Growth of Vannamei Shrimp (*Litopenaeus vannamei*) Challenge Tested Using *Vibrio parahaemolyticus* with the Addition of *Moringa Oleifera* Leaf Flour Through Feed

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ABSTRACT

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| **Aims:** To determine the effect of different feeding doses supplemented with Moringa leaf flour (*Moringa oleifera*) on the growth of vannamei shrimp infected with *Vibrio parahaemolyticus.*  **Study design:** QuantitativeExperimental  **Place and Duration of Study:** This study will be conducted over a period of 60 days, from January to March, at the Fish Health Laboratory, Aquaculture Study Program, University of Mataram.  **Methodology:** The experimental method is the approach used in this study, as it involves testing the administration of moringa leaf powder at different doses in the feed. The dosage applied in this study is arranged using a Completely Randomized Design (CRD), which consists of 5 treatments and 3 replications, resulting in a total of 15 experimental units.  **Results:** **The research results showed that the addition of Moringa leaf flour to feed at different doses had a significant effect on improving the survival rate to 85%, specific growth rate by weight to 1.65%/day, specific growth rate by length to 2.3%/day, FCR to 1.33, and phagocytic activity (PA) to 74% in shrimp that received the supplemented feed.**  **Conclusion: The addition of Moringa leaf flour through feed had a significant effect on the parameters of Survival Rate, Specific Growth Rate by Weight, Specific Growth Rate by Length, Feed Conversion Ratio (FCR), and Phagocytic Activity.** The best results were obtained in treatment P5 with 6% Moringa leaf flour supplementation, yielding a survival rate of 85%, Specific Growth Rate by Weight of 1.66, Specific Growth Rate by Length of 2.3%/day, Feed Conversion Ratio (FCR) of 1.33, Phagocytic Activity of 74%. Water quality parameters remained within optimal ranges, with dissolved oxygen at 6.8–8.3 mg/L, pH at 7.5–8.4, temperature at 28.4–31.1°C, ammonia at 0–3 mg/L, and salinity at 30–35 ppt. |

*Keywords: Immunostimulant, Moringa leaf flour, Litopenaeus vannamei.*

1. INTRODUCTION

Vannamei shrimp is one of the leading aquaculture commodities in Indonesia, with great potential and significant prospects for increasing national foreign exchange earnings (Pantjara *et al.,* 2015). One of the most prominent sectors is the cultivation of vannamei shrimp (*Litopenaeus vannamei*). The high demand for vannamei shrimp in international markets greatly contributes to foreign exchange. Moreover, 77% of vannamei shrimp production comes from Asian countries, including Indonesia (Hidayat *et al.,* 2019).

The high market demand for vannamei shrimp has led many communities to engage in its cultivation. According to Farionita *et al*. (2018), Indonesia’s vannamei shrimp production reached 650,000 tons in 2020, with Lampung Province being the largest producer, accounting for 19.43% of the national total. Vannamei shrimp possess several advantages: they are more disease-resistant, tolerant to drastic temperature changes, and prefer bottom-dwelling areas, allowing for higher stocking densities (Hidayat *et al.,* 2019).

However, the increasing cultivation of vannamei shrimp has given rise to various problems. Common issues in vannamei shrimp farming include imbalanced interactions between the environment, aquatic biota, and disease-causing agents. Poor environmental quality—such as high organic matter content—can degrade water quality, making cultured organisms more susceptible to disease. Shrimp diseases can be caused by viruses, bacteria, or parasites. One of the most common diseases affecting vannamei shrimp is vibriosis, caused by bacteria from the genus *Vibrio* (Setyati *et al.,* 2016).

A particularly harmful species is *Vibrio parahaemolyticus*, which frequently infects shrimp (Sarjito *et al.,* 2016). This bacterium can cause hemocyte lysis, body reddening, and even death. According to Widowati (2018), if *Vibrio* bacteria are ingested by humans, they can cause gastrointestinal infections characterized by vomiting, diarrhea, and vascular damage. This species can proliferate rapidly in environments with accumulated organic matter on pond bottoms. Therefore, proper management is essential to prevent and mitigate these issues.

