**Dried Skeletonema costatum in Feed Formulation for the Growth of Vaname Shrimp (Litopenaeus vannamei)**

Dewi Putri Lestari¹*, Arning W. Ekawati², Maftuch²

¹ Graduate Program, Faculty of Fisheries and Marine Sciences, University of Brawijaya, Malang, Indonesia  
² Faculty of Fisheries and Marine Sciences, University of Brawijaya, Malang, Indonesia

**Abstract**

The aim of this study was to determine the effect and the best dosage used by the *Skeletonema costatum* in feed formulation on the growth of Vaname shrimp. This experiment used Completely Randomized Design (CRD) with four treatments and three replications. Treatment was given by using dried *S. costatum* in feed formula (iso protein 37% and iso energy 3.6 kkal/g feed). Feed treatment was the substitution of fish meal protein A = 0%, B = 2.5%, C = 5% and D = 7.5% with dried *S. costatum* protein. The observed parameters include Survival Rate (SR), Survival Growth Rate (SGR), Feed Efficiency Ratio (FER), and Protein Efficiency Ratio (PER). The results showed that the use of dried *S. costatum* in feeding are effective in increasing the specific growth rate, feed efficiency ratio and the ratio of protein efficiency than controls. The best dosage in feeding formula is ranged from 4.39% to 4.75%.

**Keywords:** feeding formula, *Skeletonema costatum*, Vaname Shrimp

**INTRODUCTION**

Vaname shrimp (*Litopenaeus vannamei* Boone) is one of the leading commodities of Indonesian fishing industry. This shrimp has high productivity in intensive pond thus many farmers cultivate its as the substitute of tiger shrimp. Vaname shrimp is widely known for its advantages of faster ability in growing than Black Tiger and *Stylirostris* shrimp. Vaname shrimps also can be stocked at high densities, resistant to wide range of salinity, need lower protein and resistance to diseases [1,2,3].

Diatoms contain essential nutrients and also have an appropriate size as feed for Vaname shrimp. One of a diatoms which commonly used for feed is *Skeletonema costatum* (Greville) Cleve. The use of diatoms as a natural feed for Vaname shrimp can accelerate its growth in larval stadia. *Skeletonema costatum* is used as a supplementary food for basic nutrition in cultured *Artemia*, shrimp larvae and shellfish spat. Nutritional content of *S. costatum* has been widely studied, which is consisted of 31% protein, 21.5% carbohydrate and 1.3% total fat. In addition, *S. costatum* also contain fatty acid composition, free amino acids, β-1, 3 glucan and cell wall polysaccharides [4,5,6].

However, the use of diatom *S. costatum* in dry form has not been widely used. The glucan which also found in diatom acts as an immunostimulant which will enhance the body's resistance of the shrimp. Thus the aim of adding dried *S. costatum* on Vaname shrimp’s feed formulations are to enhance the growth and productivity by observing the parameter which measures the growth rate of shrimp, e.g. survival, specific growth rate, feed efficiency ratio, and protein efficiency ratio. Observed parameter chosen because related to the feed utilization and growth of the shrimp. This study aimed to determine the best used dose of dried *S. costatum* in the feed formulation on the growth of Vaname shrimp.

**MATERIALS AND METHODS**

**Preparation of Dried S. costatum**

*Skeletonema costatum* was obtained from Center of Brackish Aquaculture Situbondo, from seawater which were purified repeatedly with pure subsequently cultured in a laboratory-scale stage, semi mass scale and mass scale. Furthermore, *S. costatum* were dried using an oven in temperature 60°C for 24 hours. The dried *S. costatum* analyzed proximately for its drying content using the oven method and its crude protein concentration using the micro kjedahl.

**Preparation of feed**

Before determining the formula, other feed’s constituent material (fish meal, shrimp meal, soybean flour, tapioca flour, fish oil, vitamin, min mix and CMC) had been prepared and analyzed the proximate data according to AOAC [7].
Based on the proximate data of feed’s constituent material (Table 1), the feed formulation is determined by worksheet method. Feed formulations based on the isoprotein 37% and isoenergi 3.6 kcal.g⁻¹. The treatments were protein substitution of fish meal to S. costatum meal (Table 2). All the materials were weighed according to the formulation and mixed until it reached its homogeneity. Homogenate were molded and dried in an oven on the temperature of 30°C for 1 day. Feeds of Vaname shrimp were made in pellets form in 0.55 mm size.

**Biological Trials (In vivo)**

Biological test of feeding experiments on Vaname shrimp (Litopenaeus vannamei) were conducted for 30 days. Each treatment was repeated three times. Control diet without using S. costatum meal, compared with three feed formulas that use S. costatum meal as the independent variable. The four treatments of feed formulations observed to assess its effect on survival rate (SR), specific growth rate (SGR), feed efficiency ratio (FER), and protein efficiency ratio (PER), which is referred as dependent variable.

