The effect of fish meal and milkfish offal meal combination in different artificial feeds on growth and survival rate of tiger shrimp (Penaeus monodon)

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Abstract. The cost which spent for feed is about 50 – 70% of total component production. The method to reduce tiger shrimp production cost is using milkfish offal waste utilization as an alternative for feed substitution. This study used laboratory experimental method using completely randomized design with four treatments and three replications for each treatment. Each treatment used different milkfish offal meal (%) and fish meal (%) ratio, they were: 0%:60% (A), 20%:40% (B), 40%:20% (C), and 60%:0% (D). Feed was given four times a day at 08.00, 13.00, 17.00, and 23.00 about 8% of the shrimp biomass weight. The material used was juvenile tiger shrimp with 0.75 – 1.29 g of average biomass weight. Tiger shrimp maintained at 30 individuals of stock density in a bucket of water with 30 L volume and 30 ppt salinity. The results showed that crumble-shaped artificial feed with a different substitution percentage of milkfish offal meal had high significant effect (P<0.01) on Relative Growth Rate (RGR), Feed Utilization Efficiency, and had significant effect (P<0.05) on Protein Efficiency Ratio (PER), but it had no significant effect (P˃0.05) on survival rate (SR). The highest value of RGR was 4.90%/day in treatment B. The best PER and feed efficiency were 1.69 and 56.96% in treatment B. Survival rate of tiger shrimp ranged between 83.33 – 87.78%. The water quality was in decent condition for shrimp cultivation media. The conclusion is 20% milkfish offal meal substitution in the artificial feed provides the best growth and survival rate of shrimp.

1. Introduction
Black tiger shrimp (Penaeus monodon) is a type of large sea shrimp [1]. This large size is consumers’ preference. This type of shrimp is only spread zoogeographically in several Asia Pacific regions, such as Taiwan, Indonesia, Philippines, Thailand, and Vietnam. Tiger shrimp (P. monodon) is one of the commodities that are still superior commodities in fisheries field [2]. This commodity has a pretty good business opportunity.

In tiger shrimp cultivation (P. monodon), feed is one of the obstacles to achieving success. The quality and quantity of feed greatly contributes to this success. Feed absorbs 50-70% of the total production costs. Animal ingredients are the main ingredient, this is caused by animal ingredients have a high protein content. The utilization of animal waste as a feed material can reduce the cost of production. A lot of wastes can be used from animals, for example shrimp waste, crab skin waste, frog waste, livestock blood waste, chicken feather waste and many more [1].

Animal ingredients are the main ingredient in making shrimp feed, this is because animal-based ingredients have a high protein content. Materials that have high protein content at affordable prices can be obtained by using animal waste. A lot of wastes can be used from animals, for example shrimp waste, crab skin waste, frog waste, livestock blood waste, chicken feather waste and many more. Utilization of animal waste can reduce production costs, especially in feed production [3]. One of the waste from animals which can be used as feed ingredient is waste from milkfish [4]. Milkfish offal have a complete nutrient content. Milkfish offal meal contain high nutrient content, such as: protein 59.78%, fat 13.96%, crude fiber 0.77%, carbohydrate 1.11%, ash 12.88%, potassium 2.25%, and phosphorus 0.52%.
The purpose of this study was to find out the optimization of milkfish offal meal substitution in tiger shrimp feed in the form of crumble to determine the growth and biomass weight of tiger shrimp. This study was conducted in June - August 2012 with a period of 42 days in the Aquaculture Department Laboratory, Faculty of Fisheries and Marine Science, Diponegoro University, Semarang.