One common method to combat *V. parahaemolyticus* is the use of antibiotics. However, long-term, routine use of antibiotics at inappropriate doses can lead to bacterial resistance,environmental damage, and health risks for consumers. Thus, alternative solutions are needed to enhance shrimp immune systems, such as the use of immunostimulants. According to Setyati *et al*. (2016), immunostimulants are substances used to boost shrimp immunity by administering microbial components such as β-glucans, lipopolysaccharides (LPS), or inactivated bacterial cells. These immunostimulants directly stimulate immune cells, making them more active. However, such substances tend to be relatively expensive, requiring the search for cheaper and more accessible alternative sources, such as Moringa leaf flour.

Moringa leaves (*Moringa oleifera*) belong to the Moringaceae family. These leaves contain flavonoids, alkaloids, phenols, and saponins (Arora *et al*., 2017). Alkaloids in Moringa leaves act as antibacterial agents and can inhibit free radical chain reactions (Bamishaiye *et al.,* 2014). They also function as immunostimulants by enhancing macrophage activity (Biswas *et al.,* 2014). However, the use of Moringa leaf flour to boost the immune system in shrimp has not been widely reported. Therefore, it is necessary to conduct research on the use of Moringa leaf flour in vannamei shrimp to improve immune response, particularly when challenged with *V. parahaemolyticus*.

2. METHODS

2.1 Research Methods

The experimental method was used in this study because it required testing the administration of different doses of moringa leaf powder in the feed. The dosage applied in this research refers to a previous study, which used a range of 1–3% (Pratama, 2018). The design implemented was a Completely Randomized Design (CRD), consisting of 5 treatments and 3 replications, resulting in a total of 15 experimental units.

2.2 Research Procedure

**2.2.1 Rearing Container Preparation**

The containers used for vannamei shrimp cultivation in this study were 15 plastic tanks measuring 45 × 15 cm. The tanks were scrubbed using detergent to eliminate bacteria, then dried for 24 hours. After drying, the tanks were arranged according to a Completely Randomized Design. Each container was then filled with seawater and covered to prevent the shrimp from jumping out. Aeration was installed to increase the availability of oxygen in the water (Fadillah et al., 2019).

**2.2.2Test Animal Preparation**

The test animals used were PL-10 stage vannamei shrimp, obtained from PT. Anugrah Agung Sumbawa (AAS). The shrimp were acclimatized for 10 days to allow adaptation to the new environment. After acclimatization, the shrimp were stocked into the containers at a density of 25 individuals per tank. During the rearing period, shrimp were fed four times daily using commercial feed containing 40% protein (Junaidi et al., 2020).

**2.2.3 Test Feed Preparation**

The feed used in this study was commercial feed supplemented with moringa leaf powder at doses of 2%, 4%, and 6%. Moringa leaf powder was prepared by weighing 100 g of fresh moringa leaves to produce approximately 10 g of powder. The leaves were oven-dried at a maximum temperature of 50°C. Once dried, the leaves were blended into a fine powder and sieved through an 80-mesh screen to obtain a smooth consistency. The powder was then stored at room temperature to prevent mold growth (Fadillah et al., 2019).

**2.2.4 Test Animal Maintenance**

Maintenance was conducted for 60 days, with feeding frequency set at four times daily: at 07:00, 10:30, 14:30, and 16:00. Sampling and data collection were conducted on days 0, 22, and 45 before challenge testing, and on day 56 after the challenge test. Siphoning was done every two days during the early maintenance phase, and daily after day 22.

**2.2.5 Material Preparation**

Moringa leaf powder was obtained by oven-drying whole moringa leaves at 50°C until completely dry. The dried leaves were then blended into powder and sieved through an 80-mesh screen to obtain fine moringa flour, which was then mixed into the feed according to the predetermined doses.

