**Replacing Fishmeal with Soybean and Acetes Meal: Effects on Growth Parameters and Survival Rates of *Litopenaeus vannamei* (Boone, 1931)**

**Abstract**

Aquatic foods are increasingly recognized for their crucial role in nutrition and food security, not just as a source of protein. Replacement of fish meal with cheaper ingredients of animal origin in shrimp feed is necessary because of the rising cost and uncertain availability of fish meal. Diets should be prepared with locally available ingredients to make formulation easier and lower the cost of production. The current study evaluates the feed utilization and growth performance of *L. vannamei* post larvae fed with soybean meal and Acetes meal-based practical diets. A 60-day trial of substituting dietary fishmeal with a mixture of soybean meal and Acetes meal was conducted to assess its impact on the growth performance, survival rate and digestive enzyme activities of *Litopenaeus vannamei.* Six iso-nitrogenous experimental diets were formulated for this study, each maintaining around 36 % protein level. The control diet (T1) did not include soybean or Acetes meals. The treatment diets contained 1:1 ratio mixtures of soybean meal and Acetes meal replacing fishmeal at 20% (T2), 40% (T3), 60% (T4), 80% (T5), and 100% (T6) levels. These diets were fed to *L. vannamei* four times daily, depending on their body weight. The data on growth, feed conversion ratio (FCR), survival rate, specific growth rate (SGR) and protein efficiency ratio (PER) of *L. vannamei* were evaluated. The highest weight gain and SGR were observed in treatment T5 compared to other treatments. The higher PER and lowest FCR were recorded in treatment T5. The present investigation revealed that 80% fishmeal replacement with 1:1 soybean meal and Acetes meal significantly improves the weight gain, survival rate, SGR, FCR and PER of *L. vannamei* juveniles. The study concluded that soybean and Acetes meal can effectively serve as substitutes for fishmeal, promoting the growth and health of shrimp while reducing dependence on traditional fishmeal. This strategy supports environmental sustainability and enhances cost efficiency in shrimp farming.

**Keywords**: *Litopenaeus vannamei*, soybean meal, acetes meal, specific growth rate, survival rate

1. **Introduction**

 Aquatic foods are defined as animals, plants and microorganisms, as well as cell- and plant-based foods of aquatic origin emerging from new technologies. can be farmed or wild-caught, and are sourced from inland (for example, lakes, rivers and wetlands), coastal (estuaries, mangroves and near-shore) and marine waters, producing a diversity of foods across all seasons and geographic regions (Golden *et al.,* 2021; Li *et al.,* 2025). Aquatic foods are increasingly recognized for their crucial role in nutrition and food security, not just as a source of protein (FAO, 2022). The diet of whiteleg shrimp (*Litopenaeus vannamei*) must have a substantial quantity of protein. Conventionally, shrimp feed contains between 25% and 35% dietary protein (Ayisi *et al.,* 2017), in which a minimum of 12% is fish meal (Suarez *et al.,*2009). Despite fish meal being an indispensable part of crustacean feed, overfishing and the rising demand for livestock feed make it an unsustainable source (Sanchez-Muros *et al.,* 2020). Therefore, it is expected that the fish meal used in shrimp feed would decrease, whereas the amount of alternative protein used is going to increase (Tacon and Metian, 2008).

The Pacific white shrimp (*Litopenaeus vannamei*) is a euryhaline species capable of tolerating a wide range of salinities, including waters with salinity levels below 0.5 ppt (). According to Araneda et al. (2008), this species has recently gained significant interest in aquaculture due to its high survival rates, rapid growth and adaptability to various environmental conditions*.* Compared to other shrimp species, Pacific white shrimp are widely farmed because of their flavour, low fat level (0.4%–3%, wet weight), and high protein content (17%–20%, wet weight) (Zhang *et al.,* 2022). An estimated 58.1 million tons of Pacific white shrimp were produced annually worldwide, accounting for 80% of all cultivated shrimp production and having a production value of almost 26.7 billion USD (FAO, 2020; FAO, 2022).