2. Research Methods

The basis of the treatment is the development of previous study. The treatment of previous study used the ratio of milkfish offal compared to fish meal as follows, treatment A (25% : 75%), B (50% : 50%), C (75% : 25%) [5]. The experimental design used in this study was a Completely Randomized Design (CRD) with 4 treatments and each with 3 replications. The difference in substitution of milkfish offal meal; fish meal; and Acetes indicus meal was given to the treatment as follows:

1. Treatment A, 0% : 60%
2. Treatment B, 20% : 40%
3. Treatment C, 40% : 20%
4. Treatment D, 60% : 0%

The container in the study used a bucket with 30 L water volume. The tools in the experiment included feed making tools and water quality measuring tools. Shrimp juvenile biomass weight from 0.75 to 1.29 g. The proximate results of raw materials are presented in Table 1.

Data collection included initial weight of tiger shrimp, final weight of tiger shrimp, weight of feed given, weight of remaining shrimp, number of tiger shrimp at the end of the study, and water quality. Feed efficiency (FE) is calculated based on Tacon's [6] formula:

\[
FE = \left( \frac{W_t - W_o}{F} \right) \times 100 \%
\]

(1)

Where:
- \( FE = \) Feed Efficiency (%)
- \( W_t = \) Shrimp weight at the end of the study (g)
- \( W_o = \) Shrimp weight at the beginning of the study (g)
- \( F = \) The amount of feed consumed during the study (g)

Protein efficiency ratio (PER) is calculated based on the Zonneveld [7] formula:

\[
PER = \left( \frac{W_t - W_o}{P} \right) \times 100 \%
\]

(2)

Where:
- \( PER = \) Protein efficiency ratio (%)
- \( W_t = \) Shrimp biomass at the end of the study (g)
- \( W_o = \) Shrimp biomass at the beginning of the study (g)
- \( P = \) The protein weight of the feed consumed (g)

The relative growth rate (RGR) is calculated based on the Takeuchi [8] formula:

\[
RGR = \left( \frac{W_t - W_o}{W_o \times t} \right) \times 100 \%
\]

(3)

Where:
- \( RGR = \) Relative Growth Rate (%)
- \( W_t = \) Shrimp biomass at the end of the study (g)
- \( W_o = \) Shrimp biomass at the beginning of the study (g)
- \( t = \) Length of study (days)

The feed conversion ratio is calculated based on the Zonneveld [7] formula:

\[
FCR = \frac{F}{(W_t + d) - W_o}
\]

(4)

Where:
FCR = Food Conversion Ratio
F = The amount of feed consumed
W_t = Shrimp biomass at the end of the study (g)
W_o = Shrimp biomass at the beginning of the study (g)
D = Shrimp biomass that died during the study (g)

Survival rate (SR) is calculated based on Effendie [9] formula:
\[
SR = \frac{N_t}{N_o} \times 100\%
\]

Where:
SR = Survival Rate (%)
N_t = Number of tested shrimp that lived at the end of the study (shrimp)
N_o = Number of shrimp tested at the start of the study (shrimp)

Measurement of water quality data includes temperature, pH, DO and ammonia content. The tool used to measure physical parameters is water quality checker (WQC). Ammonia content analysis was carried out at the Semarang Health Center Laboratory by entering the research water sample.

Data obtained during research such as feed utilization efficiency (EPP), protein efficiency ratio (PER), relative growth rate (RGR), feed conversion (FCR) and survival rate (SR) were analyzed using analysis of variance (ANOVA). If a different effect is obtained, Duncan's test is carried out to find out which treatment has a significantly different effect.

3. Results and Discussion

Table 1. Proximate analysis of feed ingredients in dry weight / 100 g dry

| Ingredients          | Ash    | Fat   | Crude Fiber | Protein | NFE   | Total |
|----------------------|--------|-------|-------------|---------|-------|-------|
| Fish meal            | 38.13  | 1.35  | 12.48       | 35.20   | 12.84 | 100.00|
| Soybean meal         | 5.76   | 4.64  | 13.56       | 38.09   | 37.95 | 100.00|
| *Acetes indicus* meal| 22.48  | 3.80  | 9.23        | 61.14   | 3.35  | 100.00|
| Milkfish offal meal  | 11.71  | 27.51 | 16.99       | 41.41   | 2.38  | 100.00|
| Dextrin meal         | 20.48  | 0.61  | 4.56        | 2.01    | 72.34 | 100.00|