This study used Vaname shrimp (Litopenaeus vannamei) in juvenile stadia with weight 6.41±0.55 g per shrimp, derived from Center of Brackish Aquaculture Situbondo. The Vaname shrimps were maintained in an aquarium sized 45x45x45 cm³ volume of 71 liters filled with sea water and the range of the salinity for 33-34 ppt. The outer surface of aquarium was covered with black plastic to imitate the real habitat of the shrimps. The aeration was also included in the aquarium.

Shrimp was acclimatized in the experimental container for 7 days toward the environment and feed. The day before the study was conducted, the shrimp were not feeded and weighed it right after fasting to determine the initial weight. Shrimp were stocked with initial weights uniformly with density of 12 shrimp per aquarium. Feed trials were given as much as 10% of the biomass weight, 4 times daily; as much as 20% at 07.00, 20% at 11.00, 20% at 17.00 and 40% at 21.00 of the amount given per day. Shrimp were weighed every 10 days. Removal of remains feed were done every morning before feeding and the water replaced as much as 20-30% of the total volume.

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### Table 1. Composition of experiment feed ingredients for vaname shrimp (Litopenaeus vannamei)

| Ingredient                | Dried Content (%) | Protein (%) | Fat (%) | Ash Content (%) | Rugged fiber (%) | BETN** | Energy (kcal/gr)*** |
|---------------------------|-------------------|-------------|---------|----------------|------------------|--------|---------------------|
| Fish meal*                | 92.19             | 56.86       | 6.12    | 28.7           | 4.91             | 3.41   | 296.16              |
| Shrimp meal*              | 92.50             | 50.36       | 4.33    | 1.33           | 8.94             | 35.04  | 380.55              |
| S. costatum meal*         | 87.38             | 24.70       | 2.22    | 55.55          | 1.04             | 16.49  | 184.74              |
| Soybean flour*            | 91.74             | 45.65       | 0.14    | 7.90           | 4.23             | 42.08  | 352.18              |

**Description:**

*: Result analysis of Laboratory Nutrition and Feed, Faculty of Animal Husbandry, University of Brawijaya

**: BETN = 100 – Protein – Fat – Ash content – Rugged fiber

***: Energy = (4 x %Protein) + (9 x %Fat) + (4 x %BETN)

### Table 2. Experiment feed formula of Vaname shrimp (Litopenaeus vannamei)

| Ingredient (%) | Treatment Dose | A | B | C | D |
|----------------|---------------|---|---|---|---|
|                |               | A | B | C | D |
| Fish meal      | 24.73         | 23.10 | 21.47 | 19.85 |
| Shrimp meal    | 26.45         | 26.45 | 26.45 | 26.45 |
| Soybean meal   | 21.07         | 21.07 | 21.07 | 21.07 |
| S. costatum meal | -        | 3.74 | 7.49 | 11.23 |
| Tapioca meal   | 8.31          | 7.78 | 7.25 | 6.72 |
| Fish oil       | 9             | 9    | 9    | 9    |
| Vit + Min Mix  | 5             | 5    | 5    | 5    |
| CMC            | 5.44          | 3.86 | 2.27 | 0.68 |
| Total          | 100           | 100  | 100  | 100  |

**Description:**

A = S. costatum meal protein substitution on fish meal protein 0%

B = S. costatum meal protein substitution on fish meal protein 2.5%

C = S. costatum meal protein substitution on fish meal protein 5%

D = S. costatum meal protein substitution on fish meal protein 7.5%
Measurement of water quality during the study include temperature, DO (Dissolved oxygen), pH and salinity which was done every day in the morning and evening. Otherwise, ammonial content was measured at the beginning and end of the study.

Data analysis

Data were analyzed using SPSS 21.0 version with one way ANOVA test. The analysis was used to examine the effect of treatment, continued to Least Significant Difference (LSD) test with Duncan test method. This test followed by the analysis of orthogonal polynomials to get the best treatment value.