Dietary protein is formulated as aqua feed’s primary and most expensive component (Furuya et al.*,* 2004). Despite its static global production, fishmeal is generally considered the ideal protein source for aquatic animals (Trushenski *et al.,* 2006). Aquaculture shrimp are given commercial feed, which usually consists of about 12-25% fish meal (Tacon and Barg, 1998). Feeding and nourishment are critical components to take into account in shrimp farming (Andriani & Pratama, 2023). In semi-intensive culture systems, additional feed can account for over 50% of the total production expenses. Since proteins represent the most expensive element in shrimp feeds, the amount of protein used in feed formulations influences the overall cost of the diet. Ingredients high in protein that can serve as replacements for fish meal, either entirely or in part, consist of terrestrial plant meals and animal by-products (Samocha *et al.,* 2004). The demand for fish meal is on the rise. As a result, it is anticipated that the prices of fish meal will keep climbing. Consequently, it becomes essential to explore alternative protein sources for shrimp feed (Hardy, 2001). Plant protein sources are lower in price and have consistent nutrient composition, like oil seeds, which frequently serve as valuable alternatives to fish meals in both economic and nutritional aspects.

Soybean meal is estimated as an affordable and nutritious feed ingredient that has a high crude protein level and a fairly balanced amino acid composition in comparison to other plant-based proteins (Gatlin *et al.,* 2007). Among sources of plant protein, soybean meal has gathered significant interest as a substitute for fish meal in aquatic animal feeds due to its well-balanced amino acid composition, reliable nutritional content, global accessibility, and cost-effectiveness (Divakaran *et al.,* 2000). In a study, dietary soybean meal was capable of completely replacing dietary fish meal without negatively affecting the growth performance of the juvenile *L. vannamei* (0.03 g) and economic profits within an 18-week feeding trial in a semi-intensive shrimp production pond system (Chen et al., 2024). Soybean meal is the best replacement for fish meal due to its excellent amino acid profile, high protein content (about 48%) and lower cost and availability than other plant protein sources (Storebakken *et al.,*2000). Another study revealed that acetes meal can be used up to 50% to replace fish meal in practical diets for shrimp (*L. vannamei*) under the experimental conditions employed. Use of locally available non-conventional protein source can help in reduction of shrimp feed price due to replacement of costly fish meal protein (Mahida et al., 2017).

On the northwest coast of India, the non-private shrimp average accounts for 24% of the total marine fish production, and about 65% of the shrimp production arrives in Maharashtra (Srinath *et al.,* 1987). In India, annually about 60,000 tonnes of non-penaeid shrimps are landed, and Acetes species comprises nearly 75-80% of the catch*.* The genus Acetes of sergestid shrimp, which are epiplanktonic, commonly referred to as ‘Javala’ when fresh and ‘Kolim’ when dried, that are found in plentiful numbers and are harvested from the coastal waters of northwest India (Parmar *et al.,* 2016). Dried Acetes samples contain 63.76% protein, 15.5% moisture, 6.03% fat and 13.62% ash (Sridhar, 1983). It could serve as an appropriate alternative protein source to substitute fish meal in aquaculture feed.

Plant proteins are produced in larger quantities than fish meal, their production is more suitable, they are often cheaper, and their expanded use does not endanger over-exploitation of limited resources as can occur with fisheries products. Replacement of fish meal with cheaper ingredients of animal origin in shrimp feed is necessary because of the rising cost and uncertain availability of fish meal. Diets should be prepared with locally available ingredients to make formulation easier and lower the cost of production. Therefore, the current study evaluates the feed utilization and growth performance of *L. vannamei* post larvae fed with soybean meal and Acetes meal-based practical diets.

**2. Materials and Methods**

**2.1. Experimental location**

The experiment was carried out for 60 days at the Aquaculture Laboratory, College of Fisheries Science, Junagadh Agricultural University, Veraval.

**2.2. Procurement of shrimps for experiment and Experimental tanks**

*L. vannamei* post-larvae (PL -10) were brought from a commercial shrimp hatchery. They were acclimatized in 500-litre circular FRP tanks with continuous aeration and proper feeding for 15 days using commercial shrimp feed. Throughout the acclimatization process, the shrimp received a commercial diet two times a day at 4% of their body weight. The experiment was conducted in rectangular plastic aquarium tanks of size 2x1x1 feet. Aquarium tanks were filled with 35 litres of filtered and disinfected seawater.

**2.3. Experimental design**

The experimental design consisted of 6 test diets (Table 1), following a completely randomized design (CRD).

