Fisheries Journal, 16 (3), 1429-1443 (2026)
http://doi.org/10.29303/jp.v16i3.1870

PRODUCTION PERFORMANCE OF INTENSIVE WHITELEG SHRIMP (*Penaeus vannamei*) FARMING WITH BUSMETIK AND BUTAMIRA METHODS

Kinerja Produksi Budidaya Intensif Udang Vaname (*Penaeus vannamei*) dengan Metode Busmetik dan Butamira

Diah Ayu Satyari Utami[1*], Adriansyah[1], I Gede Rezza Mahendra[1], Wahyu[2], Meilya Suzan Triyastuti[3]

[1]Department of Aquaculture, Marine and Fisheries Polytechnic of Jembrana
[2]Study Program of Technology of Fish Breeding, State Polytechnic of Lampung
[3]Department of Fishery Product Processing Techniques, Marine and Fisheries Polytechnic of Bitung

Desa Pengambengan, Jembrana 82218, Bali, Indonesia

*Corresponding Author: dplongitm@gmail.com

(Received September 23th 2025; Accepted March 6th 2026)

ABSTRACT

This study evaluated the production performance of intensive whiteleg shrimp (*Penaeus vannamei*) farming using BUSMETIK (plastic pond, 1600 m²) and BUTAMIRA (household-scale pond, 250 m²) methods at the Marine and Fisheries Polytechnic of Jembrana, Bali. Shrimp were stocked at 370 individuals/m² (BUSMETIK) and 172 individuals/m² (BUTAMIRA) and cultured for 75 days (October–December 2023). Culture management included pond preparation, blind and demand feeding strategies, aeration, water quality control, and probiotic applications. Growth and production performance were assessed through survival rate (SR), average body weight (ABW), average daily growth (ADG), feed conversion ratio (FCR), and water quality parameters. Results showed that both systems supported stable water quality and effective shrimp growth. BUSMETIK ponds demonstrated higher productivity due to greater stocking density, while BUTAMIRA provided efficient production with lower operational inputs, making it suitable for household-scale adoption. Overall, both culture methods proved feasible for small-scale intensive shrimp farming, offering promising strategies to support Indonesia's shrimp production targets and provide opportunities for smallholder farmers.

Keywords: BUSMETIK, BUTAMIRA, Intensive Farming, *Penaeus vannamei*, Production Performance

ABSTRAK

Penelitian ini mengevaluasi kinerja produksi budidaya intensif udang vaname (*Penaeus vannamei*) dengan metode BUSMETIK (tambak plastik, 1600 m²) dan BUTAMIRA (tambak skala rumah tangga, 250 m²) di Politeknik Kelautan dan Perikanan Jembrana, Bali. Udang ditebar dengan padat tebar 370 ekor/m² (BUSMETIK) dan 172 ekor/m² (BUTAMIRA) serta dipelihara selama 75 hari (Oktober–Desember 2023). Manajemen budidaya meliputi persiapan tambak, pemberian pakan dengan metode blind feeding dan demand feeding, aerasi, pengelolaan kualitas air, serta aplikasi probiotik. Parameter kinerja produksi yang diamati mencakup *survival rate* (SR), *average body weight* (ABW), *average daily growth* (ADG), *feed conversion ratio* (FCR), dan kualitas air. Hasil penelitian menunjukkan kedua sistem mampu menjaga kualitas air dan mendukung pertumbuhan udang yang optimal. Tambak BUSMETIK menghasilkan produktivitas lebih tinggi karena padat tebar yang lebih besar, sedangkan BUTAMIRA lebih efisien dengan *input* operasional rendah, sehingga sesuai untuk diterapkan pada skala rumah tangga. Secara keseluruhan, kedua metode terbukti layak untuk budidaya udang vaname intensif skala kecil dan berpotensi mendukung target produksi udang nasional serta pemberdayaan petambak kecil.

Kata Kunci: Budidaya Intensif, BUSMETIK, BUTAMIRA, Kinerja Produksi, *Penaeus vannamei*

INTRODUCTION

Brackish water aquaculture is quite popular in Indonesia. Especially, shrimp farming. (Amelia *et al*., 2021). Indonesian pond farmers have long practiced shrimp farming because shrimp is a prime aquaculture commodity in the fisheries sector that can increase foreign exchange through exports of fishery commodities (Bidayani & Vallen, 2023). In 2022, Indonesia's total shrimp production reached 1.19 million tons with a composition of 77.5% from cultivated production and 22.5% from captured production. Indonesia is also the world's 4th largest shrimp exporter with a global market share of 6.6%. (Rachmawati, 2023). The national shrimp production target in 2024 is aimed to reach around 2 million tons of production or an increase in shrimp export value of 250% (Suhana *et al.*, 2023). To achieve the production target, various steps need to be taken to improve the current shrimp farming production performance.

One strategy to improve shrimp farming production performance is intensifying the farming system. Intensive shrimp farming systems are characterized by shrimp nutrients primarily from artificial feeds and are stocked at higher densities, necessitating management practices such as aeration and pond drainage to maintain water quality (Ali *et al*., 2022; Amelia *et al*., 2021; Yi *et al*., 2018; Thakur *et al*., 2018). Intensive shrimp production systems are more efficient, use fewer resources, and result in less impact on the environment compared to more extensive shrimp production systems (Elwin *et al*., 2020). In Indonesia, small shrimp farmers have also begun to adopt intensive farming systems on a small or mini scale.

Intensive shrimp farming on a small or mini scale using tarpaulin/High-Density Polyethylene (HDPE) as a lining material for ponds or culture tanks (Fatalattof *et al*., 2022; Zulkarnain *et al*., 2018). The local shrimp farmers in Indonesia called this BUSMETIK system or plastic pond shrimp farming for a shrimp pond with an area of 1000 m^2 and BUTAMIRA or household-scale mini pond shrimp farming for a pond area of 100 m^2. Some of the advantages of this system are the ease of managing water quality (Purwanto *et al*., 2023; Satanwat *et al*., 2023), low production costs (Widodo *et al.*, 2016), high profitability (Putra *et al*., 2023), and more importantly it only needs a small area to practice. These advantages make this system feasible to be implemented by many small farmers in Indonesia.

This study aims to examine the specific small scale shrimp culture practices, namely BUSMETIK and BUTAMIRA implemented at Marine and Fisheries Polytechnic of Jembrana. By examining these culture practice, the study aims to present a thorough picture of the production performance of small-scale intensive shrimp culture, and also providing insights into the industry's opportunities as well as its challenges.

RESEARCH METHODS

Time and Place

This study was conducted for 75 days starting from October 16, 2023 to December 31, 2023. The location of the study was at the Teaching Factory (TEFA) BUSMETIK and BUTAMIRA, Marine and Fisheries Polytechnic of Jembrana, Bali.

