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EFFECTIVENESS OF SILVER NANOPARTICLES UTILIZATION FROM MICROALGAE CHLORELLA PYRENOIDOSA AND DUNALIELLA SALINA FOR VANAME SHRIMP FARMING IN THE MUARA TAMI DISTRICT OF JAYAPURA

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Abstract
Muara Tami district in Jayapura has significant potential for vaname shrimp farming. However, environmental problems and pathogens are often the main obstacles that reduce the productivity of this culture. One of the innovative solutions being developed to overcome these problems is the application of nanoparticle innovation in aquaculture, especially silver nanoparticles (AgNPs). This study aims to assess the effectiveness of using silver nanoparticles obtained from microalgae Chlorella pyrenoidosa and Dunaliella salina as an alternative that can support the development of vaname shrimp farming. The research method used a qualitative approach, with data collected through direct observation, involving the manufacture of silver nanoparticles from microalgae C. pyrenoidosa and D. salina, which were then used as feed for vaname shrimp. After observation, the data were processed and supported by related literature. The results showed that the application of silver nanoparticles from microalgae was effective on the growth and survival rate of cultured vaname shrimp in Muara Tami District. Thus, these findings indicate that microalgae have great potential as natural agents that can help reduce toxicity in aquaculture environments, creating healthier and more sustainable shrimp farming conditions.

Keywords: Silver nanoparticles, microalgae chlorella pyrenoidosa, dunaliella salina, vaname shrimp, Jayapura

INTRODUCTION

Vaname shrimp or with another name *LitoPenaeus vannamei* is one type of shrimp with high economic value and an alternative that can be cultivated in Indonesia, apart from tiger shrimp (*Panaeus monodon*) and white shrimp (*Panaeus merguensis*) (Anisa et al., 2021). *LitoPenaeus vannamei* is a type of shrimp that is widely produced and exported by Indonesia. In 2021, Indonesia was listed as the fourth largest shrimp exporting country in the world after Ecuador, India, Vietnam, and Argentina (Yulisti et al., 2021). Due to the high export value, vaname shrimp farming is now increasingly important in Indonesia, as it is one of the leading fishery commodities, including in the Muara Tami District, Jayapura. Muara Tami District is the largest district in Jayapura City with an area of 45,370.14 hectares. This area has great potential in the aquaculture sector, both for brackish water and freshwater fisheries. According to the Head of Jayapura City Fisheries Office, Matheys Sibi, out of 5,000 hectares of land available for fish farming, only around 2,000 hectares are utilized. This shows that there are still great opportunities for aquaculture development in the area.

However, vaname shrimp farming faces serious challenges that affect its sustainability. Poor management practices have led to crop failures, decreased production, and low business productivity, which in turn hampers the shrimp industry's potential to contribute significantly to the economy. This has led to concerns among shrimp farmers about the quality of their products (Primartono & Agus Prasetio, 2024). Vaname shrimp farming also faces other challenges, such as increasingly common disease outbreaks. Increased markets and intensification of aquaculture production have led to the emergence of various diseases and environmental degradation. These conditions threaten large-scale production systems, where farmed shrimp are often exposed to unfavorable conditions. Over the past 10 years, disease outbreaks have been a major constraint limiting aquaculture production in many regions (El-Saadony et al., 2022).

Under stressful conditions, vaname shrimp are susceptible to various pathogens, including viruses such as white spot and yellow head, and bacterial pathogens such as Vibrio spp. (e.g., *V. harveyi*, *V. alginolyticus*, *V. parahaemolyticus*, *V. vulnificus*, and *V. cholerae*), which cause vibriosis disease. Shrimp infected with the disease show symptoms of slow growth, low survival rates, and decreased resistance to disease. Other symptoms include lethargy, tail cramps, and disoriented turning behavior, especially when in environments with low salinity levels. Diseases caused by Vibrio spp. can even cause mass mortality, resulting in a drastic reduction in production as well as significant economic losses, especially in many Asian countries (Chang et al., 2024).

To overcome the challenges in vaname shrimp farming and utilize its great potential, several alternatives have been developed, one of which is the use of silver nanoparticles produced from microalgae. Silver nanoparticles (AgNPs) produced from microalgae such as Chlorella pyrenoidosa and Dunaliella salina have been investigated for their antibacterial and antioxidant properties. Studies have shown that silver nanoparticles have various biological activities, including antipermeability, antiangiogenic, antiviral, anti-inflammatory, and antifungal, making them a potential solution in controlling diseases (El-Naggar et al., 2020). The use of these nanoparticles in aquaculture has the potential to increase the effectiveness of disease control and maintain water quality, which is critical for the health and survival of vaname shrimp.

