

Dietary *Streptococcus thermophilus* Probiotic Improves Growth of Pacific White Shrimp and Nile Tilapia

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Abstract. *The intensive culture of Pacific white shrimp (Litopenaeus vannamei) and Nile tilapia (Oreochromis niloticus) is constrained by high feed costs, underscoring the need for strategies that enhance growth and feed efficiency without compromising environmental quality. Probiotics are increasingly proposed as functional feed additives, yet the performance of Streptococcus thermophilus in these two key tropical species remains poorly documented. This study evaluated the effects of graded dietary levels of S. thermophilus on growth performance, feed utilization, survival, and water quality in shrimp and Nile tilapia reared under controlled hatchery conditions. Shrimp (PL 15) and Nile tilapia juveniles (4–6 cm) were cultured separately in 25 L plastic tanks (effective water volume 15–16 L), at densities of 50 shrimp tank⁻¹ (31–32 ppt) and 15 tilapia tank⁻¹ (10–15 ppt), respectively, for 40 days. A completely randomized design with five treatments (0, 5, 10, 15, and 20 mL S. thermophilus/kg feed) and three replicates per treatment was used, with isoproteic diets based on fish meal and plant ingredients. Growth parameters (absolute weight and length gain, specific growth rate), feed conversion ratio, feed efficiency, survival, and basic water quality variables were measured and analyzed by one way ANOVA followed by Duncan's test. Dietary S. thermophilus significantly enhanced absolute weight gain and specific growth rate in both shrimp and tilapia, while absolute length gain remained unchanged (P > 0.05). The 15 mL/kg treatment produced the best overall performance, with shrimp and tilapia reaching the highest weight gain, lowest feed conversion ratios (1.26 and 1.20, respectively), and feed efficiencies above 79%, whereas survival exceeded 70% in all probiotic groups and reached 100% in some tilapia treatments. Water quality, including dissolved oxygen, temperature, and pH, remained within recommended ranges, and probiotic pH (2–4) reflected active lactic acid fermentation without detrimental effects on rearing conditions. These findings demonstrate that dietary S. thermophilus at 10–15 mL/kg is an effective strategy to improve growth and feed utilization in shrimp–tilapia systems while maintaining suitable water quality, offering a practical approach to reduce feed-related production costs in sustainable tropical aquaculture.*

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INTRODUCTION

Aquaculture development is expected to support sustainable aquatic food production by cultivating high value species with strong market demand (Putra, 2021). Pacific white shrimp (*Litopenaeus vannamei*) is one of the most economically important marine commodities in Indonesia and has become a priority species in national aquaculture development programs (Amelia et al., 2021; Mustafa et al., 2023). Similarly, Nile tilapia (*Oreochromis niloticus*) is widely consumed due to its relatively high protein content, thick flesh, and favorable taste (Abd El-Hack et al., 2022; Furuya et al., 2023; Yossa et al., 2023). This species also exhibits broad environmental adaptability, including tolerance to a wide range of salinities, allowing its culture in brackish and marine environments as Nile tilapia (Yue et al., 2024; Dildar et al., 2025). In addition, Nile tilapia demonstrates resistance to various diseases and tolerance to fluctuations in water temperature (Ismarica et al., 2022; Suratno et al., 2023; Juanda et al., 2024).

Despite their aquaculture potential, the production of these species still faces several technical constraints, particularly the high cost of feed (Boyd et al., 2020). In Pacific white shrimp farming, elevated feed prices often lead farmers to reduce feed rations, thereby slowing shrimp growth (Villarreal, 2023). A similar issue occurs in Nile tilapia culture, where feed represents a critical factor influencing the growth performance of cultured organisms. The high price of commercial feed combined with high feed consumption rates can significantly increase operational costs and reduce production efficiency in aquaculture systems (Tan et al., 2024).

Previous studies have demonstrated that probiotics can be used as feed additives to enhance growth performance in aquaculture species (Dachi et al., 2019; Leong et al., 2023; Vasyliuk et al., 2023). Probiotics may function as growth promoters, improve host resistance to pathogenic microorganisms, enhance digestive processes, maintain water quality, increase stress tolerance, and support reproductive performance (Fioramonti et al., 2003; El-Saadony et al., 2021; Mujeeb et al., 2022). One potential probiotic bacterium is *Streptococcus thermophilus*, a lactic acid bacterium that produces the enzyme lactase, which contributes to digestive processes (Iyer et al., 2010). This bacterium has previously been applied to improve the growth of Lena sturgeon (Karpunina et al., 2022). However, previous probiotic studies in Pacific white shrimp and Nile tilapia have predominantly used *Bacillus* spp., *Lactobacillus* spp., or mixed bacterial consortia, and information on *S. thermophilus* as a dietary probiotic in either species, particularly with respect to graded dose response effects on growth, feed utilization, and survival, is virtually absent. In addition, no study has evaluated whether a single lactic acid bacterium can exert comparable probiotic effects in two intensively farmed but biologically distinct hosts, namely a marine crustacean and an euryhaline finfish, even though both are often cultured in the same coastal regions and targeted for integrated farming systems.