Tools and Materials

The tools used during this research included a feeding tray (anco), sampling nets, feed scales, shrimp scales, water sample containers, thermometer, pH meter, saline refractometer and Secchi disk. The materials used included production inputs, consisting of PL-11 shrimp fry and commercial shrimp feed with a protein content of 32-36%. Water disinfectants such as CuSO4, 90% Trichloroisocyanuric Acid (TCCC), and CaCO3 were also used as a culture water disinfectant. The water quality management materials used during cultivation were commercial probiotic starters containing *Lactobacillus plantarum*, *Lactobacillus fermentum*, *Bacillus subtilis*, and *Pseudomonas putida*. Molasses served as the carbon source for the probiotic culture. The materials used for water quality measurement are DO measurement kits (Merck 1.11107.0001), Alkalinity (Merck 1.11109.0001), Ammonia (Merck 1.14657.0001), Nitrite (Merck 1.14774.0001) and Nitrate (Merck 1.11170.0001).

Research Design

This study used a case study of shrimp culture practice at the Teaching Factory (TEFA) BUSMETIK and BUTAMIRA, Marine and Fisheries Polytechnic of Jembrana, Bali. A BUSMETIK ponds with a pond area of 1600 m^2 and a BUTAMIRA pond with a pond area of 250 m^2 were used in this study. Direct observation during aquaculture activities was used to collect primary data. Secondary data was taken from the interviews and discussions with aquaculture technicians. Literature studies were also used to complement secondary data. Technical aspects of culture practice observed included pond preparation, seed distribution, feed management, water quality management, growth monitoring, pest and disease control, and harvesting. Aquaculture production performance is calculated at the end of the production cycle or after harvesting.

Work Procedure

Small-scale shrimp farming activities of BUSMETIK and BUTAMIRA start from pond preparation and end with harvesting activities. During aquaculture activities, direct observation is carried out on all aquaculture processes including aquaculture preparation techniques, shrimp fry stocking, shrimp rearing, water quality management, feed management, fish health management, and the harvesting process. During pond preparation, observations are made on the procedures and stages before the shrimp fry distribution stage. After the pond and water are ready, the shrimp fry is stocked for each pond. The shrimp fry used is bought from private companies with a size of PL 10 or post-larvae 10 days. The stocking density of the fry used in this study was 370 shrimp/m^2 for the BUSMETIK pond and 172 shrimp/m^2 for the BUTAMIRA.

The shrimp will be reared in the pond and feeding is done with commercial feed. The blind feeding method is used during day of culture (DOC) 0-30 days and the demand feeding method during DOC 31 to harvest. Water quality management, pest and disease control are also carried out during rearing period until harvest.

Research Parameter

The research parameters measured in this study were technical parameters derived from the cultivation activities carried out. These parameters consisted of production performance and water quality.

Aquaculture Production Performance

The measurement of production performance parameters measured in this study uses the following formula:

a. Survival Rate (SR, %)

$$SR = \frac{\text{Total Shrimp Harvested}}{\text{Total Shrimp Stocked}} \times 100$$

b. Average Body Weight (ABW, gr)

$$ABW = \frac{\text{Total Biomass (kg)}}{\text{Total Shrimp Count}}$$

c. Harvest size (shrimp count/kg)

$$Size = \frac{\text{1000gr of final harvest biomass}}{ABW}$$

d. Average Daily Growth (ADG, gr/day)

$$ADG = \frac{\text{Final ABW (g)} - \text{Initial ABW(g)}}{\text{Day of Culture (day)}}$$

e. Feed Conversion Ratio (FCR)

$$FCR = \frac{\text{Total Feed Consumed (kg)}}{\text{Total Biomass Produced (kg)}}$$

Water Quality Parameter

The water quality parameters measured in this study consisted of temperature, brightness, salinity, pH, dissolved oxygen (DO), ammonia, nitrite, nitrate, and alkalinity. Water quality parameter values are obtained from measurement results using water quality measurement tools and kits.

Data Analysis

All data obtained were analyzed descriptively by comparison with references from literature.

RESULT

Aquaculture Preparation

The stages of aquaculture preparation are divided into 2 stages. Namely preparation of the preparation of the water media for cultivation. Preparation of the pond consists of cleaning and drying it, repairing the pond's construction, liming it, and setting the waterwheel for aeration. All stages are carried out for *BUSMETIK* and *BUTAMIRA* ponds. The drying method used is drying with sunlight for 14 days. Pond construction repairs are carried out on aquaculture facilities, such as waterwheels, water pipes, drain pipes, inspection bridges, HDPE plastic pond linings, pest-barrier nets, and others. Furthermore, liming is carried out on the pond using $CaCO_3$ on the base of the plot, the dose used is 100 gr/m^2 for each type of pond. At this stage, the waterwheels are also adjusted for each pond. The use of the waterwheel is adjusted to the age of the culture and the shrimp's demands for oxygen.

The next stage is the preparation of the water media for cultivation. At this stage, several treatments are carried out on the water to prepare the water to be ready to receive shrimp fry. Water preparation is carried out the same for both types of ponds and is carried out for 15 days with the following treatments.

Tabel 1. Water treatment method during aquaculture preparation stage

Day	Treatment	Dosage to water	Time*
1	Copper(II) sulfate ($CuSO_4$)	2.5 ppm	17:00
2	TCCA (Trichloroisocyanuric Acid)	30 ppm	17:00
5	PC	-	17:00
6	PC	-	17:00
7	$CaCO_3$ +PC+ PCAW	10 ppm $CaCO_3$; 10 ppm PCAW	07:30
8	PC + PCAW	10 ppm PCAW	17:00
9	PC + PCAW	10 ppm PCAW	17:00
10	$CaCO_3$ + PC+ PCAW	10 ppm $CaCO_3$; 10 ppm PCAW	07:30
11	PC + PCAW	10 ppm PCAW	17:00
12	PC + PCAW	10 ppm PCAW	17:00
13	$CaCO_3$ + PC + PCAW	10 ppm $CaCO_3$; 10 ppm PCAW	07:30
14	PC + PCAW	10 ppm PCAW	17:00
15	PC + PCAW	10 ppm PCAW	17:00

Footnote: *Central Indonesia Time (UTC+8); **PC** (Probiotic culture); **PCAW** (Probiotic culture application to water

The process of pond preparation starts with the addition of 2.5 ppm of $CuSO_4$ in the pond water. Additionally, 30 ppm of TCCA (Trichloroisocyanuric Acid) was added on the 2nd day. For 2 days (days 3 and 4), the water mixing process will be carried out with the help of a water wheel. On the 5th day, the paddle wheel is stopped to encourage the sedimentation of chemical treatment residues in previous water management. On the 5th day, probiotic culture (PC) activities began with a dose of 0.25 ppm probiotic starter and 0.5 ppm molasses mixed with 15 liters of water. The probiotic starter used is a commercial probiotic containing *Lactobacillus plantarum*, *Lactobacillus fermentum*, *Bacillus subtilis*, and *Pseudomonas putida* with a bacterial density of 10^6 cfu/ml per species. This culture process is carried out for 48 hours, and the probiotic culture application to water (PCAW) will be spread on the 7th day. The PC process was continued from the 6th day until the 15th day. Meanwhile, PCAW continued from the 8th day until the 15th day. The spreading of $CaCO_3$ during the preparation period was also carried out every 3 days starting on the 7th day until the 13th day. At the end of the pond preparation, the pond base is siphoned to remove sludge and residues of the disinfectant used.

