E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(4): 280-287

www.fisheriesjournal.com
Received: 14-05-2020
Accepted: 16-06-2020

Alfian Adi Prakoso
Coastal Resource Management Study Program, Faculty of Fisheries and Marine Science, Diponegoro University. Jalan Prof. Soedarto, SH Tembalang Semarang, Indonesia

Joko Suprapto
Aquatic Resources Department, Faculty of Fisheries and Marine Science, Diponegoro University. Jalan Prof. Soedarto, SH Tembalang Semarang, Indonesia

Dan Subandiyono
Aquaculture Department, Faculty of Fisheries and Marine Science, Diponegoro University. Jalan Prof. Soedarto, SH Tembalang Semarang, Indonesia

Corresponding Author:
Alfian Adi Prakoso
Coastal Resource Management Study Program, Faculty of Fisheries and Marine Science, Diponegoro University. Jalan Prof. Soedarto, SH Tembalang Semarang, Indonesia

Influence of protein and the level of energy-protein feed ratio on growth of banana shrimp (*Fenneropenaeus merguiensis* de Man)

Alfian Adi Prakoso, Joko Suprapto and Dan Subandiyono

Abstract
Banana shrimp is an economically valuable fishery commodity. Shrimp farming activities use artificial feed as a source of nutrition. The quality of artificial feed can be assessed from protein and energy content. Feeds with protein levels that are too high result in production costs to swell and potentially pollute the environment. Based on several studies, shrimp can be fed relatively lower feed with an energy-protein balance ratio. Based on these descriptions, research is needed to get the optimal protein and energy-protein ratio for the growth of shrimp. The purpose of this study was to determine the effect of protein content and the level of energy-protein feed ratio on the growth of banana shrimp. The study used laboratory experimental methods with a completely randomized design (CRD) factorial pattern. The treatment consisted of two factors, namely protein content (25%; 30%; 35%; 40%) and energy-protein ratio (8.5 kcal/g and 9.5 kcal/g), then control using commercial feed with levels protein 40% with an energy-protein ratio of 8.5 kcal/g. During the study, collected data were on weights, mortality, leftover feed, shrimp body proximate, and faeces. The data was used to calculate the feed consumption level (FCL), protein efficiency ratio (PER), protein digestibility, protein retention, energy digestibility, energy retention, food conversion ratio (FCR), survival rate (SR), and relative growth rate (RGR). The results showed that the best PER, protein digestibility, protein retention, and RGR values were found in the treatment of protein 35% energy-protein ratio 8.5 kcal/g, while the best feed consumption level value, energy digestibility, and survival rate were found in the protein treatment 40% ratio energy-protein 9.5 kcal/g. Based on the regression analysis, the optimal treatment was the energy ratio of 8.5 kcal/g with a protein content of 34.4%.

Keywords: *Fenneropeneus merguiensis,* protein and energy-protein levels, growth, nutrition

Introduction

Banana shrimp (*Fenneropenaeus merguiensis* de Man) is a native shrimp of Asia Pacific which has high economic value when compared to other fishery commodities. According to Pramonowibowo *et al.* (2007) [1], the production of banana shrimp is still dominated by fishermen's catch, but this local shrimp has the potential to be cultivated in Indonesia. The success of the development of shrimp farming determined by various factors, one of which is the feed that plays a role in meeting nutritional requirements. Technically, the feed used as an energy source for body activity of shrimp and on sufficient conditions the feed used for growth [2].

The content of protein and energy in feed is one of the main factors in formulating formulations. Energy from non-protein is sufficiently available, most of the protein used for growth, but if the energy from non-protein was not fulfilled, the protein will be used as an energy source and its function as a builder will be reduced [3]. The right balance between energy and protein in the feed is needed to achieve optimal growth [4].

Various studies state that *Penaeid* shrimp require a wide range of feed protein content. Protein content of 60% significantly had a good growth performance for banana shrimp seeds compared with 40-55% protein feed, but the 60% protein content feed was considered not applicable to the current cultivation business reality [5]. This is because it will make the cost of feed swell. According to, the feed protein content of 30% and 42% in banana shrimp did not show significant growth differences [6]. Determination of the ratio of energy-protein (E/P) in feed aims to obtain optimal shrimp growth. Low amount of energy in the feed causes the protein content to be used as an energy source, otherwise excess energy will make the shrimp appetite decrease, so that growth will decrease [7]. Information on E/P in banana shrimp and other *Penaeid* shrimp is available. Juvenile banana shrimp that were fed with 40% protein content and E/P 10.5 kcal/g can provide optimum growth [8]. Giant tiger prawn (*Penaeus monodon*) which is fed with 36.64% protein content and E/P 8.48 kcal/g can achieve optimum growth [9]. Vannamei shrimp (*Litopenaeus vannamei*) fed with 45% protein content and E/P 9.5 kcal/g can provide the best growth [4].

Based on some of the above research results, it can be concluded that shrimp can be cultivated at relatively lower protein levels by considering the energy-protein ratio in the feed. The purpose of this research is to find out the best protein content and energy-protein ratio level for the growth of banana shrimp. The results of the research are expected to be the basic information in determining feed formulations for banana shrimp.