Source: Faculty of Animal and Agricultural Sciences Laboratory Diponegoro University

Table 2. Composition of experimental feed ingredients (g / 100g feed)

| Feed material          | Treatment |
|------------------------|-----------|
|                        | A        | B       | C       | D       |
| Fish meal              | 30.68    | 20.45   | 10.23   | -       |
| Milkfish offal meal    | -        | 8.7     | 17.39   | 26.08   |
| *Acetes indicus* meal  | 11.78    | 11.78   | 11.78   | 11.78   |
| Soybean meal           | 31.5     | 31.5    | 31.5    | 31.5    |
| Dextrin meal           | 18.04    | 19.57   | 21.1    | 22.64   |
| Fish oil               | 2        | 2       | 2       | 2       |
| Corn oil               | 3        | 3       | 3       | 3       |
| Lecithin               | 1        | 1       | 1       | 1       |
| Vitamin mix            | 1        | 1       | 1       | 1       |
| Mineral mix            | 0.5      | 0.5     | 0.5     | 0.5     |
| CMC                    | 0.5      | 0.5     | 0.5     | 0.5     |

Proximate results of feed are presented in the Table 3.
Table 3. Proximate results of feed in dry weight (g / 100g feed)

| Nutrients          | Feed Standard Value | For Juvenile Tiger Shrimp |
|--------------------|---------------------|--------------------------|
|                    | A       | B       | C       | D       |                        |
| Protein (%)        | 30.04   | 31.79   | 30.10   | 29.56   | 30-50%                  |
| Fat (%)            | 7.23    | 7.43    | 7.63    | 7.78    | 3-15%                   |
| Carbohydrate (%)   | 29.22   | 29.16   | 29.39   | 30.49   | 20-40%                  |
| Ash (%)            | 13.22   | 11.16   | 10.23   | 12.72   |                         |
| Crude Fiber (%)    | 20.29   | 20.46   | 22.64   | 19.45   |                         |

Source: Faculty of Animal and Agricultural Sciences Laboratory Diponegoro University

Feed energy results are presented at Table 4.

Table 4. Test feed energy result

| Test feed energy | Protein energy (kcal)* | Fat energy (kcal)* | NFE Energy (kcal)* | E/P (kcal/g)* | Energy total (kcal)* |
|------------------|------------------------|--------------------|--------------------|---------------|----------------------|
|                  | A         | B        | C        | D         | A          | B        | C        | D          |
| Protein energy   | 105.14    | 111.27   | 105.35   | 103.46    |            |          |          |            |
| Fat energy       | 58.56     | 60.18    | 61.80    | 63.02     |            |          |          |            |
| NFE Energy       | 73.05     | 72.90    | 73.48    | 76.23     |            |          |          |            |
| E/P (kcal/g)     | 7.88      | 7.69     | 7.99     | 8.21      |            |          |          |            |
| Energy total     | 236.75    | 244.35   | 240.63   | 242.70    |            |          |          |            |

Information:
Energy calculation based on NRC, 1977 (Protein = 3.5 kcal / g; Fat = 8.1 kcal / g; NFE = 2.5 kcal / g)

3.1. Survival Rate (SR)
The results of the analysis of variance of survival rates for each treatment are presented in Figure 1.

Figure 1. Survival Rate (SR) of Juvenile Tiger Shrimp

Different milkfish offal meal substitution on artificial feed given to tiger shrimp did not have a significant effect (P > 0.05) on SR. SR value results starting from the highest were found in treatment B, which was 87.78 ± 1.92%; treatment C was 86.67 ± 5.77%; treatment A was 85.56 ± 1.92%; and treatment D that was equal to 83.33 ± 8.82%. The high SR value results supported by the amount of feed which was given is sufficient to support the basic needs of shrimp. Therefore, high survival rate has a positive influence on growth. This condition was supported by water quality data during the study that adequately supports shrimp life.
Water quality is a limiting factor in the cultivation environment, because it affects the survival and production of tiger shrimp that indirectly affects the appetite of shrimp so that it affects the growth of shrimp. Water quality parameters during cultivation in all treatments were still in a decent range. This is because cleaning was done every morning to remove dirt and leftovers. Furthermore, the aeration system run continuously causes the water quality of media remain stable in a decent range, so that it can support the level of feed consumption and shrimp feed utilization, and increase shrimp growth.