Shrimp Fry Stocking

The stocking of shrimp fry starts with the acclimation process of the shrimp fry with its transport container for 30 minutes to 1 hour in the pond at 17:00 Central Indonesia Time (CIT). Simultaneously, 1-2 transport containers are used as samples to check the quality and quantity of the fry through visual and microscopic observations. The visual characteristics observed include body length and uniformity of size, swimming activity, body shape, and color. At the same time, microscopic observations consist of the muscle-gut ratio, hepatopancreas, intestinal bolus, ectoparasites, intestines, necrosis, and deformation after visual and microscopic observations on the fry. Stress tests are given to the fry samples using the drastic multilevel salinity reduction method. After the examination, the fry bag in the pond will be opened, and the fry will slowly swim outside the bag to the pond.

The number of shrimp larvae stocked in both BUSMETIK and BUTAMIRA ponds in this study is presented in the Table 2.

Table 2. The Quantity of Stocked Shrimp Fry in BUSMETIK and BUTAMIRA Ponds

No.	Date	Pond Type	Fry Supplier	Quantity (ind)	Stocking Density (ind.m^{-3})
1.	20-09-2023	BT[b]	PT Prima Larva Bali	217,000	135
2.	24-09-2023	BR[c]	PT Suri Tani Pemuka	94,000	376
3.	10-11-2023[a]	BR[c]	PT Suri Tani Pemuka	43,000	172

Footnote: [a]2[nd] cycle for BUTAMIRA pond; [b]BUSMETIK type pond; and, [c]BUTAMIRA type pond

Feeding Management

There are two feeding methods used in this study for both types of ponds, namely the blind feeding method and the on-demand feeding method. The feed used is commercial feed with different types, protein content, and usage periods. The starter feed used is in the form of flour with a protein content of 40% for the day of culture (DOC) 0 to 10 days. The first grower feed is in the form of crumble with a protein content of 32% for the DOC period of 11-30 days. The second grower feed is in the form of pellets with a protein content of 30% for DOC 31 until the shrimp harvest is carried out. The amount of first feeding during the blind feeding period is 3 kg per 100,000 shrimp fry for both BUSMETIK and BUTAMIRA ponds. Next, additional feed is added every day according to the feeding program. The blind feeding program used during this study is presented in Table 3.

Table 3. Blind Feeding Program in BUSMETIK and BUTAMIRA Ponds

DOC (day)[a]	Shrimp Size		Feed Type	Daily Feed Addition (gr.day^{-1})[b]		Feeding Frequency
	Weight (g)	Length (cm)		BT[c]	BR[e]	
1–10	PL 10	0.8–1.4	Starter	200	50	4
11–20	0.1–1.5	0.1–1.5	Grower	400	100	4
21–30	2.0–3.5	2.0–3.5	Grower	600	150	4

Footnote: [a]Day of culturr (DOC);[b] daily feed addition per 100.000 shrimp fry per day; [c]BUSMETIK type pond; and, [d]BUTAMIRA type pond

DOC 30 undergoes an on-demand feeding program up until the shrimp harvest. Each pond has two feeding trays as a feed control tool and is a consideration when adding and reducing feed for shrimp. The percentage of indicator feed in the feeding trays are 0.5% (DOC 31-40), 0.8% (DOC 41-50), and 1% (DOC 51 until harvest) of the amount of feed given at that time with an inspection time of 1, 1.5, and 2 hours for each percentage. The decision to increase or reduce the amount of feed is based on the results of the feeding tray inspection. If feed in both of the feeding trays is empty during the inspection time, then an additional 5% feed will be added. If only one, while the other is still left, then no addition or reduction in the amount of feed is given. However, when both feeding trays still have feed left at the time of inspection, a 5% feed reduction is carried out. Feeding is done by spreading feed directly from the side of the plot or 2-3 m from the pond embankment. The frequency of feeding is four (4) times a day during the on-demand feeding period.

Water Quality Management

Water quality management carried out on both types of ponds includes water exchanges, siphoning, removing mud from the inlet or outlet channels, probiotics culture application, liming application, and cleaning of plankton die-off. Water exchanges are carried out according to the cultivation period or day of culture (DOC). During DOC 1-19, no water exchanges are carried out. The water exchange process begins on the 20th DOC, after the first pond bottom siphoning process is carried out, and continues until harvest. The percentage of water exchanges is 10-20% every three (3) days for DOC 20-40, 20-30% every two (2) days for DOC 41-60, and 30-50% every day for DOC 60 until harvest. Meanwhile, siphoning is done every 3 days in the afternoon when DOC 20-40, once a day in the afternoon when DOC 41-60 days, and at DOC 61 days until harvest, siphoning is done twice a day in the morning and afternoon. The probiotic culture application is carried out daily with a dose of 0.5 ppm for probiotic starter and 1 ppm molasses. The probiotic starter used during the culture process is the same as the probiotic used during the pond preparation period. Meanwhile, the provision of lime in the form of $CaCO_3$ is also carried out with a dose of 10 ppm twice (2) times a week. The result of water quality monitoring during the study is presented in Table 4.

Table 4. Water Quality Parameters

Parameters (unit)	BT[a] 135 ind.m^{-3}	BM 1st cycle[b] 376 ind.m^{-3}	BM 2nd Cycle[b] 172 ind.m^{-3}
Temperature (^{0}C)	26.5–30.3	27.9–30.5	27.3–30.9
Salinity (ppt)	30–40	32–35	32–38
pH (unit)	7.3–8.9	7.3–8.4	7.6–8.6
Water brightness (cm)	20–32	30–35	20–37
Dissolved Oxygen (ppm)	4.9–7.1	4.1–6.2	4.3–6.6
Ammonia (ppm)	0.25–0.5	0.25–0.5	0.15–0.5
Nitrite (ppm)	0.1–1	0.25	0.25–0.5
Nitrate (ppm)	50–100	50	25–100
Total Alkalinity (ppm)	199.4–279.5	230.3–256.3	80.1–220.6

Footnote: [a]BUSMETIK type pond; [b]BUTAMIRA type pond

Production Performance

Production performance in this study was observed based on the technical parameters of shrimp cultivation. Observations were made on both types of ponds. The results of production performance observations can be seen in Table 5.