Materials and methods

Materials

The tools used in the study include electric scales, flouring machines, drying machines, pellet moulding machines, ovens, reservoir tanks, storage tanks, rearing containers, aeration installations, filter paper, rulers, pH meters, Water Quality Checkers, and refractometers. The materials used in this research were detergent, chlorine, sodium thiosulfate, seawater, freshwater, and banana shrimp (*F. merguiensis* de Man) from Brackish Water Aquaculture Fisheries Centre Jepara domestication with an average initial weight of 0.42 grams.

Methods

This study used a completely randomized design (CRD) factorial pattern with three replications. Factors in the study consisted of 25%; 30%; 35%; 40% protein content with an energy-protein ratio of 8.5 kcal/g and 9.5 kcal/g, and commercial feed with a protein content of 40% and the energy-protein ratio of 8.5 kcal/g as a control, so there were as many as 27 experimental units with 25 stocking densities per container with a capacity of 100 litres of water. Materials and formulations of artificial feed used in the study are presented in Table 1, then proximate test results are presented in Table 2, while the composition of ingredients and proximate commercial feed used as controls is given in in Table 3. Feeding using a dose of 10% per day of biomass with a frequency of 4 times, namely at 08.00; 12.00; 16:00; and 20:00 WIB.

Variables to evaluate feed quality were Feed Consumption Level (FCL), protein digestibility, protein retention, energy digestion, and energy retention, while variables to evaluate the level of production performance include Food Conversion Ratio (FCR), Survival Rate (SR), and Relative Growth Rate (RGR). These variables were calculated by the formula:

FCL (g) = Feed Given - Remaining Feed [10]

$$\text{Protein Digestion}(\%) = \frac{PC}{PP} x\ 100\%$$

where,

$$PC\ (\%) = Pi - Pf \quad [10]$$

Information

PC = The amount of protein digested (%)
PP = The amount of protein in the feed (%)
Pi = The amount of protein consumed (%)
Pf = The amount of protein in faeces (%)

$$\text{Protein Retention}\ (\%) = \frac{Pt - P0}{Pi} x\ 100\% \quad [11]$$

Information

Pt = The amount of final protein in shrimp (g)
P0 = The amount of initial protein in shrimp (g)
Pi = The amount of protein consumed (g)

$$\text{Energy Digestibility}\ (\%) = \frac{EC}{EP} x\ 100\%$$

where,

$$EC\ (\%) = Ei - Ef \quad [10]$$

Information

EC = The amount of energy digested (%)
EP = The amount of energy in the feed (%)
Ei = The amount of energy consumed (%)
Ef = The amount of energy in faeces (%)

$$\text{Energy Retention}\ (\%) = \frac{Et - E0}{Ei} x\ 100\% \quad [11]$$

Information

Et = The amount of final energy in shrimp (g)
E0 = The amount of initial energy in shrimp (g)
Ei = The amount of energy consumed (g)

$$\text{Food Conversion Ratio} = \frac{FC}{BMt + D} \quad [12]$$

Information

FC = Feed consumed (g)
BMt = Biomass at the end of the rearing period (g)
D = Biomass of dead shrimp (g)

$$\text{Survival Rate}\ (\%) = \frac{Nt}{N0} x\ 100\% \quad [13]$$

Information

Nt = The number of shrimps that live at the end of the rearing period
N0 = The number of shrimps that die at the end of the rearing period

$$RGR\ (\%/day) = \frac{Wt - W0}{W0\ x\ t} x\ 100\% \quad [14]$$

Keterangan

Wt = Final average weight (g)
W0 = Initial average weight (g)
T = Rearing period (days)

Statistical analysis

Statistical analysis was performed to determine the effect of the treatment that was carried out. Some stages in the statistical analysis in this study include two-way ANOVA test, normality test, homogeneity test, additive test, one-way ANOVA test, Tukey test at 95% confidence level, linear and non-linear test (polynomial), scoring in each treatment, and simple linear regression analysis.

Results and discussion

Based on Table 4, feed with a protein-energy (E/P) ratio of 8.5 kcal/g had a negative polynomial patterned Feed

Consumption Level (FCL), where Feed Consumption Level at the protein content above 30% tended to decrease followed by increased protein content in the feed. These results are thought to be due to the fulfilment of the protein and energy requirements of banana shrimp (*F. merguiensis* de Man) at a protein feed level above 30%. Satisfaction of shrimp protein requirements was influenced by the content of essential amino acids and essential fatty acids found in feed [15]. These results differ from the E/P 9.5 kcal/g treatment, where the value of the FCL increases with increasing protein content in the feed. The highest FCL in all treatments was found in protein 40% with E/P 9.5 kcal/g with a value of 36.32 g. This is because the treatment has a high survival value, so it has implications for feed requirements. Besides, the protein treatment of 40% E/P 9.5 kcal/g uses squid oil in a relatively more amount compared to other treatments, so that shrimp can respond to feed quickly. One of the determinants of the FCL value was how the feed can stimulate shrimp appetite, where good feed attractants can increase the value of feed consumption, but this can lead to high values of Food Conversion Ratio (FCR), low feed efficiency in shrimp [16]. The results showed that both E/P 8.5 kcal/g and 9.5 kcal/g had positive polynomial patterns, where FCR values tended to be high in feeds with low protein feed levels and significantly decreased in feeds with 35% protein content, then FCR has the potential to increase in feed with protein levels above 35%. Based on Table 5, the best FCR values were obtained in the control and protein treatments of 35% E/P 8.5 kcal/g with FCR values of 2.24 and 2.28, respectively. These results were significantly different ($P < 0.05$) with the treatment of 25% protein content and E/P 8.5 kcal/g and 9.5 kcal/g which had FCR values of 3.54 ± 0.16 and 3.47 ± 0.28. These results are also in consistent with research conducted by Gopal and Raj (1990) [17], in which the protein content of 35% and 40% showed the best FCR results in *indicus* white shrimp with each value of 2.11 and 2.38 respectively. According to Anggoro and Subandiyono (2010) [18], revealed that the FCR value was influenced by several factors, including nutrient content and energy. The definition of FCR also interpreted as to how far the feed can provide a good and efficient growth response. When viewed biologically, FCR showed the use of efficient feed, where only a small amount of food was overhauled to meet the energy requirements of metabolism, the rest was used for growth [19].