Investigating the application of *S. thermophilus* as a dietary probiotic is therefore important to evaluate its potential to improve growth performance and feed utilization efficiency in aquaculture species. Probiotic supplementation in feed can increase populations of beneficial bacteria that enhance nutrient availability and digestive efficiency, potentially improving feed efficiency and reducing production costs (Ayyat et al., 2014; Muhammadar et al., 2018; Dias et al., 2020; Aviz et al., 2021). Therefore, this study aimed to evaluate the effects of dietary supplementation of *Streptococcus thermophilus* on the growth performance and survival rate of Pacific white shrimp (*Litopenaeus vannamei*) and Nile tilapia (*Oreochromis niloticus*).

MATERIALS AND METHODS

Experimental animals and diets

This study was conducted from July 2022 to August 2023 at the Hatchery Facility of the Faculty of Fisheries and Marine Sciences, Universitas Syiah Kuala. The experiment employed a completely randomized design (CRD) with five dietary treatments and three replicates per treatment, which is a commonly used minimum level of replication to obtain reliable error estimates in aquaculture feeding trials (Akter et al., 2019). Nile tilapia juveniles (initial length 4–6 cm) and shrimp postlarvae PL 15 were reared separately (monoculture) in cylindrical plastic containers rather than aquaria.

Each species was maintained in 25 L plastic containers (top diameter ± 30 cm, height ± 35 cm) supplied with continuous aeration via a single air stone. The effective water volume was 15 L for tilapia (salinity 10–15 ppt) and 16 L for shrimp (salinity 31–32 ppt). Tilapia were stocked at a density of 15 fish per container (225 fish in total), whereas shrimp were stocked at 50 individuals per container, and all containers were randomly assigned to dietary treatments.

The experiment employed five dietary treatments with three replicates per treatment. The treatments consisted of a control diet without probiotic supplementation (A) and diets supplemented with *S. thermophilus* at 5 mL kg⁻¹ (B), 10 mL kg⁻¹ (C), 15 mL kg⁻¹ (D), and 20 mL kg⁻¹ (E) of feed. All experimental diets were isoproteic and formulated using fish meal, soybean meal, fine rice bran, shrimp meal (for tilapia), tapioca flour, corn flour, squid/fish oil, vitamin premix, and mineral premix as the main ingredients, adapted and modified from Arisa et al. (2021). The dry ingredients were finely ground, weighed according to the formulation, thoroughly mixed, and then blended with oil and water to form a homogeneous dough. The dough was pelleted using a meat grinder, air dried at room temperature to a constant moisture, and stored at 4 °C until use. Probiotic suspensions of *S. thermophilus* were sprayed onto the pellets at the designated volumes (mL kg⁻¹ feed), mixed gently to ensure uniform coating, and allowed to air dry before feeding.

Probiotic preparation

For probiotic preparation, 70 g of powder was dissolved in 1.4 L of sterile distilled water in a tightly closed glass bottle and vigorously shaken until a visually uniform, milky white suspension was obtained (no visible clumps). The culture was then incubated at room temperature (± 28 – 30 °C) for 5 days before use as a feed additive. During the incubation period, bacterial density was determined using the Total Plate Count (TPC) method on Tryptic Soy Agar (TSA). Serial ten fold dilutions of the probiotic suspension were prepared in 0.9% NaCl solution, and aliquots (0.1 mL) from appropriate dilutions (10^{-3} , 10^{-6} , and 10^{-9}) were spread onto TSA plates in duplicate. Plates were incubated at 35–37 °C for 24–48 h, and colonies with typical lactic acid bacteria morphology were enumerated; counts were expressed as colony forming units (CFU) per mL of suspension after multiplying by the corresponding dilution factor.