Table 5. The Production Performance of Shrimp Cultivation in BUSTMETIK and BUTAMIRA Ponds

Poduction Performance	Shrimp Pond		
	BT[d]	BM[e] 1st cycle[f]	BM[e] 2nd cycle
Shrimp stocking density (ind.m^{-3})	135	356	172
Final ABW[a] (gr)	22	3.8	9.3
ADG[b] (gr.day^{-1})	0.30	-	0.33
Final size (ind.kg^{-1})	45	263	108
DOC[c] (day)	97	34	50

Footnote: [a]Final average body weight (ABW); [b]Average Daily Growth (ADG); [c]Day of culture (DOC); [d]BUSMETIK type pond; [e]BUTAMIRA type pond; [f]1st production cycle

The comparative analysis of shrimp farming production performance between BT and BM ponds revealed that BT ponds consistently outperformed BM ponds across both the first and second cultivation cycles. In BT ponds, shrimp farming operations were successfully sustained until the end of the cycle, achieving a final average body weight (ABW) of 22 grams per shrimp, an average daily growth (ADG) rate of 0.30 grams/day, a harvest size of 45 individuals per kilogram (ind./kg), and a duration of culture (DOC) of 97 days. In contrast, BM ponds experienced cultivation failure during the first cycle due to a disease outbreak, suspected to be Acute Hepatopancreatic Necrosis Disease (AHPND). As a result, farming activities in BM ponds were terminated at DOC 34, yielding an ABW of 3.8 grams per shrimp and a harvest size of 263 ind.kg^{-1}. However, BM ponds demonstrated improved performance during the second cycle, with farming activities continuing up to DOC 50 at the time of this study. During this cycle, BM ponds achieved an ABW of 9.3 grams per shrimp and a harvest size of 108 ind.kg^{-1}.

DISCUSSION

The study results showed that shrimp cultivation activities in both types of ponds were conducted using proper shrimp cultivation methods, specifically in lining ponds (plastic base; HDPE), in accordance with SNI 8008:2014 standards (SNI, 2014a). This is evident from the series of cultivation processes, which include preparation of containers and cultivation media, stocking shrimp seeds, shrimp maintenance, feed management, water quality management, pest and disease control, and harvesting at the end of the cultivation cycle. Drying the pond bottom by exposing it to sunlight serves to clean the pond floor, sterilize any remaining sources of pests and diseases from the previous cycle, and maintain the HDPE lining of the pond (Boyd & Quieroz, 2014; Khumaidi *et al*., 2022; Kurniaji *et al*., 2023; Ritonga *et al*., 2021; SNI, 2014b). For ponds with an HDPE base, the drying process typically takes 1–2 weeks but can be shortened to 3–4 days under hot and sunny weather conditions (Widiastiti *et al*., 2024). Maintaining facilities and infrastructure in aquaculture operations is a crucial step to ensure the success of the production cycle and to optimize the use of equipment such as paddle wheels, water pumps, pond liners, inspection bridges, and other essential tools.

Liming the bottom of the pond with agricultural lime ($CaCO_3$) serves to increase the pH value and total alkalinity while maintaining the balance of minerals in the water (Whangcai *et al*., 2004; Jose Priya & Kapalli, 2024; Mandal & Duyari, 2024). The high-water pH resulting from the reaction between lime and water is recommended as an effective sterilization method in shrimp farming (Boyd, 2017). Additionally, this practice has been shown to enhance microbial activity and improve overall pond productivity, further supporting its use in sustainable aquaculture systems.

The use of $CuSO_4$ (copper sulfate) serves as a fungicide and algaecide, effectively eliminating moss and algae in ponds while also controlling external parasites and pathogenic bacteria (Mustafa *et al*., 2010). When applied at a concentration of 1.2 ppm, $CuSO_4$ can manage the invasion of shellfish pests in pond water without adversely affecting water quality (Malavé *et al*., 2025). The recommended dosage for $CuSO_4$ should not exceed 1.5 ppm (Iskandar *et al*., 2022; Kurniadji *et al*., 2023). However, higher doses, such as the 2.5 ppm observed in this study, may have long-term negative effects on shrimp, including potential copper accumulation in their tissues (Mustafa *et al*., 2010).

Trichloroisocyanuric acid (TCCA) is a widely used chlorine-based disinfectant in aquaculture. It is a white crystalline compound with a slight chlorine-like odor that releases free chlorine when dissolved in water. TCCA is highly effective against bacteria, viruses, and fungi, making it a valuable tool for maintaining water quality and preventing disease outbreaks in shrimp ponds (Zhang *et al*., 2023). In this study, a dosage of 30 ppm was applied in both types of ponds, which aligns with the recommended range of 25–30 ppm for shrimp pond water sterilization (Rakhmanda *et al*., 2021; Utami *et al*., 2022) and adheres to the SNI 8008:2014 standards (SNI, 2014a). The use of TCCA is crucial for preventing disease outbreaks and ensuring the success of the production cycle.

The probiotic bacteria used during the water preparation stage play a crucial role in supporting the success of shrimp cultivation. Probiotics are introduced by applying a starter bacterial culture combined with a carbon source, such as molasses, and incubated for 48 hours.

This method is designed to optimize production costs while ensuring effective probiotic activity. The species and density of probiotic bacteria in the starter culture meet the standards set by the Indonesian Ministry of Marine Affairs and Fisheries (PERMEN KP No. 1, 2019). Among these, *Lactobacillus plantarum* and *Lactobacillus fermentum* have been shown to enhance shrimp growth and disease resistance by regulating nutritional immune responses, improving gut flora, and maintaining optimal water pH levels (Bachruddin *et al*., 2018; Indariyanti & Aprilia, 2022; Du *et al*., 2022). Additionally, *Bacillus subtilis* has demonstrated significant benefits in shrimp rearing, positively influencing growth performance, chemical composition, digestive enzyme activity, antioxidant status, immunological indices, and disease resistance in whiteleg shrimp (Monier *et al*., 2023). Similarly, Pseudomonas putida contributes to maintaining water quality by efficiently removing ammonia and other nitrogen compounds, thereby enhancing shrimp health and overall pond performance (Tran *et al*., 2019).

The application of agricultural lime ($CaCO_3$) at a concentration of 10 ppm, twice a week during water preparation, aims to promote plankton growth and maintain stable water pH levels as well as total alkalinity (Boyd, 2017; Mustafa *et al*., 2010; Sandi *et al*., 2020). At the end of the preparation period, pond bottom siphoning is conducted to enhance water quality by removing residual deposits from the materials used during the water preparation process. This step helps maintain optimal water quality and ensures the pond bottom is in the best possible condition before stocking (Iskandar *et al*., 2022). A series of water preparation steps must be carefully followed to ensure the water is in optimal condition when shrimp fry are introduced to the pond.