**Table 1. Experimental treatment details**

|  |  |
| --- | --- |
| **T1** | Diet (100% fish meal protein) |
| **T2** | Diet (80% fish meal and 20% Soybean meal + Acetes meal mixture in a 1:1 ratio) |
| **T3** | Diet (60% fish meal and 40% Soybean meal + Acetes meal mixture in a 1:1 ratio) |
| **T4** | Diet (40% fish meal and 60% Soybean meal + Acetes meal mixture in a 1:1 ratio) |
| **T5** | Diet (20% fish meal and 80% Soybean meal + Acetes meal mixture in a 1:1 ratio) |
| **T6** | Diet (0% fish meal and 100% Soybean meal + Acetes meal mixture in a 1:1 ratio) |

**2.4. Experimental diet preparation**

Six experimental diets were formulated and prepared based on the treatment details at the Fish Nutrition and Biotechnology Laboratory, Department of Aquaculture. Raw materials such as fish meal, soybean meal, acetes meal, wheat flour, tapioca powder, plant oil, animal oil, vitamins and minerals are procured from Veraval's local market. The required quantities of ingredients were collected and weighed accurately as per feed formulation (Table 2). The ingredients were mixed well, and the dough was prepared. The feed mixture was cooked at 121°C under 15 lbs pressure for 10 to 15 minutes. After steam cooking the feed mixture, vitamins and minerals were added and mixed well. The dough was then extruded in the form of pellets by using a mechanical pelletizer. The pellets were spread on a plastic sheet and sun-dried till moisture content was reduced to less than 10%. The pelleted feed was then packed in marked plastic jars for the experiment. Crude protein values were obtained by the micro-Kjeldahl digestion and distillation method. The proximate analysis of different experimental diets is given in Table 3.

**Table 2. Feed formulation for different experimental diets (on an as-fed basis, g/100g)**

|  |  |
| --- | --- |
| **Ingredient**  | **Experimental Diets (36 % Protein)** |
| **T1**1**(control)** | **T2**2**(20%)** | **T3**3**(40%)** | **T4**4**(60%)** | **T5**5**(80%)** | **T6**6**(100%)** |
| **Fish meal** | 40.00 | 32.00 | 24.00 | 16.00 | 8.00 | 0.00 |
| **Soybean meal** | 0.00 | 4.00 | 8.00 | 12.00 | 16.00 | 20.00 |
| **Acetes meal** | 0.00 | 4.00 | 8.00 | 12.00 | 16.00 | 20.00 |
| **GNOC**7 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| **MOC**8 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 |
| **DORB**9 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| **Wheat flour** | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| **Tapioca powder** | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| **Sunflower oil** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Fish oil** | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| **VM mixture**10 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| **Total** | 100 | 100 | 100 | 100 | 100 | 100 |

1T1-Diet with 100% fish meal protein, 2T2- Diet with 80% fish meal and 20% Soybean meal + Acetes meal mixture in a 1:1 ratio, 3T3- Diet with 60% fish meal and 40% Soybean meal + Acetes meal mixture in a 1:1 ratio, 4T4- Diet with 40% fish meal and 60% Soybean meal + Acetes meal mixture in a 1:1 ratio, 5T5- Diet with 20% fish meal and 80% Soybean meal + Acetes meal mixture in a 1:1 ratio, 6T6- Diet with 0% fish meal and 100% Soybean meal + Acetes meal mixture in a 1:1 ratio

7GNOC-groundnut oil cake, 8MOC- mustard oil cake, 9DORB- De-oiled rice bran, 10VM mixture- vitamin-mineral mixture

**Table 3. Proximate analysis of all treatment diets (on dry matter basis, g/100g, n=3)**

|  |  |
| --- | --- |
|  | **Experimental Diets** |
|   | **T11** | **T22** | **T33** | **T44** | **T55** | **T66** |
| **CP7 (%)** | 36.10 | 36.07 | 36.06 | 36.04 | 36.00 | 35.99 |
| **EE8(%)** | 6.37 | 6.36 | 6.33 | 6.29 | 6.23 | 6.20 |
| **NFE9 (%)** | 43.17 | 43.24 | 43.22 | 43.27 | 43.40 | 43.39 |
| **CF10(%)** | 5.44 | 5.41 | 5.47 | 5.46 | 5.47 | 5.49 |
| **TA11(%)** |  8.92 | 8.91  | 8.93 | 8.95  | 8.90  | 8.96  |