Rearing conditions and experimental design

The Nile tilapia (*Oreochromis niloticus*) trial was conducted in 25 L cylindrical plastic containers (15 units), each filled with 15 L of clean brackish water adjusted to a salinity of 10–15 ppt. Salinity was measured by gradually mixing filtered seawater with dechlorinated freshwater using a refractometer, and fish were acclimated by increasing salinity in steps of 2–3 ppt per day until the target range was reached. Tilapia juveniles were then randomly stocked at a density of 15 fish per container (initial total length 4.0–6.0 cm; mean \pm SD $\approx 5.0 \pm 0.6$ cm; initial body weight 1.5–3.0 g; mean \pm SD $\approx 2.2 \pm 0.4$ g) and fed the experimental diets. Continuous aeration was supplied to each container via a single air stone connected to a central blower.

For the Pacific white shrimp (*Litopenaeus vannamei*) trial, PL 15 shrimp were reared separately from tilapia (monoculture) in 25 L transparent plastic containers, each containing 16 L of seawater at a salinity of 31–32 ppt. Shrimp were stocked at a density of 50 individuals per container (initial total length 1.2–1.8 cm; mean \pm SD $\approx 1.5 \pm 0.2$ cm; initial body weight 0.03–0.06 g; mean \pm SD $\approx 0.045 \pm 0.010$ g) and supplied with continuous aeration as described for tilapia. Shrimp were fed a formulated diet containing approximately 35.6% crude protein, based on fish meal, soybean meal, fine rice bran, tapioca flour, corn flour, vitamin premix, mineral premix, and squid oil.

All dietary treatments (A–E) were randomly assigned to the rearing units for each species, and shrimp and tilapia were maintained in separate sets of containers throughout the 40 day experimental period. The respective experimental diets were offered according to the feeding protocol described below, and growth performance and feed utilization were evaluated under the different probiotic supplementation levels (Muhammadar et al., 2018).

Feeding management

Feeding trials were conducted for 40 days for both Pacific white shrimp and Nile tilapia juveniles. Shrimp were fed at 10% of biomass per day, divided into three meals at 08.00 a.m., 12.00 a.m. and 04.00 p.m., whereas tilapia were fed at 6% of biomass per day in two meals at 08.00 a.m. and 04.00 p.m. The higher ration and feeding frequency for shrimp were selected because early postlarval stages have smaller stomach capacity and higher mass specific metabolic rates than juvenile finfish, and therefore require more frequent meals to sustain rapid growth, as commonly recommended for *L. vannamei* nursery culture. Before each feeding, aeration was stopped, the probiotic-supplemented diet was compacted into small pellets and broadcast evenly into each tank, and aeration was resumed 15 minutes after feed distribution; uneaten feed and feces were siphoned every 2–3 days to maintain water quality.

Fish and shrimp were sampled every 10 days and at the end of the trial. For each tank, all individuals were gently netted and anesthetized with clove oil (40–50 $\mu\text{L L}^{-1}$). Total length was measured to the nearest 0.1 cm with a measuring board, and body weight was recorded to the nearest 0.01 g for tilapia and 0.001 g for shrimp using an electronic balance. Dissolved oxygen and temperature were measured daily using a digital DO meter and thermometer, pH was recorded every two days with a calibrated pH meter, and salinity was checked with a handheld refractometer to ensure values remained within the target ranges of 10–15 ppt for tilapia and 31–32 ppt for shrimp.

Growth performance and feed utilization

Absolute weight gain was calculated as the difference between final and initial biomass (Effendie, 2002; Putra et al., 2022):

$$W_m = W_t - W_o \quad (1)$$

where W_m is absolute weight gain (g), W_t is final biomass (g), and W_o is the initial biomass (g).

Absolute length gain was determined as the difference between final and initial mean total length (Effendie, 2002; El Rahimi et al., 2021):

$$L = L_t - L_o \quad (2)$$

where L is absolute length gain (cm), L_t is the final mean length (cm), and L_o is the initial mean length (cm).

Specific growth rate (SGR) or daily growth rate was calculated according to (Howe, 1996; Putra et al., 2021; Safriani et al., 2019) :

$$SGR = \frac{\ln W_t - \ln W_o}{t} \times 100(3)$$

where SGR , as the specific growth rate, is expressed as %/day, W_t and W_o are final and initial mean body weights (g), and t is the duration of the rearing period (days).

Survival and feed efficiency

Survival rate was calculated as described by (Abbas et al., 2023; Gunawan et al., 2024; Putra et al., 2025):

$$SR = \frac{N_t}{N_o} \times 100(4)$$

where SR is the survival rate (%), N_t is the number of individuals at the end of the trial, and N_o is the initial number stocked.