Protein Efficiency Ratio (PER) was an illustration of the amount of protein that can be absorbed and utilized for growth. Based on the results of the study, the PER (Table 4) value in the E/P treatment was 8.5 kcal/g and 9.5 kcal/g tended to decrease along with the increase in protein content in the feed. Feeds with 30% protein and 35% at E/P 8.5 kcal/g had better PER values compared to other treatments with values of 1.25 ± 0.07 and 1.25 ± 0.12, respectively. Then the PER value decreased and showed a significant difference (P <0.05) at a protein level of 40% E/P 9.5 kcal/g with a PER value of 0.87 ± 0.05. These results were also following the research of Lee and Lee (2018) [20], that shrimp in juvenile stages experienced a significant decrease in PER values at 40% protein content. According to Colvin (1976) [21], excess protein levels in shrimp tend to be used for metabolic energy compared to tissue growth, where PER values in shrimp also have an inverse relationship with protein levels in feed. The analysis illustrates that it is necessary to reduce protein levels of shrimp feed in line with the development of stadia. High protein levels considered inefficient because the protein was expensive source of energy compared to carbohydrates and also fats [22].

Evaluation of feed quality can be seen from the value of protein digestibility (Table 4), where it illustrates how much protein in the feed can be digested by the body of shrimp. According to Suarez *et al.* (2008) [16], the higher the digestibility value of protein, the more protein has the potential to be a useful product in the body of shrimp. The results showed that there was a tendency to decrease the digestibility value of feed protein with a protein content above 35% in both E/P treatments. The treatment of protein feed levels of 35% with E/P 8.5 kcal/g had the best average protein digestibility value compared to other treatments, which was 76.92% and significantly different (P <0.05) with protein treatment of 25% E/P 9.5 kcal/g with a value of 52.58%. The highest protein digestibility value also correlates with observations on protein retention variables. Feed with protein treatment of 35% E/P 8.5 kcal/g has the highest protein retention value of 33.92% and significantly different from the lowest value of 14.22% in protein treatment 25% E/P 9.5 kcal/g. Based on these results, it can be said that with high protein digestibility, the protein that can be retained in the body of banana shrimp (*F. merguiensis* de Man) also getting higher. The correlation also occurred in vannamei shrimp (*Litopenaeus vannamei*), suggested that protein feed at 35% has higher protein digestibility and retention and was significantly different (P<0.05) significantly different from protein treatment feed of 25%, but not significantly different (P> 0.05) with the treatment of feed at 40% protein content [23]. The low value of protein digestibility in the 25% protein treatment caused by suboptimal nutrition so that the storage or retention of protein in the body also becomes low. Protein digestion and protein retention are interrelated, where shrimp will be able to digest and store protein optimally at certain levels [24].

Besides protein digestibility (Table 4), the research also examined energy digestibility variables. Value of energy digestibility is a picture of energy derived from sources of protein, fat, and carbohydrates that digested by shrimp [25]. Based on the results of the study, banana shrimp tends to experience a decrease in the value of energy digestibility in feed with protein above 30% E/P 8.5 kcal/g, whereas in the E/P treatment 9.5 kcal/g experience a different trend, where the value of energy digestibility has increased along with increasing levels of protein or energy in the feed. The highest digestibility value in the study obtained in the treatment of protein 40% E/P 9.5 kcal/g that was 35.85%, but in statistical analysis, there was no significant difference (P> 0.05) with other treatments. The high-energy digestibility value in the treatment of protein 40% E/P 9.5 kcal/g caused by the high-fat content in the feed given. This result negatively correlated with energy retention, where the energy retention value has an inverse relationship with energy digestibility. The energy retention (Table 4) value of the protein treatment 40% E/P 9.5 kcal/g was 15.10% and relatively low when compared to the protein treatment 30% E/P 9.5 kcal/g was equal to 20.23% (P < 0.05). The correlation between energy digestibility and energy retention values above shows that high energy digestibility values do not necessarily increase energy storage or retention in the body, so it can be assumed that shrimp will store energy after a certain amount of metabolic processes and will be excreted. This was also following the opinion of Kaligis (2005) [3], energy content that was too high used for metabolic requirements or the rest excreted through urine and faeces. Besides, there was also the possibility that in feed with protein 40% E/P 9.5 kcal/g convert existing nutrients to be used as metabolic energy and maintenance of the body with a greater amount than those stored in the body, so that energy retention in shrimp to be low. Protein and energy balance needed in formulating feed for shrimp, so it can fulfil the concept of protein-sparing effect. The feed can be said to have a good balance of protein and energy if most of the protein is used for growth, while non-protein-energy from fats and carbohydrates is used as source of energy [26].