1T1-Diet with 100% fish meal protein, 2T2- Diet with 80% fish meal and 20% Soybean meal + Acetes meal mixture in a 1:1 ratio, 3T3- Diet with 60% fish meal and 40% Soybean meal + Acetes meal mixture in a 1:1 ratio, 4T4- Diet with 40% fish meal and 60% Soybean meal + Acetes meal mixture in a 1:1 ratio, 5T5- Diet with 20% fish meal and 80% Soybean meal + Acetes meal mixture in a 1:1 ratio, 6T6- Diet with 0% fish meal and 100% Soybean meal + Acetes meal mixture in a 1:1 ratio

7CP-crude protein, 8EE- ether extract, 9NFE- Nitrogen-free extract, 10CF- crude fibre, 11TA- total ash

**2.5. Experimental procedure**

*L. vannamei* juveniles (2.05 ± 0.01 g) were stocked at 20 species per experimental tank in all 18 aquarium tanks. *L. vannamei* were given treatment diets four times a day, at 6:00, 11:00, 16:00, and 21:00 hours, with ad libitum during the experimental period. Daily total feed fed was 6% to 8% of body weight. Experimental feeds were composed of around 36 % protein. The requirement quantity of feed was weighed before feeding *L. vannamei* PL. The study was carried out using a completely randomized design (CRD) consisting of six treatments and three replications. Growth of *L. vannamei* was measured at each fortnight interval. All the animals were collected from each tank and their weights were recorded. The average weight of the animals in each tank was determined at fortnight intervals. The weight of *L. vannamei* was measured with an electronic balance using a glass beaker filled with water to reduce stress. Special care was taken to minimize the stress on animals during weight measurement. Continuous aeration was implemented during the entire experimental duration to sustain the dissolved oxygen concentration in every aquarium. Water quality was maintained by replenishing 10 % of the bottom water from each tank. Prior to the morning and evening feedings, small tubes were used to siphon out the tanks in order to eliminate leftover food and waste.

**2.6. Growth parameters and survival rate**

The subsequent mathematical formulas were utilized to determine different growth parameters, which include specific growth rate (SGR) (% day-1), percentage weight gain (WG %), feed conversion ratio (FCR), protein efficiency ratio (PER), and survival percentage.

SGR (%/day) = $\frac{Inof final wet weight -Inof initial wet weight }{Duration of experiment (days)}$× 100

WG % = $\frac{Final wet weight \left(g\right)-Initial wet weight (g)}{Initial wet weight (g)}$× 100

FCR = $\frac{Feed intake (dry weight) ( g)}{Body weight gain (wet weight) ( g)}$

PER = $\frac{Body weight gain (wet weight)( g)}{Protein intake (dry weight)(g)}$× 100

Survival (%) = $\frac{Total number of shrimps harvested at the end of feeding trial }{Total number of shrimps stocked at the starting of feeding trial }$× 100

**2.7. Proximate composition analysis of experimental diets and whole body of the shrimp**

As reported by AOAC (1995), the proximate composition of both the experimental diets and the whole body of the shrimp was examined. The proximate composition of the shrimp’s entire body was represented as a percentage of its wet weight, while the composition of the experimental diet was shown in grams per 100 grams on a dry matter basis. The standard formula was calculated using moisture, total ash, ether extract, crude protein, crude fibre, nitrogen-free extract (NFE), and total carbohydrate.

Moisture %= $\frac{sample weight before drying \left(g\right)- sample weight after drying (g)}{ sample weight before drying (g)}$ × 100

Total ash (%) = $\frac{ash weight (g)}{ dry sample weight (g)}$ × 100

Crude protein (%) = Total nitrogen content (%) × 6.25

Ether extract = $\frac{Wt. of the dried reeiver flask plus extracted lipid \left(g\right)-Wt. of the dried receiver flask (g)}{Weight of the dried sample (g)}$ × 100

Crude fibre (%) = $\frac{Wt.of the fat,protein and NFE free dried sample \left(g\right)- Wt.of the ash (g)}{Wt.of the sample before lipid extraction (g)}$ × 100

NFE (%) = 100- (CP% + EE% + CF + TA%)

Total carbohydrate (%) = 100 − (CP% + EE% + TA%)

**2.8. Water quality parameters**

The physicochemical characteristics of the water were examined every 15 days following the procedures outlined in the APHA (2005) standard.