**2.2.6 Test Bacteria Preparation**

The bacteria were obtained through a postulate test aimed at increasing virulence. Existing bacterial cultures from the fish health laboratory were cultured in liquid TSB medium and incubated for 24 hours to promote bacterial growth. From the culture, 0.1 mL of bacteria was injected into 10 shrimp intramuscularly. Once the shrimp died, they were homogenized with a sufficient amount of NaCl and centrifuged for 15 minutes at 1000 RPM to obtain the supernatant. This supernatant was then cultured on TCBS medium at a volume of 100 µL and incubated for 24 hours to produce more virulent bacteria for use in the challenge test.

**2.2.7 Challenge Test**

The challenge test aimed to evaluate the effect of moringa leaf powder on shrimp infected with *Vibrio parahaemolyticus*. The test was carried out for 10 days at the end of the treatment period (day 51). Shrimp were fasted for one day prior to infection with V. parahaemolyticus. The infection was done via intramuscular injection between the second and third segment of the shrimp's back at a dose of 100 μL per shrimp with a bacterial density of 10⁶ CFU/mL. During the challenge test, immune response data were collected and shrimp mortality was recorded (Fuandila et al., 2019).

**2.3 Research Parameters**

#### 2.3.1 Survival Rate (SR)

The survival rate is a parameter that needs to be observed daily from the beginning to the end of the study. SR is used to determine the number of shrimp that survive. It is calculated using the following formula:  
SR = (Nt / No) × 100%  
Description:

* SR = Survival rate (%)
* No = Number of shrimp at the beginning of the study
* Nt = Number of shrimp at the end of the study

#### 2.3.2 Specific Growth Rate (SGR) in Weight

The specific growth rate in weight is the percentage of the difference between final and initial weight, divided by the duration of the rearing period. According to Ridwan (2019), the formula is:  
SGR = [(LnWt - LnWo) / t] × 100%

Description:

* SGR = Specific growth rate in weight (%/day)
* Wo = Initial average weight of shrimp (g)
* Wt = Final average weight of shrimp (g)
* t = Duration of rearing period (days)

#### 2.3.3 Specific Growth Rate in Length

The specific growth rate in length is the percentage of the difference between final and initial length, divided by the duration of the rearing period. According to Putra (2018), the formula is:  
SGRL = [(LnLt - LnLo) / t] × 100%

Description:

* SGRL = Specific growth rate in length (%/day)
* Lt = Final average length of shrimp (cm)
* Lo = Initial average length of shrimp (cm)
* t = Duration of rearing period (days)

#### 2.3.4 Feed Conversion Ratio (FCR)

FCR is the ratio between the amount of feed given and the shrimp biomass produced. It is calculated at the end of the rearing period using the formula by Effendi (1997) in Ihsanudin et al. (2014):  
FCR = F / [(Wt + D) – Wo]

Description:

* FCR = Feed Conversion Ratio
* F = Total feed given (g)
* Wt = Final weight (g)
* Wo = Initial weight (g)
* D = Weight of dead shrimp during the rearing period (g)

#### 2.3.5 Phagocytic Activity (PA)

Phagocytic activity is observed by taking 0.1 ml of hemolymph, adding 25 µl of *Staphylococcus* sp. bacteria (10⁷ CFU mL⁻¹), and incubating for 20 minutes. Then, 10 µl of the mixture is placed on a slide, fixed with methanol for 5 minutes, and air-dried. The sample is stained with Giemsa for 15 minutes, rinsed with distilled water, and observed under a microscope at 40× magnification (Pujianti et al., 2014).  
PA = (Number of phagocytosing cells / Total phagocyte cells) × 100%

#### 2.3.6 Blood Glucose

The blood profile of shrimp can be assessed through their blood glucose levels. Blood glucose concentration serves as a primary indicator of stress in fish or shrimp. In shrimp, a glucose concentration exceeding 150 mg/dL indicates an increased energy demand during the molting process and the need to maintain homeostatic glucose levels in the hemolymph. Extreme environmental changes make shrimp more susceptible to stress, leading to elevated glucose levels in their hemolymph (Widodo et al., 2011).