3.2. Relative Growth Rate (RGR)

The results of the values and analysis of variance of relative growth rate for each treatment are presented in Figure 2.

![Figure 2. Relative Growth Rate of juvenile tiger shrimp](image)

Growth is an increasing in all sizes and generally, the measured growth is the weight gain of all parts of the body [10]. The results showed that the difference in the amount of milkfish offal meal substitution in artificial feed produces RGR values starting from the highest value to the lowest value was treatment B of 4.90 ± 0.28%/day, treatment C was equal to 4.13 ± 0.29%/day, treatment A was 3.91 ± 0.33%/day, and treatment D was 3.65 ± 0.19%/day. It is suspected that shrimp in treatment B can digest feed better than other treatments.

The results of analysis of variance showed that the milkfish offal meal substitution in artificial feed gave a very significant effect (P <0.01) on the relative growth rate value of juvenile tiger shrimp (P. monodon). The results showed that the highest relative growth rate was in treatment B of 4.90 ± 0.28%/day and the lowest value in treatment D was 3.65 ± 0.19%/day. It is suspected that the substitution of milkfish offal meal in feed can be utilized by shrimp through nutrient absorption process and feed energy that produce growth.

The Duncan's multiple range test results showed that treatment B was significantly different from the treatments C, A and D. The greater the usage of milkfish offal meal substitution in artificial feed, will cause a decrease in growth rate. This is suspected that treatment B had a combination of animal protein sources that were suitable for tiger shrimp feeding. The results obtained that the usage of milkfish offal meal substitution by 20% produces the best growth. It is suspected that treatment B could utilize nutrients and energy in feed better than treatment C, A and D. So that the shrimp could absorb the nutrients for better growth.

The results showed that the highest RGR value in juvenile tiger shrimp was treatment B, which was 4.90 0.28% / day and the lowest was in treatment D, which was 3.65 0.19% / day. This is because treatment B had nutritional feed, energy (see Table 3 and Table 4) that was balanced and more efficient at utilizing nutrients, so that absorption of nutrients and energy in feed could be used for growth. Feed energy in treatment B has the lowest value, and below standard compared to other treatments which was 7.69 kcal / g compared to treatment D which has the highest feed energy of 8.21 kcal / g (see Table 4), but treatment B is better in utilizing feed energy and absorbing nutrients for growth well compared to treatment D. It is suspected that treatment D (60% of milkfish offal meal substitution) has not been able to utilize the feed energy optimally, therefore it produces the lowest RGR value.
Growth is also influenced by the balance of nutrients in the feed [11]. Basically, the growth of tiger shrimp depends on the available energy and how the energy used in the body [12]. In order for growth of the organism, it requires sufficient amount of nutrient energy. Energy nutrients that enter the body of the shrimp are used for various processes in the body such as growth, metabolism, tissue formation, physical activity, maintenance.

One function of protein is for growth, replacing damaged tissue, or reproducing [3]. The growth of tiger shrimp can be optimal if the nutrient content in feed can be fulfilled. Protein regulating substances also play an important role in the formation of enzymes and regulate various metabolic processes in the body of the shrimp. The element of carbon contained in it has a function as an energy source when energy needs are not met by carbohydrates and fats. The feed provided is not just have to be sufficient and on time, but it must have adequate nutrients and energy [13].

3.3. Feed Utilization Efficiency (FUE)

The results of the value and analysis of variance of feed utilization efficiency for each treatment are presented in Figure 3.