**2.9. Statistical analysis**

The data from this study (growth parameters) were analyzed using version 22.0 of the Statistical Package for the Social Sciences (SPSS). To compare the means among different experimental groups, one-way ANOVA and Duncan's multiple-range tests were employed, revealing a significant difference at the 5% probability level (p<0.05). Each dataset was presented with its mean ± standard error (SE).

1. **Results**
	1. **Shrimp growth parameters and survival rate**

In the current study, different experimental diets combining soybean meal and Acetes meal mixture in a 1:1 ratio significantly (p<0.05) affected the growth of *L. vannamei* (Table 4). Treatments with these mixtures (T2, T3, T4, T5, T6) showed significantly (p<0.05) higher WG (Weight Gain), FBW (Final Body Weight), WG% (Percentage Weight Gain), SGR (Specific Growth Rate) and PER (Protein Efficiency Ratio), compared to the control group (T1, without soybean meal and Acetes meal mixture). Among the soybean meal and Acetes meal mixture treatments, the T5 treatment (comprising 20% fish meal and 80% soybean and Acetes meal mixture) achieved the highest FBW, WG, WG%, PER, and SGR compared to T2, T3, T4, and T6. The control treatment (T1) had a significantly higher feed conversion ratio (FCR) than the other experimental diets (p<0.05), with T5 exhibiting the lowest FCR among the treatments. Additionally, there were no significant differences in survival rates (p>0.05) among all treatments (T1, T2, T3, T4, T5, and T6).

**Table 4.** Growth indices and survival of *L. vannamei* fed with different experimental diets for 60 days.

|  |  |
| --- | --- |
| **Parameters** | **Experimental Treatments** |
| **T11** | **T22** | **T33** | **T44** | **T55** | **T66** | ***p-value*** |
| **FBW7 (g)** | 6.33±0.09a | 7.14±0.07b | 7.80±0.05d | 8.11±0.02e | 8.63±0.01f | 7.54±0.02c | 0.000 |
| **WG8 (g)** | 4.28±0.08a | 5.09±0.07b | 5.75±0.05d | 6.06±0.03e | 6.58±0.02f | 5.49±0.02c | 0.000 |
| **WG%9** | 208.49±4.10a | 248.47±3.67b | 280.19±2.66d | 296.03±2.56e | 321.02±1.77f | 267.88±0.33c | 0.000 |
| **SGR10****(% day**-**1)** | 1.88±0.02a | 2.08±0.01b | 2.22±0.01d | 2.29±0.01e | 2.39±.0.01f | 2.17±0.01c | 0.000 |
| **FCR11** | 1.64±0.01e | 1.43±0.01c | 1.44±0.01c | 1.33±0.01b | 1.24±.0.01a | 1.51±0.01d | 0.000 |
| **PER12** | 1.68±0.01a | 1.93±0.01c | 1.92±0.01c | 2.08±0.02d | 2.23±.0.01e | 1.83±0.01b | 0.000 |
| **Survival (%)** | 85.00±2.88 | 86.66±1.66 | 86.66±1.66 | 90.00±2.88 | 91.66±1.66 | 83.33±1.66 | 0.139 |

Data are shown as the mean ±SE (n =3); values with various superscripts in the same row differs significantly (p <0.05). 1T1-Diet with 100% fish meal protein, 2T2- Diet with 80% fish meal and 20% Soybean meal + Acetes meal mixture in a 1:1 ratio, 3T3- Diet with 60% fish meal and 40% Soybean meal + Acetes meal mixture in a 1:1 ratio, 4T4- Diet with 40% fish meal and 60% Soybean meal + Acetes meal mixture in a 1:1 ratio, 5T5- Diet with 20% fish meal and 80% Soybean meal + Acetes meal mixture in a 1:1 ratio, 6T6- Diet with 0% fish meal and 100% Soybean meal + Acetes meal mixture in a 1:1 ratio, **7**FBW =final body weight, **8**WG = weight gain, **9**WG% =percentage weight gain, **10**SGR =specific growth rate, **11**FCR =feed conversion ratio, **12**PER =protein efficiency ratio

* 1. **Proximate composition analysis of shrimp whole body**

Table 5 shows the effects of various soybean and Acetes meal mixtures on the proximate composition of shrimp. The data indicate no significant differences (p>0.05) in the levels of total moisture, total ash, crude protein, total carbohydrate, and total lipid across all experimental groups (T1, T2, T3, T4, T5, and T6).