Feed conversion ratio (FCR) was determined following (Abbas et al., 2025; Muhammadar et al., 2023):

$$FCR = \frac{F}{W_t - W_o + D} (5)$$

where FCR is the feed conversion ratio, F is the total feed intake (g), W_t and W_o are final and initial biomass (g), and D is the total biomass loss due to mortality (g) or the number of dead animals, depending on the original formulation.

Feed efficiency was calculated according to (Alifia et al., 2025; Fahira et al., 2025):

$$FE = \frac{W_t - W_o}{F} \times 100(6)$$

where FE is feed efficiency (%), W_t and W_o are final and initial biomass (g), and F is the total feed intake (g).

Statistical analysis

All growth, survival, and feed utilization data were subjected to one-way analysis of variance (ANOVA) at a significance level of 5% to evaluate the effects of dietary probiotic supplementation. When significant differences among treatments were detected, means were separated using Duncan's multiple range test (DMRT) to identify differences among individual treatment groups. All statistical analyses were performed using SPSS software (IBM SPSS version 12.5).

RESULTS AND DISCUSSION

Growth performance

Dietary supplementation with *Streptococcus thermophilus* significantly affected absolute weight gain in both Pacific white shrimp and Nile tilapia after 40 days of rearing, as shown in Tables 1 and 2. In contrast, SGR in Pacific white shrimp was not significantly influenced by dietary treatments ($P > 0.05$), indicating that the probiotic did not alter relative growth rate in this species over the experimental period, although effects on tilapia SGR were observed. For shrimp, absolute length gain showed no significant differences among treatments ($P > 0.05$) (Figure 1). While the highest absolute weight gain (0.39 ± 0.05 g) and SGR ($1.85 \pm 0.01\%/day$) were observed in treatment D (15 mL/kg feed) (Figure 2), which differed significantly from treatment B (0.30 ± 0.02 g, $P < 0.05$).

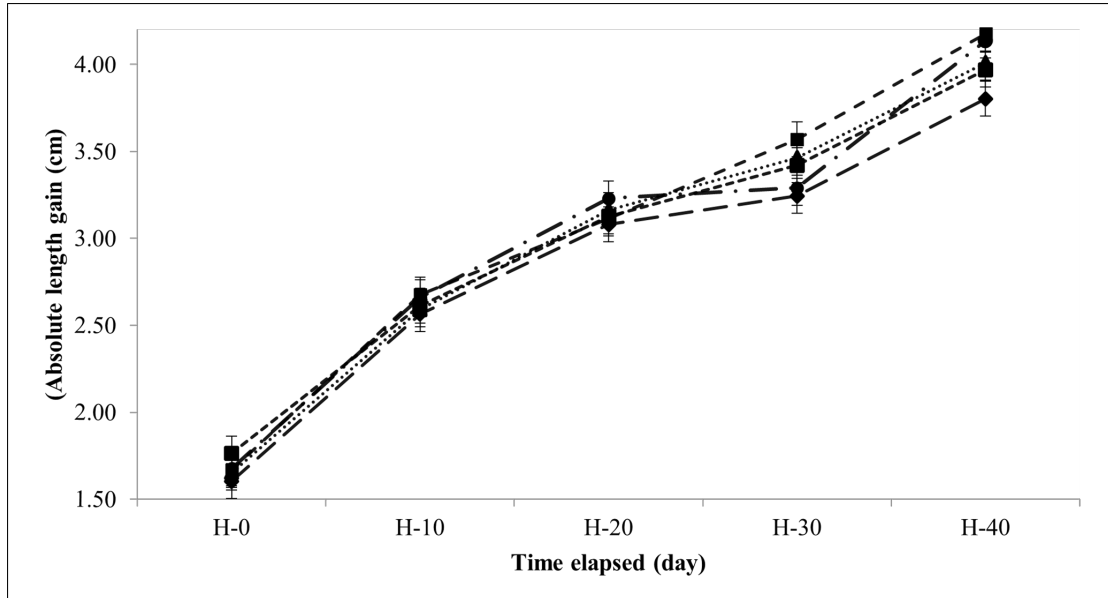


Figure 1: Absolute length gain of Pacific white shrimp (*Litopenaeus vannamei*) in 40 days of rearing. The legend symbols represent the dietary treatments as follows: dashed line with square markers = treatment A (control, without probiotic); solid line with diamond markers = treatment B (diet with 5 mL *S. thermophilus*/kg feed); dotted line with triangle markers = treatment C (10 mL/kg); dashed line with square block markers = treatment D (15 mL/kg); and solid line with circle markers = treatment E (20 mL/kg).