The acclimatization process and inspection of shrimp fry before their release into the pond are critical stages that must be carefully conducted. Acclimatization helps shrimp fry adapt to environmental changes, such as differences in salinity, pH, and water temperature between the transportation bag and the pond (Surianti *et al*., 2024). Inspecting the shrimp fry before release ensures an accurate count for feed calculation and verifies their health condition. Proper fry counting enhances feed efficiency during the cultivation process. Additionally, quality checks—including visual and microscopic observations, stress tests, and health assessments—are essential for the success of shrimp cultivation (Yanti *et al*., 2017; Utami *et al*., 2022). Shrimp release should be conducted when the sun is not too intense, such as in the morning or late afternoon. The shrimp fry release process observed in this study adhered to the guidelines outlined in SNI 8008:2014 (SNI, 2014b).

The shrimp stocking density in BT ponds, at 135 ind.m^{-3}, and in BM ponds during the second cycle, at 172 ind.m^{-3}, is classified as intensive. In contrast, the stocking density in BM ponds during the first cycle, at 375 ind.m^{-3}, falls into the super-intensive category (Ministry of Marine Affairs and Fisheries, 2016; Nguyen *et al*., 2017; Purnamasari *et al*., 2017; Wahyudi *et al*., 2022; Yustiati & Andriani, 2022; Putra *et al*., 2023; Nisa *et al*., 2024). The high stocking density in BM ponds during the first cycle presents several challenges, including a rapid decline in water quality (Ray *et al*., 2010a; Ray *et al*., 2010b), an increased risk of disease outbreaks (Mustafa *et al*., 2023), relatively low growth and survival rates (Burford *et al*., 2003), and poor feed efficiency (Assad, 2021). Stocking density is primarily determined by the cultivation techniques employed. The system used in this study is an intensive cultivation system that relies on water wheels as the primary source of aeration. In this system, the optimal stocking density is heavily influenced by the number of water wheels utilized. According to SNI 8008:2014 (SNI, 2014b), the recommended stocking density for intensive ponds with HDPE construction and aeration provided by water wheels ranges from 100 to 120 ind.m^{-3}.

The protein content, type of feed, and feeding frequency used in both pond types adhere to the general standards for whiteleg shrimp farming in Indonesia, as outlined in SNI 8008:2014 (SNI, 2014b). In this study, the initial feed amount during the blind feeding period was 3 kg per 100,000 shrimp fry, which falls within the recommended range of 1–3 kg per 100,000 fry

(Lusiana e*t al*., 2021). This relatively high initial feed quantity aims to promote shrimp fry growth, ensuring they reach the target size by the end of the 30-day blind feeding period (DOC 30). However, while an abundant feed supply can stimulate growth, it may also accelerate water quality deterioration (Fahrur *et al*., 2023).

The daily feed addition is applied at different rates in BT and BM ponds. These two types of ponds differ in terms of pond area and total shrimp density. BT ponds, with a total area of 1600 m², are better equipped to minimize fluctuations and declines in water quality compared to BM ponds, which are only 250 m². Changes and declines in water quality parameters—such as temperature, pH, dissolved oxygen levels, nitrogen waste, and alkalinity—are more likely to occur in smaller ponds. This is because larger water volumes can dilute pollutants, nutrients, and organic matter, reduce their concentration and potentially slow the rate of water quality deterioration (Dodds, 2020). Additionally, larger water bodies generally have a greater buffering capacity, enabling them to resist changes in pH, temperature, and dissolved oxygen levels. This helps mitigate the impact of external factors, such as temperature fluctuations, on water quality (Smith & Schindler, 2009). In smaller ponds, oxygen levels can deplete more rapidly due to increased organic matter decomposition and respiration by aquatic organisms. In contrast, larger ponds typically maintain more stable oxygen levels, which supports better water quality (Scheffer *et al*., 2006). Furthermore, smaller ponds are more susceptible to rapid nutrient accumulation (e.g., nitrogen and phosphorus), which can lead to eutrophication and algal blooms. Larger ponds, on the other hand, can better manage nutrient inputs without immediate adverse effects (Søndergaard *et al*., 2005).

The demonstrated superiority of larger pond systems (BT ponds; 1,600 m²) in intensive shrimp cultivation, compared to smaller BM ponds (250 m^2), is strongly linked to their capacity to stabilize critical water quality parameters. The increased water volume in BT ponds mitigates rapid degradation of water quality by diluting metabolic byproducts (e.g., ammonia, nitrites) and organic waste, thereby slowing the accumulation of stressors that impair shrimp health. Maintaining better water quality is essential for successful shrimp farming (Ariadi *et al*., 2023). This stability fosters optimal physiological conditions, directly enhancing growth performance through balanced dissolved oxygen, pH, and temperature regimes (Al-Masqari *et al*., 2022; Yessy *et al*., 2024). Furthermore, improved water quality enhances feed utilization efficiency by promoting metabolic activity and nutrient absorption (Alarcón-Silvas *et al*., 2021; El-Sayed, 2021). The buffered environment of BT ponds also reduces disease susceptibility by minimizing stress-induced immunosuppression (Hassan *et al*., 2022), which is exacerbated in smaller ponds by fluctuating water conditions. This stability lowers the incidence and severity of pathogen outbreaks (Millard *et al*., 2021) and improves shrimp resilience to high-density stressors (Mirbakhsh *et al*., 2021). Collectively, these factors—water quality regulation, metabolic efficiency, and disease resistance—explain the superior production metrics observed in BT ponds. These findings highlight the importance of scaling pond systems to optimize environmental stability, a critical factor for sustainable intensification of shrimp aquaculture.

CONCLUSION

Small-scale intensive whiteleg shrimp farming using the BUSMETIK and BUTAMIRA methods at Marine and Fisheries Polytechnic of Jembrana was conducted following best practices in shrimp farming. The production performance results indicate that the BUSMETIK method yields superior outcomes compared to the BUTAMIRA method in intensive shrimp cultivation system. These results underscore the importance of optimized pond design and water quality stability in intensive shrimp farming systems. To enhance the viability of the BUTAMIRA method, further research is warranted to refine its operational protocols, particularly in mitigating environmental stressors and improving feed management strategies.

Addressing these limitations could enable broader adoption of BUTAMIRA while aligning with sustainable aquaculture objectives.

ACKNOWLEDGEMENT

The author would like to express gratitude to Marine and Fisheries Polytechnic of Jembrana for supporting this research.

REFERENCES

Alarcón-Silvas, S. G., León-Cañedo, J.A., Fierro-Sañudo, J. F., Ramírez-Rochín, J., Fregoso-López, M. G., Frías-Espericueta, M. G., & Páez-Osuna, F. (2021). Water quality, water usage, nutrient use efficiency and growth of shrimp *Litopenaeus vannamei* in an integrated aquaponic system with basil *Ocimum basilicum*. *Aquaculture, 543,* 737023. https://doi.org/10.1016/j.aquaculture.2021.737023

Ali, H., Rahman, M. M., Jaman, A., Basak, S. K., Eltholth, M., & Murray, F. (2022). Economic performance characterization of intensive shrimp (*Penaeus monodon*) farming systems in Bangladesh. *Aquaculture, Fish and Fisheries, 2*(1), 57–70. https://doi.org/10.1002/aff2.24

Al-Masqari, Z. A., Guo, H., Wang, R., Yan, H., Dong, P., Wang, G., & Zhang, D. (2022). Effects of high temperature on water quality, growth performance, enzyme activity and the gut bacterial community of shrimp (*Litopenaeus vannamei*). *Aquaculture Research, 53*(9), 3283–3296. https://doi.org/10.1111/are.15860

Amelia, F., Yustiati, A., & Andriani, Y. (2021). Review of shrimp (*Litopenaeus vannamei* (Boone, 1931)) farming in Indonesia: Management operating and development. *World Scientific News, 158,* 145–158.