**Table 5.** Proximate composition (on a % wet weight basis) of *L. vannamei* fed with different experimental diets for 60 days.

|  |  |
| --- | --- |
| **Parameters** | **Experimental Treatments** |
| **T11** | **T22** | **T33** | **T44** | **T55** | **T66** |
| **TM7** | 75.08±0.01 | 75.04±0.10 | 75.001±0.06 | 75.04±0.04 | 75.04±0.07 | 75.05±0.07 |
| **CP8** | 15.16±0.04 | 15.15±0.05 | 15.05±0.07 | 15.15±0.02 | 15.09±0.06 | 15.13±0.00 |
| **TL9** | 1.74±0.03 | 1.74±0.09 | 1.78±0.04 | 1.74±0.07 | 1.75±0.05 | 1.73±0.02 |
| **TA10** | 3.79±0.01 | 3.82±0.01 | 3.89±0.02 | 3.78±0.01 | 3.85±0.04 | 3.81±0.01 |
| **TC11** | 4.21±0.01 | 4.23±0.07 | 4.25±0.05 | 4.28±0.08 | 4.25±0.04 | 4.26±0.09 |

Data are shown as the mean ±SE (n =3);1T1-Diet with 100% fish meal protein, 2T2- Diet with 80% fish meal and 20% Soybean meal + Acetes meal mixture in a 1:1 ratio, 3T3- Diet with 60% fish meal and 40% Soybean meal + Acetes meal mixture in a 1:1 ratio, 4T4- Diet with 40% fish meal and 60% Soybean meal + Acetes meal mixture in a 1:1 ratio, 5T5- Diet with 20% fish meal and 80% Soybean meal + Acetes meal mixture in a 1:1 ratio, 6T6- Diet with 0% fish meal and 100% Soybean meal + Acetes meal mixture in a 1:1 ratio, **7**TM =total moisture, **8**TA =total ash, **9**CP = crude protein, **10**TC =total carbohydrate, **11**TL= total lipid

* 1. **Water quality parameters**

In this study, the water's physicochemical parameters, including temperature (°C), dissolved oxygen (mg/L), pH, alkalinity (mg/L), and salinity (ppt), were maintained at optimum ranges for the vannamei juveniles throughout the 60-day experimental period (Table 6).

**Table 6.** Range of Physico-chemical parameters of the water during the experimental period

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Day** | **Temperature (ºC)** | **pH** | **Salinity (ppt)** | **DO (mg/L)** | **Alkalinity (mg/L)** |
| Day 0 | 27.3-28.7 | 7.6-7.7 | 17.5-18 | 6.50-6.83 | 120.5-130.9 |
| Day15 | 26.1-27.7 | 7.8-7.9 | 17.5-18 | 6.73-6.87 | 133.6-143.1 |
| Day 30 | 26.4-27.9 | 7.4-7.6 | 17.5-18 | 6.65-6.73 | 125.8-149.9 |
| Day 45 | 28.2-29.8 | 7.5-7.6 | 17.5-18 | 6.50-6.73 | 123.4-137.4 |
| Day 60 | 28.3-29.9 | 7.6-7.8 | 17.5-18 | 6.39-6.51 | 140.9-148.6 |

**Discussion**

Due to the diminishing marine catches and increasing market costs, fishmeal replacement with less expensive and non-conventional protein sources is necessary to intensify the shrimp culture (Shiau et al., 2023). Among sources of plant protein, soybean meal stands out as a viable alternative because of its well-rounded amino acid composition, affordability, and accessibility (Yang et al., 2015; Tacon and Forster, 2000). Acetes meal is a non-conventional protein ingredient of animal origin with the potential for fishmeal replacement (Mahida et al., 2017; Malli et al., 2017). In the present study, (T5) 80% fishmeal replacement with soybean and Acetes meal in a 1:1 ratio showed significantly (p<0.05) higher growth performance (weight gain, SGR, percentage weight gain, PER), survival and lower FCR as compared to the control (T1 treatment) fed with 100% fishmeal. Similarly, 50% of fishmeal replacement by Acetes meal showed increased growth, SGR, PER, and survival compared to the control in vannamei juveniles (Mahida et al., 2017). Malli et al. (2017) indicated that 30% of fishmeal replacement by Acetes meal showed higher growth performance in vannamei. Replacing fishmeal with soybean protein concentrate by as much as 40% will be effective without negatively impacting the Protein Efficiency Ratio (PER) (Zhu et al., 2021). Yang et al. (2015) also indicated that replacing up to 30% of fishmeal with soybean meal would not negatively impact the growth performance of shrimp juveniles. The survival rates of *L. vannamei* showed no significant differences among the treatments. However, according to Cuzon and Guillaume (1997), a minimum of 80% survival is deemed appropriate for raising crustaceans, and the lowest survival rate found in this study is 83.33%.