![Figure 3. Feed Utilization Efficiency](image)

Feed utilization efficiency is the ratio between body weight gain and the amount of feed given during the study. The results showed that the difference in the amount of milkfish offal meal substitution in artificial feed produces FUE values starting from the highest found in treatment B of 56.96 ± 0.42%, treatment C was equal to 50.18 ± 0.43%, treatment A was 49.11 ± 0.42%, and treatment D was 45.92 ± 0.57%. The increasing of feed utilization efficiency value shows that the feed consumed has good quality so that it can be used efficiently [6].

Based on the results of analysis of variance showed that milkfish offal meal substitution in artificial feed gave a very significant effect (P < 0.01) on the value of feed utilization efficiency of juvenile tiger shrimp (*P. monodon*). The results showed that the highest FUE value was found in treatment B of 56.96 ± 0.42% and the lowest was in treatment D of 45.92 ± 0.57%. It is suspected that substitution of milkfish offal meal affects the nutrient content of feed which can be digested by juvenile tiger shrimp, so that it can be used efficiently by juvenile tiger shrimp.

Based on Duncan's multiple range test results showed that treatment B was very significantly different from treatment C, A and D. During the experiment on the feed efficiency of juvenile tiger shrimp, the greater the use of milkfish offal substitution in artificial feed, will cause a decrease in feed efficiency. The results obtained that the use of substitution of milkfish offal meal by 20% (Treatment B) results in the best feed efficiency. It is suspected that the use of substitution of milkfish offal meal which affects the nutrient content of feed in each treatment (see Table 3), so that tiger shrimp can utilize the feed given for its growth.

Treatment B have a combination of animal protein sources, which are milkfish offal meal, fish meal, and *Acetes indicus* meal that is suitable for shrimp, so that shrimp can use feed in treatment B well and produce growth. The high feed efficiency shows an efficient feed utilization so that only a few food substances are overhauled to meet energy needs and the rest is used for growth [14].
3.4. **Protein Efficiency Ratio (PER)**

The results of feed protein efficiency ratio values and analysis of variance for each treatment are presented in Figure 4.

![Figure 4. Protein Efficiency Ratio (PER) of Juvenile Tiger Shrimp.](image)

Tiger shrimp requires protein from feed with the amount that suits to its needs. Protein in feed will affect shrimp’s growth. Feed with the appropriate protein content will produce maximum growth. The high and low efficiency of feed protein utilization depends on several factors including protein quality, protein content in feed such as fat and carbohydrates and the frequency of feeding [15]. Suitable nutrients can support growth, can synthesize and form new tissues if there is a damaged tissue. Based on the results of the study, the PER value starting from the highest value to the lowest value was treatment B, which was 1.69 ± 0.02%; treatment C was 1.67 ± 0.03%; treatment A was 1.64 ± 0.03% and treatment D was equal to 1.58 ± 0.58% obtained from the difference in the amount of milkfish offal meal substitution in artificial feed. Feed efficiency depends on the adequacy of nutrition and feed energy. If the feed nutrient is insufficient such as high or low energy, the weight gain that would be produced is low [16].

The results of analysis of variance showed that milkfish offal meal substitution in artificial feed had a significant effect (P < 0.05) on the protein efficiency ratio of juvenile tiger shrimp (*P. monodon*). Based on the results of the study, the highest PER value was in treatment B which was 1.69 ± 0.02% and the lowest was in treatment D which was 1.58 ± 0.58%. It is suspected that offal meal substitution affects different protein content in feed given to juvenile tiger shrimp, so that protein can be efficiently used by juvenile tiger shrimp.

Based on Duncan’s multiple range test results, treatment B was not significantly different from treatment C but significantly different from treatment A and very significantly different to treatment D. Milkfish offal meal had a high protein content of 41.41%, but when milkfish offal substitution increased, protein content in feed would decrease (see Table 3). It is assumed that milkfish offal contain more pulp, therefore the substitution can only be used up to 20%.