Survival Rate (SR)

Survival of Vaname shrimp (L. vannamei) is calculated using the formula [8]:

\[ \text{SR} = \frac{N_t}{N_0} \times 100\% \]

Description:
- \( \text{SR} \) = Survival Rate
- \( N_t \) = Final number of shrimp
- \( N_0 \) = Initial number of shrimp

Survival Growth Rate (SGR)

Observations growth of vannamei shrimp (L. vannamei) was done by weighing once every 10 days. Specific growth rate [9] can be calculated using the formula:

\[ \text{SGR} = \frac{\ln W_t - \ln W_0}{t} \times 100\% \]

Description:
- \( \text{SGR} \) = Survival Growth Rate (%BW/day)
- \( W_t \) = Average final weight of individual (gram)
- \( W_0 \) = Average initial weight of individual (gram)
- \( t \) = Time (days)

Feed Efficiency Ratio (FER)

Feed Efficiency Ratio was calculated by comparing the average final weight after reducing the initial average weight of shrimp compared to the amount of feed (dry weight of feed) using the formula [10]:

\[ \text{FER} = \frac{W_t - W_0}{F} \]

Description:
- \( \text{FER} \) = Feed Efficiency Ratio
- \( F \) = the amount of given feed (gram)
- \( W_t \) = Average final weight of individual (gram)
- \( W_0 \) = Average initial weight of individual (gram)

Protein Efficiency Ratio (PER)

Protein Efficiency Ratio [9] calculated using the formula:

\[ \text{PER} = \frac{W_t - W_0}{(F \times P_f)} \]

Description:
- \( \text{PER} \) = Protein Efficiency Ratio
- \( F \) = the amount of given feed (gram)
- \( W_t \) = Average final weight of individual (gram)
- \( W_0 \) = Average initial weight of individual (gram)
- \( P_f \) = Protein content in feed (%)

RESULT AND DISCUSSION

The Survival Rate (SR), Specific Growth Rate (SGR), Feed Efficiency Ratio (FER) and Protein Efficiency Ratio (PER) on Vaname shrimp can be seen in Table 3. The results of one-way ANOVA showed that survival rate of Vaname shrimp is not significantly different between treatments (P>0.05). It indicates that the use of S. costatum meal in the feed formulation does not cause a negative response to the survival rate of Vaname shrimp.

Factors affecting survival rate are abiotic factors such as the adaptation ability to the environment, human handling, stocking density, competitors, age and the presence of predators. High stocking density would result lower survival due to cannibalism. The range of the water quality values showed in Table 4.

| Parameters       | Treatment | A          | B          | C          | D          |
|------------------|-----------|------------|------------|------------|------------|
| SR (%)           |           | 77.78±4.81 | 86.11±4.82 | 88.89±4.82 | 88.89±4.82 |
| SGR (%BW.day⁻¹)  |           | 0.71±0.01  | 1.09±0.01  | 1.21±0.05  | 0.93±0.01  |
| FER (%)          |           | 8.22±0.35  | 12.88±0.26 | 14.74±0.76 | 11.09±0.01 |
| PER              |           | 0.22±0.01  | 0.34±0.01  | 0.40±0.02  | 0.30±0.00  |
Based on statistical analysis the water quality does not significantly affect the value of each treatment. The values of the parameters of water quality during the maintenance are in the normal range, accordance with other studies in Table 5.

Other factors that may increase the survival rate during the culture is Vaname shrimp’s feed quality and feeding level so that the feed requirements can be met without any competition. Frequency of feeding behavior of vaname shrimp was also noted by de Lima et al. [11] indicating that feeding can affect the activity of shrimp itself. In the natural ecosystem, they generally actively feed at night, therefore the shrimp included in the group of nocturnal animals. This is supported by Kordi [12], feeding were given gradually, but more frequent. Thus the shrimp are not quickly satisfied and the shrimp’s appetite is maintained.

The relationship between the amounts of substitution S. costatum meal protein to fish meal protein (x) with survival (y_2) showed in the equation:

\[ y_2 = -0.026x^2 + 0.231x + 0.698; R^2 = 0.98 \]

The best value obtained from the treatment at a dose of S. costatum meal protein substitution by 4.44% in feed formula with a specific growth rate of 1.21% BW.day^{-1}. Feed efficiency ratio indicates that better utilization of feed and absorbed feed by the body increase the growth. The increasing feed efficiency values were caused by high nutrient that can be optimally utilized by the body.

The relationship between the amounts of substitution S. costatum meal protein to fish meal protein (x) with feed efficiency ratio (y_3) showed in the following equation:

\[ y_3 = -0.008x^2 + 0.076x + 0.215; R^2 = 0.95 \]

The best dosage is 4.39% with a value of feed efficiency ratio 14.47%. The degree of protein efficiency ratio proteins is influenced by the quality of the feed. The higher the protein efficiency ratio values of feed protein quality the better it will be to increase the growth rate of shrimp. According to Buwono [14], protein quality of food is determined by the particular amino acid content of essential amino acids (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine).