Value of Survival Rate (SR) is one indicator of the level of product performance in shrimp farming activities and is a factor in how the quality of feed provided during the rearing period. The results showed the highest SR of 87% in the control treatment and 30% protein treatment with an energy ratio of 8.5 kcal/g. According to statistical analysis, these results were only significantly different (P <0.05) in the 25% protein treatment with the protein-energy ratio of 8.5 kcal/g and 9.5 kcal/g with SR (Table 5) values of 68% and 72%, respectively. The low SR value in all 25% protein content was thought to be caused by suboptimal nutrition for metabolic requirements which was then correlated with low RGR values in banana shrimp (*F. merguiensis* de Man) during the study. This reinforced by the results of research by [20], where feeds with 25% of protein content have a low SR compared to 30-50% protein content. The survival rate of all 25% of protein treatments decreased significantly compared to other treatments. Besides caused by low nutrition and energy in feed, it suspected that in the treatment of 25% protein feed levels have a high level of cannibalism. One effort to minimize the potential of cannibalism in shrimp is to provide adequate feed in terms of quality and quantity so that survival and growth rates can be achieved optimally [27].

Observation of growth in this study using the Relative Growth Rate (RGR) (Table 5) variable obtained by sampling every week on all live shrimp. According to Llalramchhani *et al.* (2019) [28], growth in banana shrimp (*F. merguiensis* de Man) can be achieved if the energy and protein in the feed are sufficient for tissue maintenance and metabolism, this is indicated by weight gain or length and the occurrence of the moulting process. Based on observations of weight gain, it can be seen that the protein treatment of 35% E/P 8.5 kcal/g has the most positive trend on the 7th day towards the 14th day and has the best weight gain until the end of the rearing period. Then the lowest growth trend found in the treatment of 25% E/P 8.5 kcal/g and E/P 9.5 kcal/g. These results indicate that feed with low protein is not optimal in meeting the metabolic requirements and growth of shrimp. In general, low protein feed can make shrimp growth not optimal and cause weight loss, to the worst possible cause of death, which is due to the protein that cannot meet the metabolic requirements of shrimp [29].

Figure 1 and 2 showed that the treatment of E/P 8.5 kcal/g and E/P 9.5 kcal/g shows the weight gain every week, this means that the feed can be absorbed for metabolic and growth requirements. The results of statistical analysis on both E/P 8.5 kcal/g and 9.5 kcal/g have the same trend, namely, there was a tendency to decrease the RGR value above the feed protein above 35%. The results of the 42 days study showed that feed with a protein content of 35% E/P 8.5 kcal/g had the best Relative Growth Rate (RGR) compared to other treatments, which was 3.57%. This value has a significant difference (P <0.05) compared to protein feed 25% E/P 8.5 kcal/g and 9.5 kcal/g. The results also showed that higher protein levels at 40% E/P of 8.5 kcal/g and 9.5 kcal/g of protein resulted in decreased RGR values, namely 3.32% and 3.12% respectively. This proves that low protein and energy levels in the feed cannot support shrimp growth well, then feeds with 40% protein content have good RGR values, but not better than 35% protein feed levels. In general, feed with a protein-energy ratio of 8.5 kcal/g has a better RGR result compared to a protein-energy ratio of 9.5 kcal/g at each protein content tested. It suspected that the high energy in the feed makes shrimp not optimal in absorbing the nutrients contained in the feed so that growth can be inhibited. Research conducted by Maghsoudloo *et al.* (2012) [15], proved that shrimp growth improved with decreasing digestible energy content, wherein the feed with a protein content of 35% protein-energy ratio 7.5 kcal/g showed the best SGR compared to the protein-energy ratio of 9 kcal/g and 10.5 kcal/g. Besides being able to potentially worsen the water quality maintenance, feed with energy that was too high will also only be excreted by shrimp through urine and faeces [28].

Determination of the best feed formulation treatment was known by scoring the results or the effect on the observed variables. There were 9 variables in this study and were divided into 2 categories, namely the evaluation of feed quality and the level of production performance. Based on Table 6, the protein treatment of 35% E/P 8.5 kcal/g gets the most score by giving the best effect on the PER variables, Protein Digestion, Protein Retention, and RGR. Next, a regression analysis was performed to determine the optimal protein content of feed for the growth of banana shrimp (*F. merguiensis* de Man).

Based on the results of the regression analysis presented in graphical form in Figure 3, shows that the optimal protein in the study was at 34.4% protein level, so it can be assumed that feed with protein content ≤ 35% can provide the best growth in banana shrimp (*F. merguiensis* de man) in the juvenile stage. This allegation is also reinforced by the results of research by Gao *et al.* (2016) [30], white shrimp weighing 0.31 - 6 grams have the best growth value with 34% protein feed content, while Shahkar *et al.* (2014) [31] added that the best RGR was obtained at 33% protein content with the fish meal as the main protein ingredient. The growth of the shrimp not only influenced by the amount of protein content of the feed but how the quality of the protein in the feed itself. The quality of the protein in the feed can be seen in the content of essential amino acids and the level of protein digestibility in the feed given to the shrimp [32]. The water parameter quality is given in Table 7.