The microalgae used in the production of silver nanoparticles are also recognized as an environmentally friendly and sustainable biological resource. This adds value to this technology, as maintaining a balanced ecosystem is an important aspect in aquaculture (Gao et al., 2024). The use of silver nanoparticles synthesized from Chlorella pyrenoidosa and Dunaliella salina also has the potential to increase the growth of vaname shrimp. So this technology is expected to be an alternative solution in increasing the productivity of shrimp farming in Muara Tami District, Jayapura.

Previous research by Kusumaningrum et al. (2021) found that Penaeus monodon larvae experienced better growth and survival rates when fed diets containing Chlorella pyrenoidosa in their early growth stages compared to Dunaliella salina. However, better results for growth and activity of shrimp larvae were obtained when microalgae were used without nanosilver, compared to regular feed.

The main objective of this study was to test the effectiveness of using silver nanoparticles synthesized from Chlorella pyrenoidosa and Dunaliella salina in vaname shrimp farming in Muara Tami District, Jayapura. The novelty of this research lies in testing the effectiveness of feed involving silver nanoparticles synthesized from microalgae on vaname shrimp. This research is expected to contribute significantly as an innovative solution to health and productivity problems in shrimp farming, especially in the Muara Tami District area. The existence of optimal results makes shrimp farmers expected to produce healthy and high quality vaname shrimp for the long term.

RESEARCH METHOD

This research employed a qualitative approach to provide a nuanced and thorough understanding of the phenomenon under investigation. Data collection was conducted through direct observation of the process of synthesizing silver nanoparticles using the microalgae *Chlorella pyrenoidosa* and *Dunaliella salina*, which were subsequently utilized as feed for Vannamei shrimp in the Muara Tami District of Jayapura.

The synthesis of the nanoparticles commenced by mixing the microalgal cultures in a 2 mM $AgNO_3$ solution, allowing for a one-hour reaction period. Following this, the mixture was stirred with a Polyacrylic Acid (PAA) solution for two hours using a magnetic stirrer. The formation of silver nanoparticles was confirmed by observing changes in color and analyzing the UV-Vis spectra within the wavelength range of 300-800 nm, with absorbance peaks at 400-450 nm signifying nanoparticle formation. The size of the silver particles encapsulated within the microalgal cells was examined using Scanning Electron Microscopy (SEM), while the morphology of the cells was assessed through Transmission Electron Microscopy (TEM).

For the growth and survival tests, postlarval shrimp (P.L.15-P.L.20) were fed with the silver nanoparticle-enriched microalgal feed over a period of seven days, during which their growth and survival rates were meticulously measured. Each experimental trial was replicated three times, with each tank housing ten shrimp. Detailed microscopic analyses were conducted using SEM to investigate the topography, crystallography, and composition of the silver nanoparticles and microalgae at varying magnifications. Upon completing the observations, all data were compiled, and a comparative analysis with relevant literature was performed to present the findings and derive meaningful conclusions. This methodological rigor enhances the validity of the results and contributes significantly to the understanding of using silver nanoparticles in aquaculture.

RESULT AND DISCUSSION

Vaname shrimp farming (*LitoPenaeus vannamei*) is the business of enlarging and managing vaname shrimp, one type of brackish water shrimp that is popularly cultivated because of its rapid growth and resistance to varied environmental conditions (Permatasari & Ariadi, 2021). Vaname shrimp has high economic value, so it is widely cultivated in various countries, including Indonesia. The cultivation process involves various stages, such as pond preparation, selection of superior seeds, water quality management, quality feeding, and disease and pest control. This cultivation is generally carried out in artificial ponds or ponds with strict supervision to ensure optimal production and environmentally friendly (Ariadi et al., 2021).

In vaname shrimp (*L. vannamei*) farming, various efforts are made so that the farming process runs well and produces optimal production. One of the main efforts is water quality management, which involves regulating temperature, salinity, pH, and dissolved oxygen to create an ideal environment for shrimp growth (Alias et al., 2023).

Table 1. Water Quality Measurement Data

Parameter	Ideal Range	Impact on Shrimp Growth
Temperature (°C)	25 - 30	Optimal temperature enhances metabolism and growth. Temperatures that are too low or high can cause stress and mortality.
pH	7.0 - 8.5	Balanced pH is important for shrimp health and nutrient availability. Extreme pH levels can inhibit growth.
Dissolved Oxygen (ppm)	≥ 5	Sufficient dissolved oxygen is required for respiration. Low levels can cause stress and mortality.

Ammonia (ppm)	< 0.5	Ammonia is toxic to shrimp. High levels can lead to mortality and hinder growth.
Nitrite (ppm)	< 0.1	Nitrite is also toxic and can affect the health and growth of shrimp.
Turbidity (NTU)	< 10	High turbidity can reduce light penetration and inhibit photosynthesis in the pond.
Salinity (ppt)	15 - 35	Affects osmoregulation and metabolism. Incorrect salinity can lead to mortality.

