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Production of Healthy Fish Feed for Tilapia (*Oreochromis niloticus*) with the Addition of *Bacillus cerius* SN7

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ABSTRACT
Most of the world's fish production comes from marine catches and is expected to continue increasing along with community growth and rising income levels. Aquaculture activities still largely rely on imported feed from other countries. This study aimed to analyze the effect of *Bacillus cereus* SN7 bacteria on the growth of saline tilapia (*Oreochromis niloticus*). The research method used was a completely randomized design (CRD) with five treatment levels and three replications. Fish were fed with protein-substituted feed containing *B. cereus* SN7 at different percentages: A0 (0%), A1 (5%), A3 (15%), and P4 (20%). The saline tilapia used were 4– 6cm in size and weighed 2.23 ± 0.72g. Fish were kept in aquariums measuring 60 × 40 × 40 cm³ with a stocking density of 10 fish/m³. The test feed was administered at 10% of the biomass weight with a feeding frequency of three times per day at 08:00, 12:00, and 17:00 WIB for a duration of 21 days. The results showed that the best treatment was the use of 20% *B. cereus* SN7 in the feed, which resulted in a feed digestibility of 66.67%, protein digestibility of 75.25%, feed efficiency of 31.14%, protein retention of 20.90%, specific growth rate of 2.74%, and a fish survival rate of 96%. Water quality during the rearing period remained within acceptable ranges: temperature between 25– 28˚C, pH 7.0– 8.0, dissolved oxygen (DO) between 3.5– 5.0mg/ L, and salinity at 17ppt. The use of *B. cereus* SN7 bacteria was shown to significantly enhance the growth of saline tilapia by improving feed digestibility, protein digestibility, feed efficiency, protein retention, specific growth rate, and survival.

INTRODUCTION

Feed is an important variable in aquaculture as it plays a direct role in supporting fish growth. The feed that promotes optimal growth is high-quality and contains complete nutrients—protein, fat, carbohydrates, vitamins, minerals, water, and energy—in balanced proportions. In feed formulations, the protein requirement for fish ranges from 250– 400g/ kg, and is generally higher than that of other farmed animals **(Ikbal *et al.*,**

2022). Protein is the primary raw material in feed, and its quality is determined by its source and amino acid content. Essential amino acids such as leucine, methionine, and lysine are crucial for fish growth. Inadequate dietary protein can result in stunted growth and reduced fish weight **(Hoseinifar *et al.*, 2018)**.

Each fish species requires different levels of protein for optimal growth, depending on factors such as age and size. Typically, fish require 35–50% protein in their feed. Juvenile tilapia need about 35%, the goldfish weighing 121 grams need 31.6%, carp weighing 0.27 grams require 43.29%, and juvenile shrimp have a maximum protein requirement of 32%. Furthermore, it has been shown that the addition of 45% soybean flour to feed (containing 25% crude protein) leads to optimal weight gain in fish farming **(Setyastuti, 2020)**.

The quality of fish feed depends on the quantity and quality of nutrients retained after digestion, absorption, and metabolism. Feed digestibility is influenced by fish size, feed composition, the amount consumed, and fish physiology **(Oliveira *et al.*, 2022)**. Digestibility reflects the usable value of the feed ingredients. It is measured by determining the amount of nutrients absorbed in the digestive tract—calculated as the difference between the feed nutrients ingested and those excreted. Factors affecting digestibility include water quality, temperature, feed type, fish size and age, nutrient content, feeding frequency, physical and chemical properties of the feed, and the digestive enzyme profile of the fish **(Horstmann *et al.*, 2023)**.

Probiotic bacteria are increasingly used in aquaculture as biological control agents, a strategy known as biocontrol **(Feliatra *et al.*, 2019)**. Probiotics used in aquaculture include lactic acid bacteria (*Lactobacillus*, *Carnobacterium*), *Vibrio* species (*V. alginolyticus*), *Bacillus* species, *Pseudomonas*, among others. The antibacterial effects of probiotics may result from the production of antibiotics, bacteriocins, siderophores, lysozymes, proteases, hydrogen peroxide, organic acids (which lower pH), ammonia, and diacetyl **(Fazlan *et al.*, 2019)**.

Partially replacing protein with *Bacillus cereus* has been shown to positively impact fish health and growth in column cultures **(Djamil *et al.*, 2020)**. Probiotics and other beneficial bacteria can enhance digestive enzyme activity. These bacteria produce extracellular enzymes like amylase, protease, and lipase, improving nutrient absorption and utilization. However, replacing fishmeal with plant-based ingredients in snapper feed has been shown to reduce fish performance and negatively affect fecal characteristics and waste removal efficiency **(Horstmann *et al.*, 2023)**.

Some commercial fish feeds still have low protein content, prompting efforts to find alternative high-protein sources. This has led to the development of industrial-scale production of non-agricultural protein products suitable for feed. One promising alternative is the use of *Bacillus cereus*, which is abundant in nature and suitable as a sustainable protein source for aquaculture. Additionally, *B. cereus* contributes to nitrogen compound removal through nitrification and nitrite processes. It is a Gram-positive, rodshaped, facultatively anaerobic heterotroph capable of forming endospores, commonly found in water, soil, food, and the fish digestive tract **(Feliatra *et al.*, 2019)**.