Table 1: The feed formulation in each treatment for 1000 grams

Raw material	Treatment							
	25%		30%		35%		40%	
	8.5	9.5	8.5	9.5	8.5	9.5	8.5	9.5
Fish flour	130	130	190	200	280	300	400	470
Soy flour	170	170	220	220	230	210	187	90
Shrimp head flour	248.5	240	140	140	100	100	80	70

Wheat flour	220	202	210	190	170	130	90	80
Rice bran	150	140	130	90	68	50	40	30
Squid oil	1	28	20	50	50	80	83	100
Corn oil	0.5	10	10	30	22	50	40	80
Vitamin Mineral Mix	50	50	50	50	50	50	50	50
CMC*	30	30	30	30	30	30	30	30

*: Carboxy Methyl Cellulose

Table 2: The proximate composition in feed test

Proximate Composition	**Treatment**							
	25%		**30%**		**35%**		**40%**	
	8.5	**9.5**	**8.5**	**9.5**	**8.5**	**9.5**	**8.5**	**9.5**
Protein	25.32	25.52	30.43	30.64	34.93	35.68	40.09	40.67
Fat	3.63	7.34	7.02	11.83	11.77	17.50	18.52	24.02
Ash	18.47	17.88	14.01	13.63	12.54	12.33	12.48	12.22
Dietary fiber	12.88	11.96	10.87	9.13	7.96	6.26	5.58	4.27
NFE*	39.70	37.29	37.66	34.76	32.80	28.22	23.33	18.81
Total (%)	100	100	100	100	100	100	100	100
Energy** (DE/Kg Feed)	2173.25	2398.44	2573.90	2897.79	3006.85	3361.53	3448.62	3837.90
Energy/ Protein (Kcal DE/g)	8.51	9.55	8.57	9.58	8.51	9.53	8.53	9.53

*: Nitrogen Free Extract
**: DE (*Digestible Energy*) which is worth of 1 g protein= 3.5 kcal; 1 g fat = 8.1 kcal; 1 g NFE = 2.5 kcal [33]

Table 3: The proximate composition of commercial control feed

Composition	**Content (%)***
Protein	40.00
Fat	5-10
Calcium	1.5-2.5
Dietary Fiber (Roughage)	2,00
Phosphor	1.5-2.0
Lysine	2,3
Energy (DE/Kg Feed)	3400
Energy/ Protein (kcal DE/g)	8.5

*: Based on the proximate composition in commercial feed packaging

Table 4: The observations of the variable evaluation of feed quality

Treatment		**Variable Evaluation of Feed Quality**					
Protein (%)	**E/P (kcal/ g)**	**FCL (g)**	**PER**	**PD (%)**	**PR (%)**	**ED (%)**	**ER (%)**
25	8.5	33.84 ± 2.06^{a}	1.11 ± 0.05^{b}	57.58 ± 6.25^{ab}	17.08 ± 0.27^{a}	33.08 ± 2.02^{a}	13.54 ± 0.78^{b}
	9.5	30.32 ± 4.56^{a}	1.15 ± 0.10^{b}	52.58 ± 2.78^{a}	14.22 ± 0.98^{a}	29.55 ± 4.60^{ab}	18.41 ± 2.72^{b}
30	8.5	35.78 ± 1.18^{a}	1.25 ± 0.07^{b}	65.69 ± 2.77^{bc}	29.32 ± 1.55^{c}	35.13 ± 1.15^{ab}	17.52 ± 0.51^{b}
	9.5	33.97 ± 1.85^{a}	1.13 ± 0.05^{b}	57.15 ± 2.63^{ab}	21.49 ± 0.77^{b}	33.31 ± 1.88^{b}	20.23 ± 1.00^{b}
35	8.5	34.07 ± 3.38^{a}	1.25 ± 0.12^{b}	76.92 ± 2.49^{c}	33.92 ± 0.53^{d}	33.55 ± 3.39^{ab}	18.36 ± 1.45^{b}
	9.5	33.03 ± 3.81^{a}	1.15 ± 0.11^{b}	70.68 ± 1.73^{c}	22.96 ± 0.68^{b}	32.54 ± 3.78^{ab}	15.67 ± 1.47^{ab}
40	8.5	31.57 ± 1.56^{a}	1.05 ± 0.05^{ab}	75.85 ± 4.02^{c}	30.59 ± 2.38^{cd}	31.19 ± 1.61^{ab}	18.44 ± 0.99^{b}
	9.5	31.51 ± 4.26^{a}	0.87 ± 0.05^{a}	69.82 ± 0.87^{c}	24.58 ± 0.49^{b}	35.85 ± 4.28^{b}	15.10 ± 1.38^{a}
Control		31.51 ± 3.55^{a}	1.11 ± 0.04^{b}	33.57 ± 2.04^{d}	75.00 ± 8.03^{c}	33.57 ± 2.04^{d}	31.11 ± 3.66^{ab}

Information
abcd: Different letters in the same column showed significant differences ($P < 0,05$)
FCL (Feed Consumption Level), PER (Protein Efficiency Ratio), PD (Protein Digestibility), PR (Protein Retention), ED (Energy Digestibility), ER (Energy Retention)

Table 5: The results of observations of variable levels of production performance