#### 2.3.7 Water Quality Parameters

The water quality parameters measured during the study included DO, temperature, pH, ammonia, hardness, and alkalinity**.**  
Measurements of DO, temperature, pH, hardness, and alkalinity were conducted across all experimental treatments, with water quality assessments carried out three times during the study: at the beginning, middle, and end. Ammonia levels were measured in all experimental treatments as well, but only twice during the study—once in the middle and once at the end.

#### Table 1 Water Quality Parameters

| **No** | **Parameter** | **Unit** | **Instrument** | **Optimal Range** |
| --- | --- | --- | --- | --- |
| 1 | Temperature | °C | Thermometer | 28–31 (Arsad *et a*l., 2017) |
| 2 | pH | - | pH meter | 7.4–8.9 (Lestari *et al.*, 2017) |
| 3 | Dissolved Oxygen | mg/L | DO meter | > 4 (Tangguda *et al.,* 2018) |
| 4 | Ammonia | mg/L | Spectrophotometer | < 0.1 (Mangampa & Suwoyo, 2016) |

3. results and discussion

**3.1 *survival rate* (SR)**

Based on the results of the Analysis of Variance (ANOVA) test, the attempt to enhance the immune system of vannamei shrimp (Litopenaeus vannamei) by adding moringa leaf powder to the feed showed a significant difference (p < 0.05) in survival rate. Therefore, Duncan's post-hoc test was conducted. The results indicated that treatment P1 (positive control) was significantly different from treatments P3 (2%), P4 (4%), and P5 (6%), but not significantly different from P2 (negative control). The highest survival rate was found in treatment P5 (6%) at 85%, while the lowest was in treatment P1 (positive control) at 64%.

**Figure 1. Survival Rate (SR)**

The addition of moringa leaf powder to the feed had a significant effect (p<0.05) on the survival rate.

Based on the results of the study (Figure 1), the highest survival rate (SR) was observed in treatment P5 at 85%, while the lowest was in P1 and P2 with the same value of 64%. This survival rate is categorized as good. This is in line with the opinion of Scabra et al. (2024), who stated that shrimp survival rates are categorized as low if <50%, moderate if >50%, and good if >70%. The high survival rate in P5 is presumed to be due to the addition of moringa leaf powder, which contains alkaloids with antibacterial properties that can inhibit bacterial activity, thus contributing to better health performance in the shrimp. Good health performance can support higher survival rates during the rearing period.

Alkaloid compounds in moringa leaf powder (as antibacterial agents) added to the feed can enhance the immune system, allowing shrimp to respond more quickly to disturbances. Alkaloids also function as immunostimulants that can increase hemocyte cells in shrimp. This is in line with the statement by Biswah et al. (2014), who reported that moringa leaves contain alkaloid compounds that act as antibacterial agents and are capable of halting free radical chain reactions, as well as playing a role as immunostimulants by enhancing macrophage activity. As shown in Figure 1, P5, which received the highest dose of moringa leaf powder, resulted in the highest survival rate compared to other treatments.

The lowest survival rate was observed in the control treatments, P1 and P2, both with a percentage of 64%. The low survival rate in P1 and P2 is thought to be due to the absence of moringa leaf powder supplementation, which negatively affected shrimp performance during the rearing period. The difference in survival rate percentages suggests that the addition of moringa leaf powder to the feed leads to a higher survival rate compared to treatments without moringa leaf powder supplementation.

**3.2 specific growth rate of weight**

Based on the ANOVA test, the immune enhancement effort for vannamei shrimp by adding moringa leaf powder to the feed showed a significant difference (p < 0.05) in specific growth rate of weight. Duncan’s post-hoc test showed that P1 (positive control) differed significantly from P3 (2%), P4 (4%), and P5 (6%), but not from P2 (negative control). The highest specific growth rate was found in P5 at 1.66 g, while the lowest was in P1 at 0.88 g.