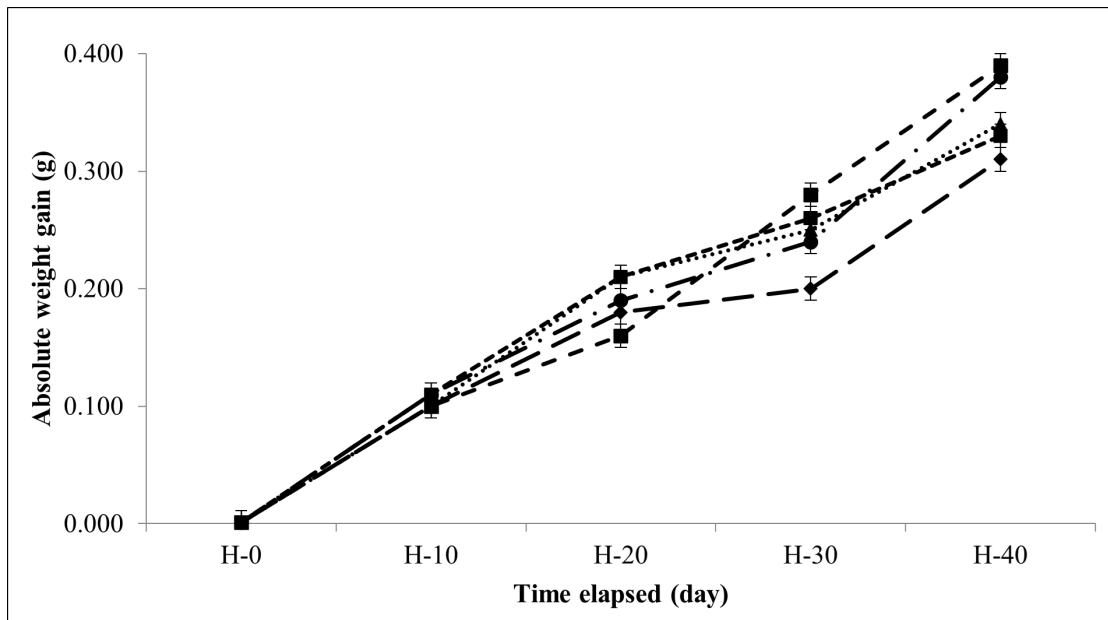


Figure 2: Absolute weight gain of Pacific white shrimp (*Litopenaeus vannamei*). The legend symbols represent the dietary treatments as follows: dashed line with square markers = treatment A (control, without probiotic); solid line with diamond markers = treatment B (diet with 5 mL *S. thermophilus*/kg feed); dotted line with triangle markers = treatment C (10 mL/kg); dashed line with square block markers = treatment D (15 mL/kg); and solid line with circle markers = treatment E (20 mL/kg).

Similarly, tilapia exhibited absolute length gain remained unaffected ($P > 0.05$) (Figure 3), but a significantly higher absolute weight gain (2.71 ± 0.47 g in D) (Figure 4) and SGR ($2.23 \pm 0.38\%/day$ in D) compared to the control (A).