Treatment		**Variable Levels of Production Performance**		
Protein (%)	**E/P (kcal/ g)**	**FCR (%)**	**SR (%)**	**RGR (%/day)**
25	8.5	3.54 ± 0.16^{d}	68 ± 4^{a}	2.68 ± 0.19^{ab}
	9.5	3.47 ± 0.28^{d}	72 ± 4^{ab}	2.27 ± 0.19^{a}
30	8.5	2.67 ± 0.16^{abc}	87 ± 5^{b}	3.17 ± 0.12^{cde}
	9.5	2.94 ± 0.12^{c}	83 ± 5^{b}	2.74 ± 0.12^{bc}
35	8.5	2.28 ± 0.22^{a}	83 ± 10^{b}	3.57 ± 0.20^{e}
	9.5	2.48 ± 0.23^{abc}	83 ± 6^{b}	3.14 ± 0.14^{cde}
40	8.5	2.36 ± 0.12^{ab}	83 ± 6^{b}	3.32 ± 0.12^{de}
	9.5	2.85 ± 0.15^{bc}	87 ± 6^{b}	3.12 ± 0.12^{bcd}
Control		3.40 ± 0.17^{de}	2.24 ± 0.09^{a}	87 ± 5^{b}

abcd: Different letters in the same column showed significant differences ($P < 0,05$)
FCR (Feed Conversion Ratio), SR (Survival Rate), RGR (Relative Growth Rate)

Table 6: The treatment scoring results

Treatment		Score of each Variable									Total Score	Ranking
Protein (%)	E/P (kcal/g)	FCL	PER	PD	PR	ED	ER	FCR	SR	RGR		
25	8.5	5	4	3	2	5	1	1	1	2	24	8
	9.5	1	6	1	1	1	7	2	2	1	22	9
30	8.5	8	8	4	6	8	4	5	7	6	56	2
	9.5	6	5	2	3	6	9	3	4	3	41	7
35	8.5	7	9	9	9	7	6	8	3	9	67	1
	9.5	4	7	6	4	4	3	6	5	5	44	6
40	8.5	3	2	8	7	3	8	7	6	7	51	4
	9.5	9	1	5	5	9	2	4	9	4	48	5
Control		2	3	7	8	2	5	9	8	8	52	3

Table 7: The water quality maintenance

Treatment		Water Quality Parameters			
Protein (%)	E/P (kcal/g)	Temperature (°C)	Dissolved Oxygen (DO) (ppm)	pH	Salinity (ppt)
25	8.5	26-30	5.0-7.3	6.5-7.7	29-31
	9.5	26-30	5.2-7.0	6.4-7.8	28-31
30	8.5	26-30	5.0-7.1	6.6-7.8	29-31
	9.5	26-30	5.1-7.0	6.5-7.8	29-31
35	8.5	26-30	5.3-7.0	6.5-7.7	29-31
	9.5	26-30	5.0-7.3	6.4-7.7	29-31
40	8.5	26-30	4.9-7.3	6.6-7.8	29-31
	9.5	26-30	4.8-7.3	6.6-7.7	28-31
K(40)	8.5	26-30	4.9-7.2	6.5-7.7	29-31
Optimal Value*		28.5-31.5	3.0-7.5	6.4-8.0	25-31

*: According to [34]