**Figure 2. Specific growth rate of weight**

The addition of moringa leaf powder to the feed had a significant effect (p<0.05) on the specific weight.

Based on the research results, the addition of moringa leaf powder in the feed showed that the highest specific growth rate in weight was observed in treatment P5, with a value of 1.65%/day, while the lowest was in P1, with a value of 0.88%/day. This result is presumably due to the presence of bioactive compounds (such as tannins) in moringa leaf powder that can slow down digestion, thereby increasing nutrient absorption time in the digestive tract. In addition to bioactive compounds, moringa leaf powder is also rich in protein and amino acids, which support the formation of both soft and hard tissues as well as muscle tissue in shrimp.

This finding is consistent with Basir et al. (2022), who stated that the increase in specific body weight of shrimp fed with moringa-supplemented diets indicates denser and more efficient tissue growth. This is attributed to the presence of bioactive compounds in moringa leaves, such as flavonoids, tannins, and saponins, which help improve digestion efficiency and nutrient absorption. As a result, most of the energy from the feed is allocated to the growth of structural tissues, directly contributing to the increase in specific weight.

**3.3 specific growth rate of length**

The ANOVA test results showed a significant difference (p < 0.05) in specific length growth rate due to the addition of moringa leaf powder to the feed. Duncan’s post-hoc test showed that P1 (positive control) was significantly different from P3 (2%), P4 (4%), and P5 (6%), but not from P2 (negative control). The highest specific length growth rate was found in P5 (6%) at 2.3%, and the lowest in P2 (negative control) at 1.6%.

**Figure 3. Specific Growth Rate of Length**

The addition of moringa leaf powder to the feed had a significant effect (p<0.05) on the specific length growth.

Based on the results of the study (Figure 3), the highest specific length growth was observed in treatment P5 with a value of 2.30%/day, while the lowest was in P1 with a value of 1.60%/day. The variation in specific length growth is presumed to be due to differences in the dosage percentage of moringa leaf powder administered in each treatment. Moringa leaves contain protein, calcium, and phosphorus, which are essential for tissue growth processes, including segment elongation during molting. Bioactive compounds such as flavonoids and tannins also contribute by enhancing metabolic efficiency and gastrointestinal health, thus supporting optimal nutrient absorption.

According to Purnomo et al. (2021), the use of Moringa oleifera leaf powder as a feed additive for vannamei shrimp provides positive effects on the increase of specific length growth, namely the rate of body length increase per unit time. Moringa leaves contain important nutrients such as high-quality plant protein, essential amino acids, vitamins A and C, as well as minerals like calcium and phosphorus, all of which support the formation and elongation of the exoskeleton during the shrimp’s molting cycle.

Basir et al. (2022) also stated that bioactive compounds such as flavonoids and tannins in moringa leaves function as antioxidants and immunostimulants, helping maintain the health of internal organs and improve metabolic efficiency. Improved metabolic efficiency accelerates tissue formation, including body length growth, thereby directly influencing the specific length increase in shrimp.

During the course of the study, molts or carapace remnants were frequently observed during siphoning. Although molting occurred in all treatments, it was more frequently found in treatments P5 and P4 with higher moringa powder concentrations. This supports the statement by Jaganmohan & Kurami (2018), who noted that the presence of molted carapaces in the rearing media is an indicator of shrimp growth.

**3.4 *feed conversion ratio* (FCR)**

According to ANOVA results, the effort to improve the immune system of vannamei shrimp through the addition of moringa leaf powder in the feed showed no significant effect (p > 0.05) on the feed conversion ratio. Treatment P1 (positive control) did not differ significantly from P2 (negative control), P3 (2%), P4 (4%), and P5 (6%). The highest FCR was observed in P1 (positive control) at 1.86, while the lowest was in P5 (6%) at 1.33.

**Figure 4. Feed Conversion Ratio (FCR)**

The addition of moringa leaf powder to the feed had a significant effect (p<0.05) on the feed conversion ratio (FCR).