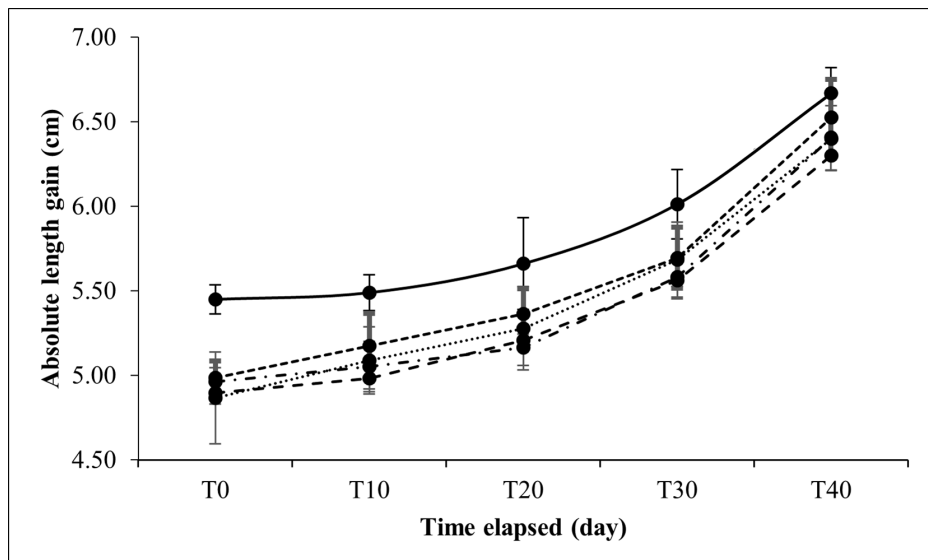


Figure 3: Absolute length gain of Nile tilapia (*Oreochromis niloticus*) fingerlings in 40 days of rearing. The legend symbols represent the following treatments: a solid line with circle markers corresponds to treatment A (control, without probiotic); a dotted line with circle markers corresponds to treatment B (diet supplemented with 5 mL probiotic/kg feed); a dashed line with circle markers corresponds to treatment C (10 mL probiotic/kg feed); a dash-dot line with circle markers corresponds to treatment D (15 mL probiotic/kg feed); and a dotted-dash line with circle markers corresponds to treatment E (20 mL probiotic/kg feed).

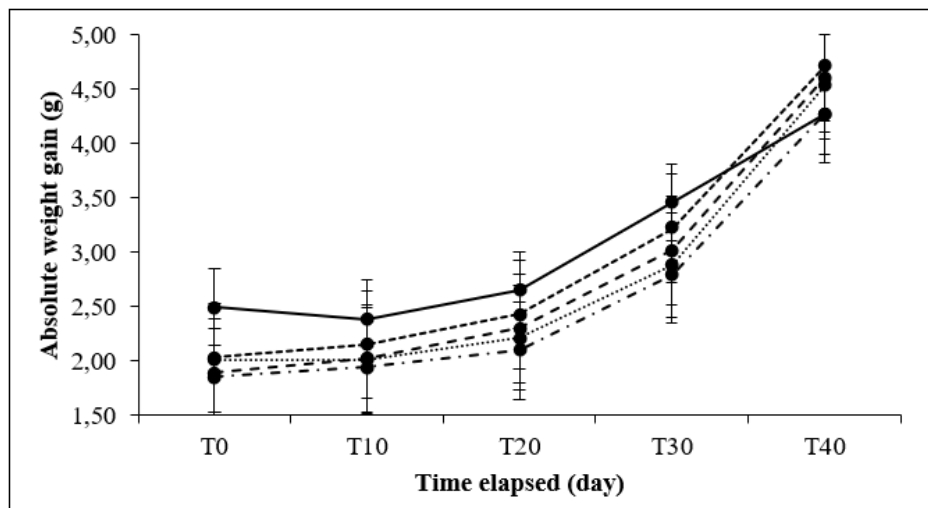


Figure 4: Absolute weight gain of Nile tilapia (*Oreochromis niloticus*) fingerlings. The legend symbols represent the following treatments: a solid line with circle markers corresponds to treatment A (control, without probiotic); a dotted line with circle markers corresponds to treatment B (diet supplemented with 5 mL probiotic/kg feed); a dashed line with circle markers corresponds to treatment C (10 mL probiotic/kg feed); a dash-dot line with circle markers corresponds to treatment D (15 mL probiotic/kg feed); and a dotted-dash line with circle markers corresponds to treatment E (20 mL probiotic/kg feed).

These results indicate that *S. thermophilus* supplementation at optimal doses (10–15 mL/kg) enhanced nutrient absorption and metabolic efficiency in both species. Several studies have reported significant growth improvements in both fish and crustaceans exposed to single or combined probiotic strains (Arisa et al., 2015; Afrilasari et al., 2016; Elsabagh et al., 2018; Alifia et al., 2025). The improved weight gain aligns with Abdul-Malik et al. (2023) and Amenyogbe (2023), who reported that higher probiotic colony counts in feed maximize digestive enzyme production, thereby increasing feed digestibility and promoting somatic growth. Probiotic bacteria likely colonized the gut, producing extracellular enzymes (protease, lipase, amylase) that break down complex feed components, as reported by De Marco et al. (2023) and Zhao et al. (2024).

Feed utilization and survival

Feed conversion ratio (FCR) and feed efficiency (FE) improved with probiotic supplementation, though not always significantly, among probiotic treatments. Shrimp FCR was lowest (1.26 in D), meeting aquaculture standards (<1.5) (Howe, 1996; Leong et al., 2023) (Table 1), while tilapia achieved 1.20 in D, indicating efficient feed use. Survival rate (SR) was highest in shrimp treatment C (86%) and tilapia C/E (100%), all exceeding 60% and categorized as good (>70% optimal) (Table 2).