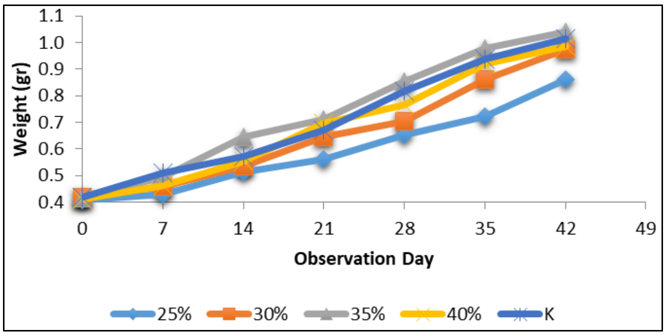

Fig 1: Weight gain per week for E/P 8.5 kcal/g treatment

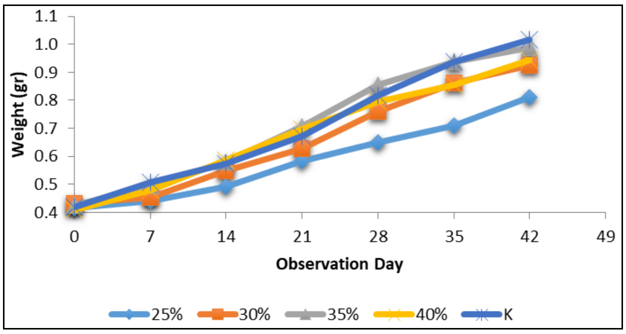

Fig 2: Weight gain per week for E/P 9.5 kcal/g treatment

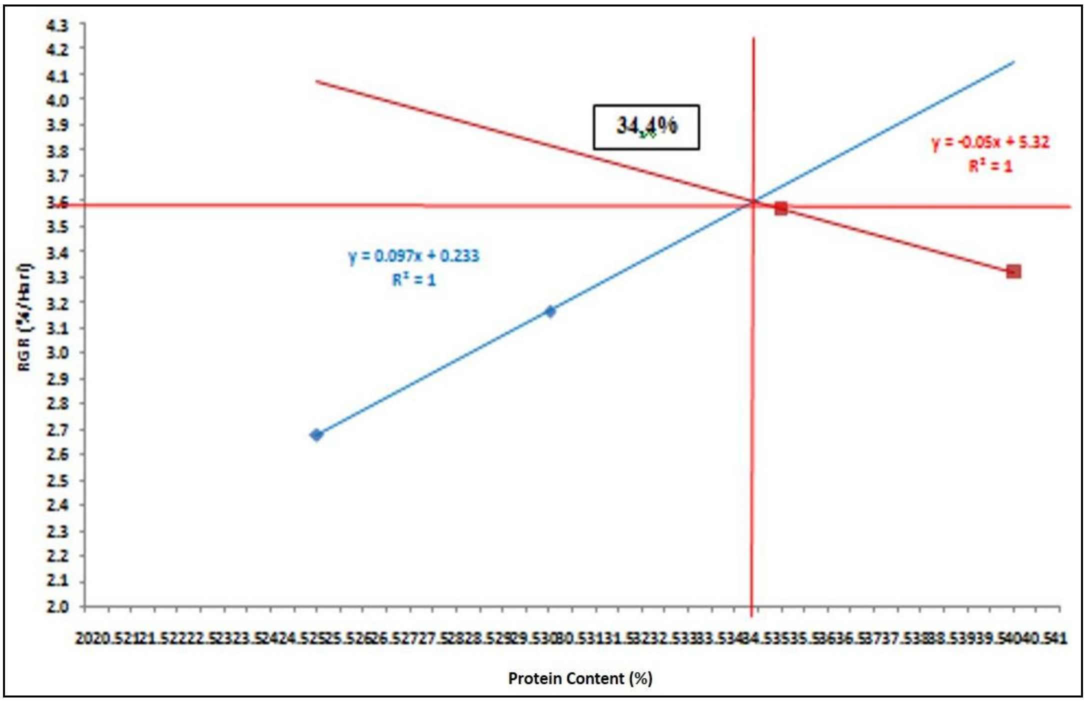

Fig 3: Optimal protein feed levels of banana shrimp

Conclusion

The results of the study showed that the best PER, protein digestibility, protein retention, and RGR values found in the protein treatment of 35% energy-protein with ratio 8.5 kcal/g, while the best Feed Consumption Level, energy digestibility, and Survival Rate found in the 40% treatment energy-protein ratio 9.5 kcal/g. Based on regression analysis shows that the optimum treatment is the energy ratio of 8.5 kcal/g with a protein content of 34.4%. The results of the study concluded that banana shrimp with feed test formulation had better growth compared to commercial feed.

