension (PR) and protein efficiency rasio (PER) shown in Tabel 1. The result shown that PR and PER did not show significant difference ($p>0.05$). The results of the feed conversion ratio (FCR) and feed cost per gain (FCG) are shown in Figure 1. The results of the FCR of redclaw crayfish did not show significant differences in the provision of commercial diet A, B, and C with values of 1.1 ± 0.0, 1.0 ± 0.1, and 1.1 ± 0.1, respectively. However, in the FCG parameter, commercial diets B and C showed significantly different values from diet A ($p < 0.05$). Diet A, with a higher diet price, did not perform better than diets B and C. The FCG values of diets A, B, and C were IDR 51,587 ± 1,072, IDR 27,679 ± 2,378, and IDR 26,579 ± 2,624 per kg of redclaw crayfish.

4. DISCUSSION

Feed is vital to determining the success of redclaw crayfish culture (Berampu et al., 2021). Redclaw crayfish require consistently available quality diet. Diet quality is influenced by its nutrient content. Crayfish growth depends on protein availability in diet because protein is a main energy source and the nutrient essential for growth. The diet quality used in the study showed the growth performance by utilizing the available diet. This crayfish accepted and consumed the three different diets given equally well among the commercial diets. This treatment also did not affect the survival rate of redclaw crayfish. This is also evidence of crayfish maintenance in this study in optimal conditions, especially water quality (Azhari et al., 2017; García-Guerrero et al., 2013; Ghanawi & Saoud, 2012; Jones, 1995; Mamonto et al., 2023; Prymaczok et al., 2012; Rihardi et al., 2013; Saoud et al., 2013).

Quantitative growth can be seen from the increase in length, average daily growth, and specific growth rate. The growth length is influenced by the molting process. Commercial diets in treatments A, B, and C have the same quality. Protein is vital as the primary source of energy needed for growth and repair of cell or tissue damaged, as well as a component of essential amino acids (Hardy & Kaushik, 2022). These three commercial diets meet the protein requirement of redclaw crayfish with a protein content of 40%. The quality of this protein is also greatly influenced by the amino acid composition; the availability of balanced essential amino acids affects the rate of protein utilization for cell proliferation so that fish can grow faster (Hardy & Kaushik, 2022).

Optimal diet utilization efficiency is achieved at the lowest FCR value, which indicates that the energy obtained by crayfish is mainly used for growth. Feed utilization efficiency is influenced by the types of nutrient sources selected. The FCR values vary between treatments, ranging from 1.0 to 1.1. According to Fry et al., (2018), with a low FCR value, the diet is more efficiently utilized in the body. Berampu et al., (2021) state that FCR value is impacted by its size and the diet quality.

Feed is the most significant variable cost component in aquaculture production activities (Ansari et al., 2021; Suprayudi et al., 2023), including in redclaw crayfish culture. The high feed efficiency will reduce feed costs. Feed cost per gain (FCG) can be a simple but effective parameter for assessing feed economics (Handayanta et al., 2018)..

Feed cost per gain (FCG) is the amount of feed to produce one kilogram of crayfish. The higher the FCG value, the higher the feed cost for redclaw crayfish to produce 1 kg of crayfish. The FCG values are influenced by the amount of feed intake, biomass, and feed price per kg in each treatment.

High feed prices do not necessarily indicate better performance. This may be due to the commercial diet was not explicitly designed for the redclaw crayfish, which has slight differences and physiological responses. Another distinction between redclaw crayfish and other crustaceans is that they better utilize diet derived from plant sources than animal sources (Cortes-jacinto et al., 2004). Animal raw materials are generally more expensive than plants; the author suspects that more expensive diet does not result in better growth performance. Due to the limitations of this study, the raw materials composition of commercial diet used in this study cannot be determined further.

5. CONCLUTION

Providing commercial diets A, B, and C to juvenile redclaw crayfish resulted in the same growth rate. Commercial diet C has the lowest feed cost per gain (FCG) performance and is the preferred commercial diet for redclaw crayfish production.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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Tabel

Tabel 1. Proximate composition of difference comercial diet

Composition	**Diet**		
	A	**B**	**C**
Crude Protein (%)	40	41	41
Lipid (%)	5	6	6
Ash (%)	13	14	12
Fiber (%)	4	5	5
NFE* (%)	38	34	36
Feed Price (IDR kg^{-1})	48.960	26.730	24.999

*Nitorgen-Free Extract (NFE) = 100–(crude protein + lipid + fiber + ash).

Table 2. Growth performance of redclaw crayfish *Cherax quadricarinatus* fed different commercial diets

Parameters	**Diet**		
	A	**B**	**C**
W_0 (g ind^{-1})	0,22±0,02[a]	0,22±0,03[a]	0,26±0,03[a]
W_t (g ind^{-1})	1,99±0,27[a]	1,85±0,05[a]	2,06±0,13[a]
B_0 (g)	4,47±0,40[a]	4,50±0,62[a]	5,18±0,59[a]
B_t (g)	39,84±5,48[a]	36,95±1,05[a]	41,24±2,59[a]
ΔL (cm)	2,4±0,2[a]	2,2±0,1[a]	2,2±0,1[a]
ADG (g day^{-1})	0,03±0,00[a]	0,03±0,00[a]	0,03±0,00[a]
SGR (% day^{-1})	3,64±0,13[a]	3,52±0,18[a]	3,46±0,29[a]
SR (%)	100±0[a]	100±0[a]	100±0[a]
FI (g)	37,24±5,17[a]	33,62±3,21[a]	38,14±1,76[a]
PER	2,37±0,05[a]	2,37±0,20[a]	2,31±0,23[a]
PR (%)	31,01±1,12[a]	32,78±10,13[a]	30,81±0,42[a]

W_0 = initial weight. W_t = final weight. B_0 = initial biomass. B_t = final biomass. ΔL = absolute length gain. ADG = average daily growth. SGR = specific growth rate. KH = survival rate. FI = feed intake. PER = protein efficiency ratio. PR = protein retention.

Figure

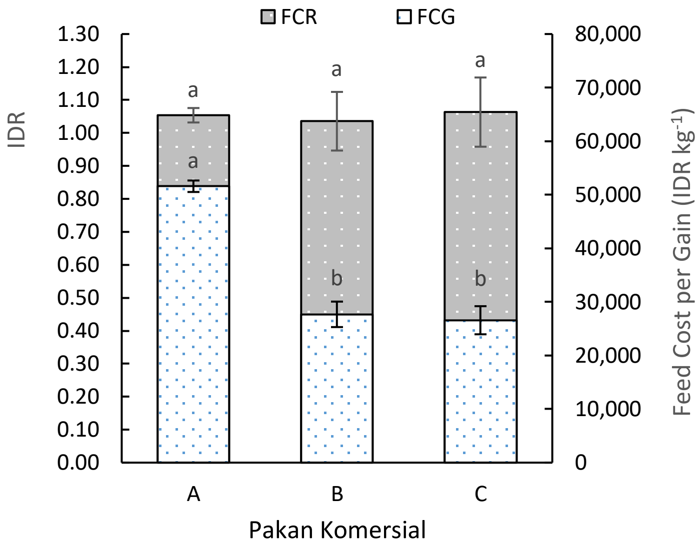

Figure 1. Feed Conversion Ratio (FCR) and Feed Cost per Gain (FCG) redclaw crayfish fed difference comercial diet for 60 days.