Table 1: Growth performance, feed utilization, and survival of Pacific white shrimp fed diets supplemented with different levels of dietary *Streptococcus thermophilus* for 40 days.

Treatment	Absolute weight (g)	Absolute length (cm)	SGR (%/day)	FCR	FE (%)	SR (%)
A (0 mL/kg)	0.33 ± 0.03 ^{ab}	2.21 ± 0.10 ^a	1.84 ± 0.01 ^a	1.59 ± 0.11 ^a	63.27 ± 4.40 ^a	70.67 ± 5.77 ^{ab}
B (5 mL/kg)	0.30 ± 0.02 ^a	2.20 ± 0.19 ^a	1.84 ± 0.00 ^a	1.44 ± 0.28 ^a	71.00 ± 12.60 ^a	80.00 ± 4.00 ^{bc}
C (10 mL/kg)	0.34 ± 0.04 ^{ab}	2.36 ± 0.15 ^a	1.85 ± 0.01 ^a	1.51 ± 0.28 ^a	67.87 ± 12.64 ^a	86.00 ± 7.21 ^c
D (15 mL/kg)	0.39 ± 0.05 ^b	2.51 ± 0.18 ^a	1.85 ± 0.01 ^a	1.26 ± 0.12 ^a	79.80 ± 7.81 ^a	71.33 ± 2.30 ^{ab}
E (20 mL/kg)	0.38 ± 0.03 ^b	2.46 ± 0.16 ^a	1.85 ± 0.01 ^a	1.27 ± 0.19 ^a	79.73 ± 11.50 ^a	62.00 ± 7.21 ^a

Different superscript letters within the same column indicate significant differences among treatments ($P < 0.05$). Values are means ± standard deviation ($n = 3$). Treatments: A = control diet without probiotic; B = diet with 5 mL *Streptococcus thermophilus*/kg feed; C = 10 mL/kg; D = 15 mL/kg; E = 20 mL/kg.

Table 2: Growth performance, feed utilization, and survival of Nile tilapia fed diets supplemented with different levels of dietary *Streptococcus thermophilus* for 40 days.

Treatment	Absolute weight (g)	Absolute length (cm)	SGR (%/day)	FCR	FE (%)	SR (%)
A (0 mL/kg)	1.76 ± 0.19 ^a	1.23 ± 0.15 ^a	1.33 ± 0.08 ^a	1.55 ± 0.03 ^a	64.67 ± 1.23 ^a	93.33 ± 6.67 ^a
B (5 mL/kg)	2.68 ± 0.39 ^b	1.53 ± 0.15 ^a	2.10 ± 0.21 ^b	1.26 ± 0.06 ^b	79.88 ± 4.13 ^b	95.56 ± 3.85 ^a
C (10 mL/kg)	2.42 ± 0.20 ^b	1.40 ± 0.10 ^a	2.09 ± 0.14 ^b	1.22 ± 0.02 ^b	82.02 ± 1.16 ^b	100.00 ± 0.00 ^a
D (15 mL/kg)	2.71 ± 0.47 ^b	1.50 ± 0.26 ^a	2.23 ± 0.38 ^b	1.20 ± 0.11 ^b	83.50 ± 7.29 ^b	97.78 ± 3.85 ^a
E (20 mL/kg)	2.52 ± 0.20 ^b	1.43 ± 0.15 ^a	2.03 ± 0.09 ^b	1.21 ± 0.04 ^b	82.88 ± 2.92 ^b	100.00 ± 0.00 ^a

Different superscript letters within the same column indicate significant differences among treatments ($P < 0.05$). Values are means ± standard deviation ($n = 3$). Treatments: A = control diet without probiotic; B = diet with 5 mL *Streptococcus thermophilus*/kg feed; C = 10 mL/kg; D = 15 mL/kg; E = 20 mL/kg.

Probiotics in aquaculture act as a biological catalyst for feed utilization and survival by optimizing the host's internal environment and metabolic efficiency (El-Saadony et al., 2021). Within the gastrointestinal tract, these beneficial microbes secrete a suite of extracellular enzymes such as protease, amylase, and lipase that break down complex feed ingredients into simpler, highly absorbable nutrients, which directly improves the Feed Conversion Ratio (FCR) and promotes faster growth (Elsabagh et al., 2018; Leong et al., 2023). Beyond digestion, probiotics provide a "biological shield" by colonizing the gut lining through competitive exclusion, effectively preventing the attachment of harmful pathogens and reducing the risk of internal infections (Ghori et al., 2022). Furthermore, these microorganisms stimulate the host's innate immune system, increasing the production of macrophages and lysozymes, thereby allowing fish or shrimp to better resist disease outbreaks (Fioramonti et al., 2003; Dias et al., 2020). This synergistic combination of superior nutrient absorption and enhanced immune defense significantly reduces mortality, ensuring higher overall survival throughout the cultivation cycle.