References

1. Pramonowibowo A, Hartoko A, dan Ghofar. White Prawn Density (*Penaeus merguiensis* de Man) Around Semarang Water Areas. Jurnal Pesisir Laut. 2007; 2(2):18-29.
2. Zainuddin, Haryati, Aslamyah S, dan Surianti. Effect of Carbohydrate Level and Feed Frequency on Feed Conversion Ratio and Survival of Juvenile *Litopenaeus vannamei*. Jurnal Perikanan (J. Fish Sci.). 2014; 16(1):29-34.
3. Subandiyono, Hasturi S. Fish Nutrition. LP2MP UNDIP. Semarang, 2016.
4. Kaligis E. Growth Response of Vannamei Shrimp (*Litopenaeus vannamei*) in Low-Maternity Media with Different Protein and Calcium Feeds. Jurnal Ilmu dan Teknologi Kelautan Tropis. 2015; 7(1):225-234.
5. Tendulkar M, dan Kulkarni AS. Effect Dietary protein Levels on Growth, Survival and Biochemical Aspects of Banana Shrimp, *Fenneropenaeus merguiensis* (De Man, 1888). Biomedscidirect Publications. 2011; 2(4):1140-1143.
6. Nur A, Wdyani DA, Romadhona B, Adiwidjaya D, dan Rahardjo S. Potential Aquaculture of Local White Shrimp (*Penaeus merguiensis*) in Indonesia. Balai Besar Perikanan Budidaya Air Payau Jepara (BBPBAP; English: Brackish Water Aquaculture Fisheries Center Jepara), 2017.
7. Syamsumarno MB, Mokoginta I, dan Jusadi D. Effect of Various Protein-energy Ratios on 30% ISO Protein Feed on Growth Performance of Catfish Seedlings (*Pangasius hypophthalmus*). Jurnal Riset Akuakultur. 2011; 6(1):63-70.
8. Boonyaratpalin M. Nutrition of *Penaeus merguiensis* and *Penaeus indicus*. Review in Fisheries Science. 1998; 6(1-2):69-78.
9. Saade E, dan Aslamyah S. Uji Fisik dan Kimiawi Pakan Buatan untuk Udang Windu *Penaeus monodon* Fab. yang Menggunakan Berbagai Jenis Rumput Laut sebagai Bahan Perekat. Torani (Jurnal Ilmu Kelautan dan Perikanan). 2009; 19(2):107-115.
10. Lovell T. Nutrition and Feeding of Fish. Auburn University. Published by Van Nostrand Reinhold. New York, 1989, 260.
11. Thung PH, Shiau SY. Effect of Meal Frequency Performance of Hybrid Tilapia *Oreochromis Niloticus x O. Aureus*, Fed Different Carbohydrate Diet. Aquaculture. 1991; 92:343-350.
12. Djajasewaka H, dan Djajadiredja R. Effect of Artificial Foods with Different Dietary Fiber Content on Growth of Carp. Buletin Penelitian Perikanan Bogor. 1985; 1:55-57.
13. Halver JE. Fish Nutrition. Academic Press, Inc. London, 1988.
14. De Silva SS, Anderson TA. Fish Nutrition in Aquaculture Series One. Chapman and Hall. London, 1995.
15. Maghsoudloo T, Marammazi JG, Matinfar A, Kazemian M, Paghe E. Effects of Different Levels of Energy and Protein Sources on the Growth Performances, Feeding, Survival Rate, and the Chemical Body Composition of Juvenile Pacific White Shrimp. Iranian Journal of Fisheries Sciences. 2012; 11(3):531-547.
16. Suarez LEC, Salazar MT, Cavazos DV, Rocha JB, Lopez MGN, Lemme A, Marie DR. Apparent Dry Matter, Energy, Protein, and Amino Acid Digestibility of Four Soybean Ingredients in White Shrimp *Litopenaeus vannamei* Juveniles. Elsevier. Aquaculture. 2008; 292:87-94.
17. Gopal C, Raj RP. Protein Requirement of Juvenile *Penaeus indicus* 1. Food Consumption and Growth. Proceeding of Indian Academic Science (Animal Science). 1990; 99(5):401-409.
18. Anggoro S, dan Subandiyono. Osmotic Response, Efficiency of Feed Utilization and Energy Retention of Fine Shrimp (*Metapenaeus elegans*) Domesticated in Various Isoosmotic Media. Aquacultura Indonesiana. 2010; 11(3):217-223.
19. Li P, Galtin DM. Nucleotide Nutrition in Fish: Current Knowledge and Future Application. Aquaculture. 2006; 251:141-152.
20. Lee C, Lee KJ. Dietary Protein Requirement of Pacific White Shrimp *Litopenaeus vannamei* in Three Different Growth Stages. Department of Marine Life Sciences. Jeju National University. South Korea. Fish and Aquatic Sciences. 2018; 21:30.
21. Colvin PM. Nutritional Studies on *Penaeid* Prawn: Protein Requirement on Compounded Diets for Juvenile *Penaeus indicus*. Aquaculture. 1976; 7:315-326.
22. Sedgwick RW. Influence of Dietary Protein and Energy on Growth, Food Consumption, and Food Conversion Efficiency in *Penaeus merguiensis* de Man. Elsevier. Aquaculture. 1979; 16(1).
23. Heptarina D, Suprayudi MA, Mokoginta Ing, dan Yaniharto D. The Effect of Feeding with Different Protein Levels on the Growth of Juvenile White Shrimp *Litopenaeus vannamei*. Prosiding Forum Inovasi Teknologi Akuakultur, 2010.
24. Kurniawan LA, Arief M, Manan A, dan Nindarwi DD. Effects of Probiotic Addition Differently on Feed to Protein Retention and Fat Retention in Vannamei Shrimp (*Litopenaeus vannamei*). Journal of Aquaculture and Fish Health. 2016; 6(1).
25. Pascual FP. Nutrition and Feeding of *Penaeus monodon*. Aquaculture Extension Manual No. 3, Third Edition. SEAFDEC, 1989.
26. Mahmood SH, Shahadat AM, Hossain ML. Growth of Black Tiger Shrimp, *Penaeus monodon*, on Fishmeal Based Formulated Diet in Southeastern Coastal Shrimp Farm of Bangladesh. Pakistan Journal of Zoology. 2005; 37:95-100.
27. Tahe S, dan Suwoyo HS. Growth and Survival of Vannamei Shrimp (*Litopenaeus vannamei*) with Different Feed Combinations in Controlled Containers. Jurnal Riset Akuakultur. 2011; 6(1):31-40.
28. Llalramchhani C, Panigrahi Anand PSS, Das S, Ghoshal TK, Ambasankar K, Balasubramanian CP. Effect of Varying Levels of Dietary Protein on the Growth Performances of Indian White Shrimp *Penaeus indicus*

(H. Milne Edwards). Aquaculture by Elsevier. 2019; S044-8486(19):31260-8.
29. Zhou Q, C, Li CC, Liu CW, Yang QH. Effects of Dietary Lipid Sources on Growth and Fatty Acid Composition of Juvenile Shrimp, *Litopenaeus vannamei.* Aquaculture Nutrition. 2007; 13:9.
30. Gao W, Tian L, Hu W, Luo M, Liu J, Xu Q. Optimal Dietary Protein Level for the White Shrimp *(Litopenaeus vannamei)* in Low Salinity Water. Israel Journal Aquacult Bamid, 2016, 68.
31. Shahkar E, Yun H, Park G, Jang IK, Kim SK, Katya K. Evaluation of Optimum Dietary Protein Level for Juvenile Whiteleg Shrimp *(Litopenaeus vannamei).* Journal of Crustacean Biology. 2014; 34:8.
32. Saldanha CM, Achuthankutty CT. Growth of Hatchery Raised Banana Shrimp *Penaeus merguiensis* De Man (Crustacea: Decapoda) Juveniles Under Different Salinity. Journal of Marine Science. 2000; 29:179-180.
33. NRC (National Research Council). 1993. *Nutrient Requirements of Fish.* National Academic of Science. Washington DC, 2000.
34. Ministerial Decree of Indonesian Minister of Maritime Affairs and Fisheries No. 28 the Year about General Guidelines for Shrimp Farming in Ponds, 2004.