The relationship between the amounts of substitution S. costatum meal protein to fish meal protein (x) with protein efficiency ratio (y_4) showed in the equation below. The best dose is 4.75% with a protein efficiency ratio 0.40.

\[ y_4 = -0.332x^2 + 2.912x + 8.082; R^2 = 0.96 \]
CONCLUSION
The use of *Skeletonema costatum* meal protein to substitute fish meal protein in feed formula of Vaname shrimp affect the specific growth rate, feed efficiency ratio and protein efficiency ratio. The best dosage of *S. costatum* meal to increase the production of Vaname shrimp ranged 4.39% - 4.75% in feed formula.

REFERENCES
[1] Briggs, M., S.F. Smith, R. Subanghae, M. Phillips. 2004. Introduction and movement of *Penaeus vannamei* and *P. stylirostis* in Asia and Pacific. FAO. 40p.
[2] Widodo, R.H., A.S. Dian. 2005. Shrimp vannamei: cultivation and market prospects disease resistance of white shrimp. Penebar Swadaya. Jakarta. 75p.
[3] Nur’aïni, Y. L., H. Bambang, S. Subyakto, T. Gemi., 2007. Active surveilance of infectious myonecrosis virus (IMNV) in pond-cultured white shrimp (*Litopenaeus vannamei*) in East Java and Bali. Jurnal Perikanan UGM. IX (1). 25-31.
[4] Granum, E., S., Kirkvold, S. M. Myklestad. 2002. Cellular and extracellular production of carbohydrate and amino acid by the marine diatom *Skeletonema costatum*: diel variations and effects of N depletion. *Mar. Ecol. Prog. Ser.* 242. 83-94.
[5] Monkonsit, S., S. Powtongsook, P. Pavasant. 2011. Comparison between airlift photobioreactor and bubble column for *Skeletonema costatum* costatume cultivation. *Eng. J.* 15(4). 53-64.
[6] Widiastruti, R., J. Hutabarat, V.E. Herawati. 2012. Effect of feeding different natural (*Skeletonema costatum* and *Chaetoceros gracilis*) to absolute biomass growth and nutrient content of local *Artemia* sp. *J. Aquacult. Manage. Technol.* 1 (1). 236-248.
[7] AOAC. 1995. Official methods of analysis 12th Ed. Association of Official Analytical Chemists. Washington DC. 114p.
[8] Degani, G., D. Levanon. 1983. The influence of low density on food adaptation, cannibalism and growth of eels (*Anquilla anquilla*). Migal. Galilee Technological Center, Kiriat Shmona. Israel. 8p.
[9] De silva, S.S., T.A. Anderson. 1994. Fish nutrition in aquaculture. Chapman and Hall. London, UK. 319p.
[10] Li, M.H., E.H. Robinson, C.S. Tucker, B.B Manning, L. Khoo. 2009. Effect of dried algae *Schizochytrium* sp., a rich source of docosahexaenoic acid, on growth, fatty acid composition, and sensory quality of channel catfish *Ictalurus punctatus*. *Aquaculture*. 292. 232-236
[11] de Lima, P.P., C.S. Pontes, M. de Fátima Arruda. 2009. Activity pattern of the marine shrimp *Litopenaeus vannamei* (Boone 1931) in laboratory as a function of different feeding frequencies. *Aquac. Res.* 1-8.
[12] Kordi, M.G.H. 2010. Cultivation of catfish in tank Tarpaulins. Andi Publisher. Yogyakarta. 114p.
[13] Sunwoyo, H.S., M. Mangampa. 2010. Probiotics application with different concentration on maintenance Vaname Shrimp (*Litopenaeus vannamei*). Proceeding of Forum on Aquaculture Technology Inovation. 239-247.
[14] Buwono, I.D. 2000. Essential need of Amino Acid in fish Ransum. Kanisius. Yogyakarta. 56p.
[15] Ramanathan, N., P. Padmavathy, T. Francis, S. Athithian, N. Selvaranjitham. 2005. Manual on polyculture of tiger shrimp and carps in freshwater. Tamil Nadu Veterinary and Animal Science University, Fisheries College and Research Institute. Thothukudi. 1-161.
[16] Suprapto. 2005. Vannamei shrimp (*Litopenaeus vannamei*) cultivation techniques manual. CV Biotirta. Bandar Lampung. 25 p.
[17] Komaraeidjaja, W. 2003. Effect of application of microbial consortium of nitrifying the ammonia concentration (NH3) in the case of pond water: In Grinting village of Brebes. *J. Tech. Env. P3TL-BPPT*. 4(2). 62-67.
[18] Taqwa, F.H., M. Fitran, B.T. Esto. 2012. Performance of post-larval shrimp vaname (*Litopenaeus vannamei*) in various long period of adaptation with the addition of a low salinity decrease Sodium, Potassium, and Calcium. Proceedings of 2nd SEMNAS on Fisheries and Marine Sciences Research. Faculty of Fisheries and Marine Sciences, Diponegoro University. Semarang. 3. 52-59.