Water quality and probiotic characteristics

Water quality parameters remained within optimal ranges for both species throughout the trial (Table 3), with dissolved oxygen ranging from 3.29 to 6.28 mg/L, water temperature from 28.3 to 31.8 °C, and pH from 7.1 to 7.8. Probiotic pH ranged from 2 to 4 during culture, decreasing due to lactic acid accumulation (Azizah et al., 2025).

Higher DO in probiotic treatments (up to 6.28 mg/L in E) suggests that microbial activity improved oxygen dynamics and organic matter decomposition, preventing hypoxia despite control dips below the optimal level. Probiotics in aquaculture serve as essential bioremediation agents that actively decompose organic waste and convert toxic ammonia (NH₃) into less toxic nitrate compounds through the biological process of nitrification (Ren et al., 2021; Qiu et al., 2023). These beneficial bacteria stabilize the aquatic ecosystem by outcompeting harmful pathogens for nutrients and maintaining consistent water quality parameters, particularly pH and dissolved oxygen levels (Elsabagh et al., 2018; Tabassum et al., 2021). By secreting extracellular enzymes, probiotics accelerate the breakdown of uneaten feed and fecal matter, preventing anaerobic decay and the build-up of lethal gases at the pond bottom (Sunitha & Krishna, 2016; Hassan et al., 2022). Ultimately, the biological activity of these microorganisms ensures an optimal nutrient cycle, creating a healthy environment that significantly boosts the growth and survival rates of the farmed species (Yuvaraj & Karthik, 2015; El-Saadony et al., 2021)

Table 3: Water quality and probiotic pH during the 40-day feeding trial for shrimp and Nile tilapia.

Parameter	A (0 mL/kg)	B (5 mL/kg)	C (10 mL/kg)	D (15 mL/kg)	E (20 mL/kg)	Reference standard
Dissolved oxygen (DO, mg/L)	3.29–4.15	4.21–6.07	4.23–6.28	4.35–6.23	5.01–6.28	>4.0 (SNI 8037, 2014)
Water temperature (°C)	28.3–31.8	28.6–31.2	28.8–31.3	28.6–31.3	28.3–31.3	28–33 (SNI 8037, 2014)
Water pH	7.1–7.8	7.6–7.8	7.5–7.8	7.7–7.8	7.6–7.8	7.5–8.5 (SNI 8037, 2014)
Probiotic pH	2–4	2–4	2–4	2–4	2–4	–

CONCLUSION

This study demonstrated that dietary supplementation of *Streptococcus thermophilus* has a measurable, dose dependent effect on growth performance and feed utilization in Pacific white shrimp (*Litopenaeus vannamei*) and Nile tilapia (*Oreochromis niloticus*) reared in separate monoculture systems for 40 days. Graded inclusion levels of 5–20 mL *S. thermophilus* kg⁻¹ feed significantly increased absolute weight gain and improved feed conversion ratio and feed efficiency, while absolute length gain remained unchanged, and specific growth rate in Pacific white shrimp was not significantly affected. Among the tested doses, 10–15 mL kg⁻¹ particularly 15 mL kg⁻¹ provided the best overall response in both species, characterized by higher final weights, lower FCR values (1.20–1.26), feed efficiencies above 79%, and high survival (>70% for all probiotic treatments and up to 100% for tilapia), without compromising water quality, which stayed within recommended ranges. These results confirm that *S. thermophilus* can be used as an effective dietary probiotic to enhance growth and feed utilization efficiency in shrimp and tilapia culture, thereby addressing the initial objective of mitigating feed related constraints in intensive systems and supporting its potential application in sustainable, cost effective tropical aquaculture.

AUTHOR CONTRIBUTION

D.F.P. designed the research, supervised the experimental process, and contributed to data interpretation; **C.A.P.** conducted the shrimp rearing trials, performed probiotic culture preparation, and collected growth data; **R.E.B.M.** managed the Nile tilapia trials, measured water quality parameters, and performed statistical analyses; **M.N.** formulated the experimental diets, conducted feed proximate analysis, and validated nutritional composition; **S.S.** and **E.M.F.** analyzed bacterial colony counts, contributed to water quality measurements, and assisted with manuscript preparation.

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CONFLICT OF INTEREST

There is no conflict of interest.

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