Ariadi, H., Azril, M., & Mujtahidah, T. (2023). Water quality fluctuations in shrimp ponds during dry and rainy seasons. *Croatian Journal of Fisheries, 81*(3), 127–137. https://doi.org/10.2478/cjf-2023-0016

Asaad, A. I. J. (2021). Small scale shrimp (*Litopenaeus vannamei*) nursery technology at high stocking density. *IOP Conference Series: Earth and Environmental Science*, *860*(1), 012025. IOP Publishing. https://doi.org/10.1088/1755-1315/860/1/012025

Bachruddin, M., Sholichah, M., Istiqomah, S., & Supriyanto, A. (2018). Effect of probiotic culture water on growth, mortality, and feed conversion ratio of vaname shrimp (*Litopenaeus vannamei* Boone). *IOP Conference Series: Earth and Environmental Science*, *137*, 012036. IOP Publishing. https://doi.org/10.1088/1755-1315/137/1/012036

Bidayani, E., & Valen, F. S. (2023). Efficiency economic of whiteleg shrimp *Litopenaeus vannamei* (Boone, 1931) cultivation with a household scale biofloc system. *Indo Pacific Journal of Ocean Life, 7*(2), 89–96. https://doi.org/10.47728/ipjol.v7i2.117

Boyd, C. E. (2017). *Lime plays crucial role in aquaculture pond management*. Global Seafood Alliance. https://www.globalseafood.org/advocate/lime-aquaculture/#:~:text=The%20high%20pH%20resulting%20from,shrimp%20ponds%20for%20this%20purpose

Boyd, C. E., & Queiroz, J. F. (2014). The role and management of bottom soils in aquaculture ponds. *Infofish International, 2,* 22–28.

Burford, M. A., Thompson, P. J., McIntosh, R. P., Bauman, R. H., & Pearson, D. C. (2003). Nutrient and microbial dynamics in high-intensity, zero-exchange shrimp ponds in Belize. *Aquaculture, 219*(1–4), 393–411. https://doi.org/10.1016/S0044-8486(02)00575-6

Dodds, W. K. (2002). *Freshwater ecology: Concepts and environmental applications.* Academic Press.

Du, Y., Xu, W., Wu, T., Li, H., Hu, X., & Chen, J. (2022). Enhancement of growth, survival, immunity and disease resistance in *Litopenaeus vannamei* by the probiotic, *Lactobacillus plantarum* Ep-M17. *Fish & Shellfish Immunology, 129,* 36–51. https://doi.org/10.1016/j.fsi.2022.07.019

El-Sayed, A. F. M. (2021). Use of biofloc technology in shrimp aquaculture: A comprehensive review, with emphasis on the last decade. *Reviews in Aquaculture, 13*(1), 676–705. https://doi.org/10.1111/raq.12491

Elwin, A., Jintana, V., & Feola, G. (2020). Characterizing shrimp-farm production intensity in Thailand: Beyond technical indices. *Ocean & Coastal Management, 185,* 105019. https://doi.org/10.1016/j.ocecoaman.2019.105019

Fahrur, M., Syah, R., Makmur, M., Suwoyo, H. S., Asaad, A. I. J., & Taukhid, I. (2023). Efek blind feeding untuk meningkatkan pertumbuhan post larva udang vaname kepadatan tinggi dan pengaruhnya terhadap kualitas air. *Berita Biologi, 22*(3), 335–342. https://doi.org/10.14203/beritabiologi.v22i3.5569

Fatalattof, A. A., Yustiati, A., & Andriani, Y. (2022). Review of shrimp cultivation techniques in plastic (BUSMETIC) ponds. *Indonesian Journal of Aquaculture Medium, 2*(1), 1–11. https://doi.org/10.29303/mediaakuakultur.v2i1.1273

Hassan, S. A., Sharawy, Z. Z., El Nahas, A. F., Hemeda, S. A., El-Haroun, E., & Abbas, E. M. (2022). Carbon sources improve water quality, microbial community, immune-related and antioxidant genes expression and survival of challenged *Litopenaeus vannamei* postlarvae in biofloc system. *Aquaculture Research, 53*(17), 5902–5914. https://doi.org/10.1111/are.16129

Indariyanti, N., & Aprilia, T. (2022). Probiotic supplementation in feed on nutritional quality, feed efficiency, and the growth of vannamei shrimp (*Litopenaeus vannamei*). *IOP Conference Series: Earth and Environmental Science*, *1012*(1), 012044. IOP Publishing. https://doi.org/10.1088/1755-1315/1012/1/012044

Indonesian National Standard (Standar Nasional Indonesia [SNI]). (2014a). *SNI 8008:2014 Produksi udang vaname (Litopenaeus vannamei, Boone, 1931) intensif di tambak lining.* Badan Standarisasi Nasional.

Indonesian National Standard (Standar Nasional Indonesia [SNI]). (2014b). *SNI 7981:2014 Konstruksi tambak plastik high density polyethylene (HDPE).* Badan Standarisasi Nasional.

Iskandar, A., Trianto, Y., Hendriana, A., Lesmanawati, W., Prasetyo, B., & Muslim, M. (2022). Pengelolaan dan analisa finansial produksi pembesaran udang vaname *Litopenaeus vannamei*. *Jurnal Perikanan Unram, 12*(2), 256–267. https://doi.org/10.29303/jpu.v12i2.634

Jose Priya, T. A., & Kappalli, S. (2023). Chemicals and their interaction in the aquaculture system. In *Biomedical applications and toxicity of nanomaterials* (pp. 277–297). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-9444-6_12

Khumaidi, A., Muqsith, A., Wafi, A., Jasila, I., & Hikam, T. (2022). Kajian teknis pembesaran udang vaname (*Litopenaeus vannamei*) secara intensif di tambak udang BPBAP Situbondo. *Jurnal Perikanan Pantura (JPP), 5*(2), 195–206. https://doi.org/10.30587/jpp.v5i2.555

Kurniaji, A., Effendi, I., Renitasari, D. P., Supryady, S., Yunarty, Y., & Awaluddin, M. I. (2023). Evaluasi kegiatan budidaya udang vaname (*Litopenaeus vannamei*) secara intensif di PT. Dewi Laut Aquaculture Garut, Jawa Barat. *Jurnal Perikanan Unram, 13*(4), 958–970. https://doi.org/10.29303/jpu.v13i4.808