Based on the results of this study (Figure 4), the lowest feed conversion ratio (FCR) was found in treatment P5 with a value of 1.33, while the highest was in P1 with a value of 1.86. The low FCR value is presumably due to the presence of nutrients such as protein, amino acids, minerals, and calcium in the feed supplemented with moringa leaf powder, enabling the absorbed feed to be utilized optimally. In addition to its nutritional content, Moringa leaves also contain bioactive compounds such as flavonoids and tannins, which act as antioxidants and immunostimulants. These compounds help maintain internal organ health and enhance metabolic efficiency.

A low feed conversion ratio (FCR) is a direct indicator of high growth rates, as feed—the primary input—is efficiently converted into biomass, supported by good physiological conditions of the shrimp. This is consistent with the findings of Rachmawati et al. (2021), who stated that improving nutrient utilization efficiency through the bioactive content of Moringa leaves can lower the FCR and directly contribute to the growth enhancement of *Litopenaeus vannamei*. A low FCR indicates efficient feed utilization, allowing more energy obtained from the feed to be directed towards shrimp body growth. In contrast, a high FCR reflects inefficiency and slower growth.

This is also supported by Purnomo et al. (2023), who reported in a similar study that supplementation of Moringa leaf extract at doses of 2.5–5 g/kg feed significantly reduced FCR values to the range of 1.0–1.2, while the control FCR remained around 1.3–1.5. This indicates the active role of Moringa bioactive compounds in enhancing feed conversion efficiency and simultaneously increasing the growth rate of vannamei shrimp.

**3.5 phagocytic activity (AF)**

The ANOVA test results indicated that the addition of moringa leaf powder to the feed significantly affected (p < 0.05) phagocytic activity (AF). Duncan’s post-hoc test showed that P1 (positive control) was significantly different from P2 (negative control), P3 (2%), P4 (4%), and P5 (6%), although P4 (4%) and P5 (6%) were not significantly different from each other. The highest phagocytic activity was observed in P5 (6%) at 74%, followed by P4 (4%) at 70%, P3 (2%) at 59%, P2 (negative control) at 55%, and the lowest in P1 (positive control) at 51%.

**Figure 5. Phagocytic Activity**

The addition of moringa leaf powder to the feed had a significant effect (p<0.05) on phagocytic activity.

### 3.5 Blood Glucose

### Based on the ANOVA test, the immune enhancement efforts using moringa leaf powder in feed showed no significant effect (p > 0.05) on blood glucose levels. Treatment P1 (0%) was not significantly different from P2 (1%), P3 (2%), P4 (3%), and P5 (4%). The highest blood glucose level was found in P1 (negative control) at 117 mg/dL, and the lowest in P4 at 46 mg/dL. High or low blood glucose levels indicate the stress level of the shrimp; the higher the glucose level, the greater the stress.

**Figure 6. Blood Glucose**

The addition of moringa leaf powder to the feed had no significant effect (p>0.05) on blood glucose levels.

Blood glucose in shrimp functions as a body fluid that plays a role in fluid balance and cellular repair processes. In this study, the blood glucose levels of shrimp ranged from 50 to 117 mg/dL. Blood glucose levels reflect the physiological condition of the shrimp; deviations—whether low or high—may indicate that the shrimp are under stress, which can compromise their immune system. This condition may be triggered by several factors, including environmental changes, biological factors, and physical stressors. According to Fendjalang et al. (2016), abnormally low or high glucose levels in shrimp can indicate a state of stress. Widodo et al. (2011) also explain that fluctuations in blood glucose levels may result from chemical, biological, physical, or environmental factors. Extreme environmental conditions, in particular, can induce stress in shrimp, leading to increased glucose concentrations in the hemolymph and a disruption of the shrimp’s immune system.