Treatment B on milkfish offal meal substitution in artificial feed gave the highest PER value which was 1.69 ± 0.02%. The usage of 20% of milkfish offal meal substitution in artificial feed has a protein content in feed of 31.79% and protein energy in feed is 111.27 kcal, so that protein content and protein energy can be absorbed by the shrimp body. The optimum utilization of protein is achieved if most of the shrimp energy needs are fulfilled from non-protein components such as fat and Nitrogen-free extracts, so the protein energy contained in feed can be maximally utilized for growth, because shrimp is able utilize fat energy and Nitrogen-free extracts for metabolism [17].

3.5. **Water Quality**

Water quality parameters observed during the study included salinity, temperature, pH, dissolved oxygen and ammonia content are presented in table 5.
Decent water quality in shrimp maintenance is one of the determinants of success for the growth of the cultivan. Water quality parameters measured during the study were temperature, pH, DO, and ammonia content. As shown in Table 5, the range of water quality in the media is still feasible for the growth of tiger shrimp corresponding to the existing literature.

Water temperature greatly affects the shrimp's living environment, especially related to metabolism, dissolved oxygen content, growth, and shrimp's appetite [21]. The range of water temperature measured during the study is 26-32°C. Tiger shrimp cannot live at temperatures which lower than 15°C or higher than 40°C [18]. Although tiger shrimp can live at 18°C and 26 °C, a good temperature range for tiger shrimp's growth and survival is between 28-30°C [3].

The pH range measured during the study is 7-8.5, this condition is very feasible for the life and growth of tiger shrimp. Most of aquatic biota are sensitive to changes in pH value, and prefer a pH value around 7-8.5 [19]. Aquatic biochemical processes is strongly influenced by the pH value, for example if the pH is low, the nitrification process will end.

The range of dissolved oxygen measured during the study was 6.26-7.62, this condition is still feasible for tiger shrimp life. Oxygen content in water which is considered to be optimum for shrimp aquaculture is 5-10 ppm [3]. However, tiger shrimp starts to be seen swimming on the surface when dissolved oxygen is below 2 ppm.

Ammonia measurement results show that the highest value was in treatment A of 0.21 ppm, while treatment B was 0.15-0.17, treatment C was 0.18-0.21, and treatment D was 0.2-0.24. Ammonia concentration which higher than 0.45 ppm can inhibit shrimp’s growth up to 50%. Tiger shrimp can grow well if the concentration of ammonia in water is not higher than 0.1 ppm [20].

4. Conclusion
Based on the results that were obtained during the study, it can be concluded:

1. Provision of artificial feed in the form of crumble with different amounts milkfish offal meal substitution gave a high significant effect (P < 0.01) on relative growth rate (RGR), feed conversion (FCR), feed utilization efficiency (FUE), and significant effect (P < 0.05) on protein efficiency ratio (PER), and did not give significant effect (P > 0.05) on survival rate (SR) of juvenile tiger shrimp.

2. The best dose of milkfish offal meal substitution for tiger shrimp (P. monodon) is 20% of milkfish offal meal, resulting in a specific growth of 4.90 ± 0.28% / day; protein efficiency ratio is 1.69 ± 0.02% and feed utilization efficiency is 56.96 ± 0.42%.

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Table 5. Water quality parameters

| Treatment | Parameters | A | B | C | D | Reference |
|-----------|------------|---|---|---|---|-----------|
| Temperature (°C) | 26 - 28    | 27 - 28 | 27 - 29 | 27 - 29 | 15-35[18] |
| pH        | 7 - 8.3    | 7 - 8.4 | 7 - 8.5 | 7 - 8.0 | 6.5-8.7[19] |
| DO (mg/L) | 6.35 - 7.33 | 6.76 - 7.62 | 6.63 - 7.42 | 6.26 - 7.23 | 5-10[3] |
| Ammonia content (mg/L) | 0.21 - 0.26 | 0.15 - 0.17 | 0.18 - 0.21 | 0.2 - 0.24 | < 0.45[20] |
| Salinity (ppt) | 25         | 25    | 25    | 25    | 19-35[2]  |
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