Lusiana, R., Sudrajat, M. A., & Arifin, M. Z. (2021). Manajemen pakan pada pembesaran udang vannamei (*Litopenaeus vannamei*) di tambak intensif CV. Bilangan Sejahtera Bersama. *Chanos chanos, 19*(2), 187–197. https://doi.org/10.35800/jcc.19.2.2021.32949

Malavé, K., Lodeiros, C., Freites-Valbuena, L., Vélez-Falcones, J., Zapata-Vívenes, É., Arrieche, D., & Pinto, R. (2025). The use of copper sulfate to control mussel (*Mytella strigata*) invasive events in the *Penaeus vannamei* shrimp farming: Doses, effects, and depuration. *Aquaculture, 598,* 741964. https://doi.org/10.1016/j.aquaculture.2024.741964

Mandal, A., & Duyari, M. (2024). Better management practices (BMPs) for sustainable shrimp farming. *Chronicle of Aquatic Science, 1*(9), 52–66.

Marine Affairs and Fisheries. (2016). *Peraturan Menteri Kelautan dan Perikanan Republik Indonesia No. 75 Tahun 2016 tentang Pedoman umum pembesaran udang windu (Penaeus monodon) dan udang vaname (Litopenaeus vannamei).* Kementerian Kelautan dan Perikanan Republik Indonesia.

Millard, R. S., Ellis, R. P., Bateman, K. S., Bickley, L. K., Tyler, C. R., van Aerle, R., & Santos, E. M. (2021). How do abiotic environmental conditions influence shrimp susceptibility to disease? A critical analysis focussed on white spot disease. *Journal of Invertebrate Pathology, 186,* 107369. https://doi.org/10.1016/j.jip.2021.107369

Mirbakhsh, M., Mahjoub, M., Afsharnasab, M., Kakoolaki, S., Sayyadi, M., & Hosseinzadeh, S. (2021). Effects of *Bacillus subtilis* on the water quality, stress tolerance, digestive enzymes, growth performance, immune gene expression, and disease resistance of white shrimp (*Litopenaeus vannamei*) during the early hatchery period. *Aquaculture International, 29*(6), 2489–2506. https://doi.org/10.1007/s10499-021-00776-4

Monier, M. N., Kabary, H., Elfeky, A., Saadony, S., El-Hamed, N. N. A., Eissa, M. E., & Eissa, E. S. H. (2023). The effects of *Bacillus* species probiotics (*Bacillus subtilis* and *B. licheniformis*) on the water quality, immune responses, and resistance of whiteleg shrimp (*Litopenaeus vannamei*) against *Fusarium solani* infection. *Aquaculture International, 31*(6), 3437–3455. https://doi.org/10.1007/s10499-023-01164-3

Mustafa, A., Sapo, I., & Paena, M. (2010). Studi penggunaan produk kimia dan biologi pada budidaya udang vaname (*Litopenaeus vannamei*) di tambak Kabupaten Pesawaran Provinsi Lampung. *Jurnal Riset Akuakultur,* 5(1), 115–133. https://doi.org/10.15578/jra.5.1.2010.115-133

Mustafa, A., Syah, R., Paena, M., Sugama, K., Kontara, E. K., Muliawan, I., & Taukhid, I. (2023). Strategy for developing whiteleg shrimp (*Litopenaeus vannamei*) culture using intensive/super-intensive technology in Indonesia. *Sustainability, 15*(3), 1753. https://doi.org/10.3390/su15031753

Nguyen, T. A. T., Nguyen, K. A. T., & Jolly, C. (2019). Is super-intensification the solution to shrimp production and export sustainability? *Sustainability, 11*(19), 5277. https://doi.org/10.3390/su11195277

Nisa, A. C., Jatayu, D., & Pratama, K. A. (2024). Productivity of white shrimp (*Litopenaeus vannamei*) with the addition of probiotics and prebiotics. *Jurnal Perikanan Unram, 14*(4), 2181–2191. https://doi.org/10.29303/jpu.v14i4.950

Purnamasari, I., Purnama, D., & Utami, M. A. F. (2017). Pertumbuhan udang vaname (*Litopenaeus vannamei*) di tambak intensif. *Jurnal Enggano, 2*(1), 58–67. https://doi.org/10.31186/jenggano.2.1.58-67

Purwanto, P., Sarjito, & Wijayanto, D. (2023). Strategy for the development of sustainable vannamei (*Litopenaeus vannamei*) shrimp culture in plastic ponds in Tegal Regency, Central Java. *Journal of Aquaculture and Fish Health, 12*(1), 115–126. https://doi.org/10.20473/jafh.v12i1.41525

Putra, A., Aulia, D., & Hertanto, D. (2023). Analisis kelayakan usaha budidaya udang vaname (*Litopenaeus vannamei*) sistem BUSMETIK di Serang, Banten. *Jurnal Agroristek, 6*(1), 15–23. https://doi.org/10.52045/jar.v6i1.520

Rachmawati, T., Nabila, N. I., & Tarumanegara, F. (2023). Compiling variables of development on shrimp export competitiveness index. In *3rd Universitas Lampung International Conference on Social Sciences (ULICoSS 2022)* (pp. 314–328). Atlantis Press. https://doi.org/10.2991/978-2-38476-024-8_37

Rakhmanda, A., Pribadi, A., Parjiyo, P., & Wibisono, B. I. G. (2021). Production performance of white shrimp *Litopenaeus vannamei* with super-intensive culture on different rearing densities. *Jurnal Akuakultur Indonesia, 20*(1), 56–64. https://doi.org/10.19027/jai.20.1.56-64

Ray, A. J., Lewis, B. L., Browdy, C. L., & Leffler, J. W. (2010a). Suspended solids removal to improve shrimp (*Litopenaeus vannamei*) production and an evaluation of a plant-based feed in minimal-exchange, superintensive culture systems. *Aquaculture, 299*(1–4), 89–98. https://doi.org/10.1016/j.aquaculture.2009.11.021

Ray, A. J., Seaborn, G., Leffler, J. W., Wilde, S. B., Lawson, A., & Browdy, C. L. (2010b). Characterization of microbial communities in minimal-exchange, intensive aquaculture systems and the effects of suspended solids management. *Aquaculture, 310*(1–2), 130–138. https://doi.org/10.1016/j.aquaculture.2010.10.019

Ritonga, L. B. R., Asmarany, A., & Aritmatika, E. (2021). Management of water quality in intensive enlargement of vannamei shrimp (*Litopenaeus vannamei*) in PT. Andulang Shrimp Farm. *Journal of Aquaculture Development and Environment, 4*(1), 218–226.

Sandi, D. T., Rahardjo, S., & Marlina, E. (2020). Kajian teknis pembesaran udang vaname (*Litopenaeus vannamei*) di PT Suri Tani Pemuka, Banyuwangi-Jawa Timur. *Bul. Jalanidhitah Sarva Jivitam, 2*(1), 37.