### 3.6 Water Quality

### Water quality, as the living medium for shrimp, is an important parameter that must be maintained to ensure optimal growth and development of the cultured shrimp. The water quality parameters in this study are presented in Table 2 below:

Table 2 : The water quality parameters

| Parameter | Research Value (Range) | Reference Value |
| --- | --- | --- |
| Dissolved Oxygen (mg/L) | 6.8 – 8.3 | > 4 (Tangguda *et al*., 2018) |
| pH | 7.5 – 8.4 | 7.4 – 8.9 (Lestari *et al*., 2017) |
| Temperature (°C) | 28.4 – 31.1 | 28 – 31 (Arsad *et a*l., 2017) |
| Ammonia (mg/L) | 0 – 3 | < 0.1 (Mangampa & Suwoyo, 2016) |
| Salinity (ppt) | 30 – 35 | (Supriatna *et al*., 2020) |

Water quality is a key factor in the success of vannamei shrimp farming.  
Water quality, as the living medium, plays a crucial role and must be properly maintained. According to Scabra *et al*. (2023), one of the primary factors determining the success of shrimp farming production is maintaining good water quality, as shrimp are aquatic organisms whose growth and health rely heavily on the quality of the water they inhabit. Efforts to maintain water quality include scheduled water exchange in accordance with siphoning routines, regular water quality monitoring, and specific treatments based on the condition of the cultivation medium. The water quality parameters measured in this study included:  
Dissolved Oxygen (DO), pH (degree of acidity), temperature, ammonia, and salinity.

Dissolved oxygen (DO) refers to the oxygen dissolved in water and is a critical water quality parameter that plays an important role in the chemical and physical processes in the aquatic environment and in shrimp physiology. DO functions as the main oxygen supply, and it must remain sufficient in the water to support shrimp survival and growth. In this study, the DO levels ranged from 6.8 to 8.3 mg/L, which is within the normal range. According to Tangguda *et al.* (2018), optimal DO levels for vannamei shrimp cultivation are above 4 mg/L.

pH (degree of acidity) indicates whether the water is alkaline, acidic, or neutral. High pH indicates alkaline water, while low pH indicates acidity. pH is often related to osmoregulation, respiration, oxygen consumption, and the shrimp’s ability to absorb nutrients. The pH levels recorded in this study were within the normal range, between 7.5 and 8.4. According to Lestari et al. (2017), the normal pH range is between 7.4 and 8.9.

Temperatur**e** is another crucial parameter that must remain stable and suitable for the cultivated species. In this study, the recorded temperature was within the optimal range, between 28.4 and 31.1 °C. According to Arsad *et al.* (2017), the optimal temperature for supporting shrimp growth ranges from 28 to 31 °C. Temperature fluctuations can impact shrimp metabolism: high water temperatures can accelerate metabolism, respiration, and osmoregulation, whereas lower temperatures can slow down these processes and reduce shrimp appetite, thereby slowing growth.

Ammonia in the water originates from the decomposition of organic matter, primarily uneaten feed and shrimp feces. According to Scabra *et al.* (2023), ammonia is a water quality parameter arising from the decomposition of nitrogen-rich organic material (such as protein) from uneaten feed. In this study, ammonia levels ranged from 0 to 3 mg/L. Some treatments showed relatively high ammonia levels, which may have been caused by the addition of natural ingredients to the feed, increasing ammonia concentration in the water medium. According to Mengampa & Suwoyo (2016), the optimal ammonia level is below 0.1 mg/L.

4. Conclusion

The addition of moringa leaf powder through feed had a significant effect on the parameters of Survival Rate, Specific Growth Rate of Weight, Specific Growth Rate of Length, Feed Conversion Ratio (FCR), and Phagocytic Activity**.**

The best results were observed in treatment P5 with the addition of 6% moringa leaf powder, showing a survival rate of 85%, specific growth rate of weight of 1.66, specific growth rate of length of 2.3%/day, FCR of 1.33, phagocytic activity of 74%, and water quality parameters remaining within the optimal range, with DO of 6.8–8.3 mg/L, pH 7.5–8.4, temperature 28.4–31.1°C, ammonia 0–3, and salinity 30–35.

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