In this study, the overall body composition of juvenile shrimps showed no significant changes (p>0.05) due to the replacement of fishmeal in their diet. The crude protein content, total carbohydrate, total ash and total lipid did not differ significantly between the control (T1) and T5 (80% replacement of fishmeal with soybean and Acetes meal in a 1:1 ratio). Zhu et al., 2021 and Yang et al., 2015 also reported that moisture, total ash and crude protein content showed no significant difference up to 30% fishmeal replacement with soybean meal and 40% fishmeal replacement with soybean protein concentrate in juvenile shrimp, respectively. Similarly, replacing 40% of fishmeal by cottonseed protein concentrate also showed no significant difference in the whole-body proximate, including moisture, crude protein, total ash content and crude lipid content of vannamei juveniles. In crustaceans, growth and weight gain usually occur by increasing their feed's lipid, crude protein, ash contents and carbohydrate (Yang et al., 2015). This study supports the above result as all the experimental feeds used in this study were iso-nitrogenous (36% CP) and iso-lipidic (6% EE).

Water quality plays a crucial role because it influences the survival of organisms in aquatic ecosystems, either directly or indirectly. (Parvathi & Padmavathi, 2018; Patra et al., 2024). During the study, water quality parameters such as dissolved oxygen (DO), alkalinity, salinity, temperature and pH were maintained within the preferred ranges (Table 6). In this study, the observed water temperatures varied between 26.1 and 29.9° C. The growth rate of penaeid shrimp is primarily affected by temperature (Tsuzum *et al.,* 2007). The thermal tolerance range for *L. vanname*i lies between 15 and 33°C, with optimal growth occurring between 23 and 30° C. (Rosenberry, 2003). The pH level of water is essential for the development and well-being of shrimp. In this study, the pH values recorded ranged from 7.4 to 7.9. Numerous researchers have indicated that a pH range of 7.6 to 8.6 is optimal for the improved growth and survival of *L. vannamei* (Xingqiang *et al.,* 2004). The salinity levels observed in the current study ranged from 17.5 to 18 ppt. *L. vannamei* is capable of enduring various salinity levels, from 0.5 to 40 ppt, due to its ability to regulate osmotic balance (Saoud *et al.,* 2003). Additionally, changes in salinity can impact the growth and nutrient absorption of shrimp (Maica *et al.,* 2014). Dissolved oxygen levels were found to range from a low of 6.39 ppm to a high of 6.87 ppm in this research. An ideal concentration of 5 ppm of DO is necessary for optimal growth and maintenance (Yaro *et al.,* 2005). Alkalinity was recorded between 120.5 ppm and 148.6 ppm, as reported in this study. As noted by Boyd and Tucker (1998), total alkalinity levels exceeding 75 ppm can be beneficial for aquaculture. Nevertheless, maintaining total water alkalinity below 100 ppm over an extended duration may negatively impact the growth performance of *L. vannamei* (Furtado *et al.,* 2011).

**Conclusion**

Replacing fishmeal with an equal mixture of soybean and Acetes meal in the diet (i.e.: 1:1) of *Litopenaeus vannamei* demonstrates significant promise for sustainable aquaculture practices. The study found that the treatment T5, which contained 80% soybean and Acetes meal in a 1:1 ratio, significantly improved the shrimp's weight gain, SGR, and PER. Additionally, treatment T5 achieved the lowest FCR among the tested diets. These findings suggest that soybean and Acetes meal can effectively serve as substitutes for fishmeal, promoting the growth and health of shrimp while reducing dependence on traditional fishmeal. This strategy supports environmental sustainability and enhances cost efficiency in shrimp farming.

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Details of the AI usage are given below:

1.

2.

3.

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