Satanwat, P., Tapaneeyaworawong, P., Wechprasit, P., Boonprasertsakul, T., Pungrasmi, W., Sritunyalucksana, K., & Powtongsook, S. (2023). Total ammonia nitrogen removal and microbial community dynamics in an outdoor HDPE-lined shrimp pond with no water discharge. *Aquaculture, 577,* 739898. https://doi.org/10.1016/j.aquaculture.2023.739898

Scheffer, M., Van Geest, G. J., Zimmer, K., Jeppesen, E., Søndergaard, M., Butler, M. G., & De Meester, A. L. (2006). Small habitat size and isolation can promote species richness: Second-order effects on biodiversity in shallow lakes and ponds. *Oikos, 112*(1), 227–231. https://doi.org/10.1111/j.0030-1299.2006.14145.x

Smith, V. H., & Schindler, D. W. (2009). Eutrophication science: Where do we go from here? *Trends in Ecology & Evolution, 24*(4), 201–207. https://doi.org/10.1016/j.tree.2008.11.009

Søndergaard, M., Jeppesen, E., & Jensen, J. P. (2005). Pond or lake: Does it make any difference? *Archiv für Hydrobiologie, 162*(2), 143–165. https://doi.org/10.1127/0003-9136/2005/0162-0143

Suhana, S., Sapanli, K., & Fauzi, S. (2023). Dampak target produksi udang dua juta ton terhadap ekonomi kelautan Indonesia: Pendekatan model input-output. *Jurnal Kebijakan Sosial Ekonomi Kelautan dan Perikanan, 13*(2), 113–124. https://doi.org/10.15578/jksekp.v13i2.11446

Surianti, S., Gibran, M. H., & Sulaeman, M. A. (2024). Manajemen budidaya udang vanamei (*Litopenaeus vannamei*) pada tambak semi intensif di Kabupaten Barru. *Jurnal Lemuru, 6*(2), 205–212. https://doi.org/10.36589/lemuru.v6i2.250

Thakur, K., Patanasatienkul, T., Laurin, E., Vanderstichel, R., Corsin, F., & Hammell, L. (2018). Production characteristics of intensive whiteleg shrimp (*Litopenaeus vannamei*) farming in four Vietnam provinces. *Aquaculture Research, 49*(8), 2625–2632. https://doi.org/10.1111/are.13729

Tran, T. T., Bott, N. J., Lam, N. D., Nguyen, N. T., Dang, O. H. T., Le, D. H., & Chu, H. H. (2019). The role of *Pseudomonas* in heterotrophic nitrification: A case study on shrimp ponds (*Litopenaeus vannamei*) in Soc Trang Province. *Microorganisms, 7*(6), 155. https://doi.org/10.3390/microorganisms7060155

Utami, D. A. S., Ramlanis, A. A., Faruq, W. E. M., & Saputra, F. (2022). Padat tebar optimum untuk mendukung optimasi kualitas air dan produksi tambak intensif udang vaname (*Litopenaeus vannamei*). *Jurnal Akuakultura Universitas Teuku Umar, 6*(1), 52–60. https://doi.org/10.35308/akuakultura.v6i1.5252

Wahyudi, D., Prihutomo, A., & Mukhlis, A. (2022). Produktivitas budidaya udang vaname (*Litopenaeus vannamei*) super intensif di bak terpal bundar dengan padat tebar berbeda. *Jurnal Perikanan Unram, 12*(4), 781–793. https://doi.org/10.29303/jpu.v12i4.740

Whangchai, N., Migo, V. P., Alfafara, C. G., Young, H. K., Nomura, N., & Matsumura, M. (2004). Strategies for alkalinity and pH control for ozonated shrimp pond water. *Aquacultural Engineering, 30*(1–2), 1–13. https://doi.org/10.1016/j.aquaeng.2003.07.001

Widiastiti, N. N., Adnyana, I. M. D. M., & Noor, S. M. (2024). Teknik budidaya udang vaname (*Litopenaeus vannamei*) secara intensif di UD. Lumiti Desa Awen, Jembrana, Bali. *Jurnal Vokasi Ilmu-Ilmu Perikanan (JVIP), 5*(1), 52–62. https://doi.org/10.29303/jvip.v5i1.320

Widodo, A., Agus, M., & Mardiana, T. Y. (2016). Analisa produksi budidaya udang vannamei (*Litopenaeus vannamei*) pada tambak plastik dengan luas yang berbeda di tambak BUSMETIK Sekolah Usaha Perikanan Menengah (SUPM) Negeri Tegal. *Pena Akuatika: Jurnal Ilmiah Perikanan dan Kelautan, 14*(1), 27–35. https://doi.org/10.31941/penaakuatika.v14i1.318

Yanti, M. E. G., Herliany, N. E., Negara, B. F., & Utami, M. A. F. (2017). Deteksi molekuler white spot syndrome virus (WSSV) pada udang vaname (*Litopenaeus vannamei*) di PT. Hasfam Inti Sentosa. *Jurnal Enggano, 2*(2), 156–169. https://doi.org/10.31186/jenggano.2.2.156-169

Yessy, L. T., Ezraneti, R., & Khalil, M. (2024). Quantitative analysis of water quality parameters and their influence on the Pacific white shrimp (*Litopenaeus vannamei*) culture: A case study of Rancong mariculture area in Lhokseumawe, Aceh, Indonesia. *Journal of Marine Studies, 1*(1), 103–115. https://doi.org/10.1234/jms.v1i1.103

Yi, D., Reardon, T., & Stringer, R. (2018). Shrimp aquaculture technology change in Indonesia: Are small farmers included? *Aquaculture, 493,* 436–445. https://doi.org/10.1016/j.aquaculture.2017.11.001

Yustiati, A., & Andriani, Y. (2022). Budidaya udang vaname pembesaran udang vannamei pada berbagai sistem akuakultur: Telaah pustaka. *Journal of Fish Nutrition, 2*(1), 26–36. https://doi.org/10.29303/jfn.v2i1.29

Zhang, H. Y., Huang, Y., Ma, N., Wang, H. B., Zhang, X. Y., Xing, Y. C., & Li, Y. R. (2023). Effect of different doses of trichloroisocyanuric acid on aquaculture pond water. *Aquaculture, 569,* 739390. https://doi.org/10.1016/j.aquaculture.2023.739390

Zulkarnain, R., Adiyana, K., Nugroho, H., Nugraha, B., Thesiana, L., & Supriyono, E. (2020). Selection of intensive shrimp farming technology for small farmers with analytical hierarchy process: A case for whiteleg shrimp (*Litopenaeus vannamei*). *IOP Conference Series: Earth and Environmental Science*, *404*(1), 012017. IOP Publishing. https://doi.org/10.1088/1755-1315/404/1/012017