Water quality plays a crucial role in shrimp farming as it directly influences their growth, health, and survival rates. Key parameters such as temperature, pH, dissolved oxygen, ammonia, and salinity must be maintained within optimal ranges to ensure shrimp can thrive. For instance, inadequate dissolved oxygen levels can lead to stress and mortality, while high ammonia concentrations are toxic and can inhibit growth. Furthermore, proper pH levels are essential for nutrient availability, and fluctuations can affect shrimp metabolism. Ensuring high water quality is thus fundamental for achieving successful shrimp production and reducing the risk of disease. In addition, the use of high-quality, disease-free shrimp fry is essential to minimize the risk of mortality and increase survival rates. Balanced and timely feeding is also necessary to ensure rapid and healthy shrimp growth (Siswoyo, 2022).

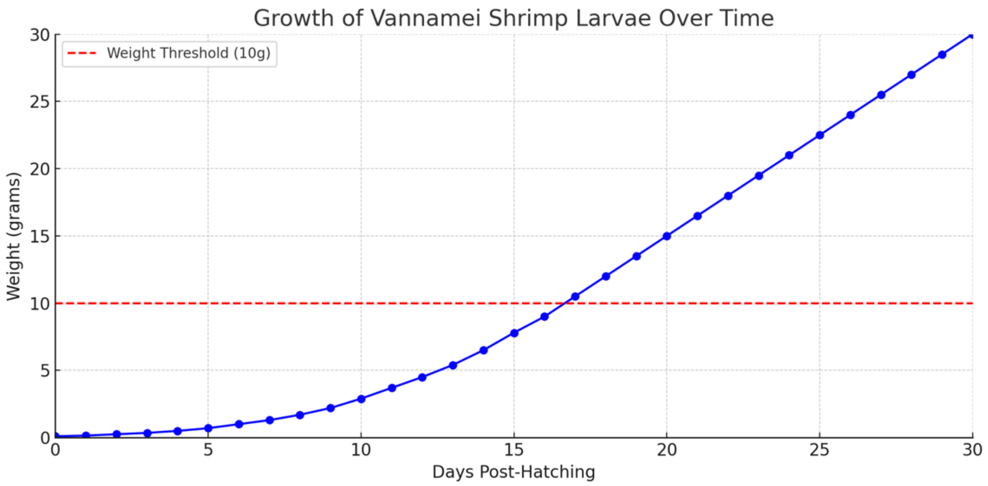

Figure 1. The growth pattern of *Penaeus vannamei*

The graph presented illustrates the growth pattern of *Penaeus vannamei* (vannamei shrimp) larvae over a 30-day period following hatching. On the vertical axis (y-axis), the weight of the larvae is measured in grams, while the horizontal axis (x-axis) represents the number of days after hatching. The blue line in the graph depicts a hypothetical growth trend, showing a consistent increase in the weight of the shrimp larvae as they develop over time. This growth trajectory is typical for vannamei shrimp, which are known for their rapid growth rates.

Additionally, a dashed red line is drawn at the 10-gram mark, which is an important threshold in shrimp farming. This weight is significant because it often indicates that the larvae have reached a stage of development suitable for transferring to grow-out ponds for further cultivation. At this stage, the shrimp are typically more resilient and better equipped to thrive in a larger pond environment, making it a critical point in their life cycle for farmers to monitor.

Pest and disease control in vaname shrimp farming is done through an integrated approach, focusing on routine monitoring and the application of advanced technology. Routine monitoring is essential for early detection of pests or diseases that can disrupt aquaculture. This step allows farmers to take appropriate preventive measures before the infection becomes widespread (Malahayati & Hasan, 2023). The use of probiotics in vaname shrimp farming acts as a biocontrol agent that can balance the microbiota of the pond environment and reduce pathogen populations. Probiotics help improve shrimp health by strengthening their immune system, and maintaining water and soil quality. On the other hand, silver nanoparticles are used due to their strong antimicrobial properties, which are effective in reducing pathogenic infections such as bacteria and viruses without causing resistance in microorganisms (Handarini et al., 2024).

Silver nanoparticles from the microalgae Chlorella pyrenoidosa and Dunaliella salina are very small (nanometer) silver particles synthesized by utilizing extracts from both types of microalgae. These microalgae contain bioactive ingredients that act as reducing and stabilizing agents during the biosynthesis process of silver nanoparticles. This technology offers an environmentally friendly alternative to chemical synthesis methods because it uses natural materials (Moghadam & Aghababai Beni, 2022). The resulting silver nanoparticles have strong antimicrobial properties, which can be used in various applications, including aquaculture, to protect farmed organisms such as shrimp from pathogen attack as well as improve the quality of the water environment (Asysyafiyah, 2022).

In addition, the application of environmentally friendly technologies is also very important in pest and disease control. This technology minimizes the negative impact on the ecosystem and the environment around the pond. Strict biosecurity systems, such as the use of water filters, equipment disinfection, and good water flow regulation, serve to prevent the entry of pathogens from outside into the pond (Alauddin & Putra, 2023). The combination of modern technology, the application of environmentally friendly principles, and strict biosecurity ensures the sustainability of vaname shrimp farming, increases productivity, and reduces the risk of pest and disease infection.

The process of making silver nanoparticles using microalgae culture begins by mixing the culture in a 2 mM silver nitrate ($AgNO_3$) solution. This reaction was allowed to proceed for one hour to allow silver ions to interact with the microalgae. Afterwards, the solution was stirred with polyacrylate (PAA) for two hours using a magnetic stirrer to improve the stability and homogeneity of the mixture. During this process, the color change in the solution became an early indicator of the formation of nanoparticles. Further characterization was carried out using UV-Vis spectroscopy at wavelengths of 300-800 nm, where absorbance peaks in the 400-450 nm range indicated the presence of silver nanoparticles.

After the nanoparticles were formed, analysis was carried out to determine their size and morphology. The size of silver particles in microalgal cells was analyzed using a scanning electron microscope (SEM), which gives an idea of the particle size on the nanometer scale. In addition, the morphology and cellular structure of microalgae that had contained silver nanoparticles were examined in more detail using transmission electron microscopy (TEM). TEM provides detailed visualization of the distribution of nanoparticles within the cell as well as the impact of nanoparticle formation on the cellular structure of the microalgae. The combination of these analyses provided an in-depth understanding of the nature of the nanoparticles and their interaction with the microalgae.

Shrimp growth and survival tests were conducted by feeding a diet based on silver nanoparticles produced from microalgae. The shrimp used in this study were at the postlarval stage, precisely between P.L.15 to P.L.20. The study was designed to last for seven days, during which period, shrimp growth and survival rates were closely observed. Each experiment was repeated three times to ensure validity of results, and each experimental tank contained ten shrimp to provide sufficient data for analysis.

In the research process, silver nanoparticle-based feeds were made using the microalgae Chlorella pyrenoidosa and Dunaliella salina, which are known for their nutritional benefits and biocontrol potential. These microalgae were selected not only for their high nutritional content, but also for their ability to produce silver nanoparticles that have positive effects on shrimp health and growth. This test aims to evaluate whether the addition of silver nanoparticles in feed can provide significant benefits to the growth and survival of vaname shrimp.

After seven days of observation, the data obtained showed a significant increase in the growth and survival of shrimp fed silver nanoparticle-based feed. These results indicate that silver nanoparticles have positive effects that can increase the shrimp's resistance to disease and accelerate their growth process. With higher survival rates, the production potential of vaname shrimp farming can be increased, providing economic benefits to farmers.

Microscopic analysis using a scanning electron microscope (SEM) was performed to observe the topography, crystallography and composition of the silver particles and microalgae at various levels of magnification. The use of SEM provided a clear picture of the interaction between silver nanoparticles and microalgae cells, as well as how they contribute to improved shrimp growth. The results of this study suggest that the use of silver nanoparticles produced from the microalgae Chlorella pyrenoidosa and Dunaliella salina as feed for vaname shrimp in Muara Tami District, Jayapura, is an effective approach in improving shrimp growth and survival, supporting the overall sustainability of shrimp farming.

Thus, the effectiveness of utilizing silver nanoparticles extracted from microalgae Chlorella pyrenoidosa and Dunaliella salina for vaname shrimp farming in Muara Tami District, Jayapura, lies in their ability to improve shrimp health and productivity. Silver nanoparticles function as an antimicrobial agent capable of inhibiting the growth of harmful pathogens in the waters, such as bacteria and viruses, thereby reducing the risk of diseases that often affect shrimp. The use of microalgae as a source of nanoparticles also provides ecological added value as it is an environmentally friendly natural material. Thus, this technology can contribute to increasing vaname shrimp yields while preserving the aquatic environment in the area.

CONCLUSION

The results of this study revealed that the use of silver nanoparticles produced from the microalgae Chlorella pyrenoidosa and Dunaliella salina as feed for vaname shrimp in Muara Tami District, Jayapura, was effective in improving shrimp growth and survival. The findings demonstrate the great potential of microalgae as natural agents that can reduce toxicity in aquaculture environments, creating healthier conditions and supporting the sustainability of shrimp farming. For further research, it is suggested that the focus should be on developing the use of silver nanoparticles from microalgae as natural antimicrobial agents. This can be done by considering the influence of various factors, such as the dose of silver nanoparticles, duration of exposure, microalgae growth media, and the type of microalgae used. Further research is expected to optimize the effectiveness of silver nanoparticles in aquaculture and ensure their safe and long-term use.

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