Efforts to utilize *B. cereus* as a protein source in aquaculture are highly recommended and represent an innovative, sustainable solution **(Feliatra *et al.*, 2021)**. Previous research has identified five strains of *B. cereus* with high potential as fish feed protein sources: *B. cereus* SN7, SP4, S5, Xmb051, and BF2—collectively referred to as the *B. cereus* consortium **(Feliatra *et al.*, 2022)**. One especially promising strain is *B. cereus* SN7, which has a protein content of 50–60% and produces mannanase enzymes **(El-Sharounya *et al.*, 2015)**.

Other research has shown that *Aneurinibacillus variabilis* (BL5), a probiotic isolated from coconut crabs, has also been developed into probiotic capsules **(Feliatra *et al.*, 2023; Ari *et al.*, 2024)**. Bacteria in general can contain 50–65% crude protein **(Purwatisari *et al.*, 2018)**. In addition to its nutritional benefits, *B. cereus* SN7 also exhibits antimicrobial activity, inhibiting *Vibrio* sp., *Aeromonas* sp., and *Pseudomonas* sp., due to the production of antimicrobial compounds such as antibiotics, bacteriocins, siderophores, lysozymes, and proteases **(Feliatra *et al.*, 2019)**.

This study aimed to determine the optimal percentage of *B. cereus* SN7 bacteria as a protein source to replace fishmeal in the diet of saline tilapia (*Oreochromis niloticus*).

MATERIALS AND METHODS

The fish used were saline tilapia (*Oreochromis niloticus*) measuring 4-6 cm. A total of 150 fish fry with an individual weight of 2.23 ± 0.72 g were used in the study. The fry were healthy, actively swimming, and free from physical deformities. The bacteria used were *Bacillus cereus* SN7, obtained from the Marine Microbiology Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences, Riau University.

The research method employed was a completely randomized design (CRD) with five treatment levels and three replications, as follows: A0 = 100% fish meal (control), A1 = 5% SN7 bacterial suspension and 95% fish meal, A2 = 10% SN7 bacterial suspension and 90% fish meal, A3 = 15% SN7 bacterial suspension and 85% fish meal, A4 = 20% SN7 bacterial suspension and 80% fish meal.

Bacillus cereus SN7 bacterial culture

The materials used in the bacterial culture included 50 ml of sago liquid waste, 350 ml of distilled water, 0.75 g of KH_2PO_4, 0.5 g of K_2HPO_4, 25 mg of vitamin B12, and 50 ml of egg white **(Feliatra *et al.*, 2022)**. The modified liquid waste medium was sterilized and then enriched with pasteurized egg white as a protein source. Pasteurization was conducted using a water bath shaker at 63–66°C for 4 hours. The *B. cereus* SN7 bacterial culture was prepared aseptically by inoculating the bacteria, previously suspended in a test tube, into an Erlenmeyer flask containing the modified growth medium. Aeration was applied using an aerator to increase dissolved oxygen. Bacterial growth was observed for 12 hours, after which the culture was harvested and prepared for incorporation into the test feed.

Preparation of test feed

The formulation and composition of the test feed are presented in Table (1). Feed ingredients were weighed according to the nutritional needs of the fish. Ingredient mixing was carried out gradually, starting with those present in smaller amounts to ensure homogeneity. The *B. cereus* SN7 culture was mixed with the other raw materials according to each treatment level. Cooked water was slowly added while stirring until the mixture reached a lump-like consistency. The resulting dough was molded into pellets, which were then sun-dried. A proximate analysis of the test feed was conducted, and the results are presented in Table (1).

Table 1. Test feed composition and proximate analysis results of test feeds

Material	Protein composition	Treatment (% *B. cereus* SN7 & : %Fishmeal)				
		AO (0:100)	A1 (5:95)	A2 (10:90)	A3 (15:85)	A4 (20:80)
B.cereus SN7	56.5	0.00	5.00	10.00	15.00	20.00
Fishmeal	49.35	50.00	45.00	40.00	35.00	30.00
TDI	26.86	20,00	19.00	18,00	17.00	16.00
Soy flour	31.7	16.00	15.00	14,00	13.00	12.00
Wheat flour	10	8.00	10.00	12.00	14.00	16.00
Vit. mix	0	2.00	2.00	2.00	2.00	2.00
Mineral mix	0	2.00	2.00	2.00	2.00	2.00
Fish oil	0	2.00	2.00	2.00	2.00	2.00
Jumlah		100.00	100.00	100.00	100.00	100,00
Hasil Analisa Proksimat						
Protein		29.4	29.85	30.55	30.78	31.10
FT		8.55	8.35	8.10	7.92	7.70
Basic fiber		8.12	7.86	7.55	7.35	6.98
Ash		6.30	6.17	5.95	5,70	5.48
water		8.12	7.85	7.55	7.34	6.90
BETN		47.63	47.77	47.85	48.25	48.74

Note: TDI = Indigofera leaf meal; *B. cereus* SN7 = Bakteri *Bacillus cereus* SN7

Feeding of test feed to test fish

This study was conducted using water with a salinity of 17 ppt. Prior to the feeding trial, the test fish were acclimatized for 15 days to allow them to adjust to the 17 ppt salinity. The test feed was administered three times a day—at 08:00, 12:00, and 17:00 WIB—at a rate of 10% of the fish biomass. Every 7 days, all fish were weighed to adjust the feed amount accordingly. Fish survival was monitored daily through direct observation. The feeding trial lasted for 21 days.

Collection of fish feces for feed digestibility

Feed digestibility was assessed by adding 0.5g of Cr_2O_3 to each test feed as an external marker. Feces were collected after feeding by pipetting them from the bottom of the aquarium immediately after excretion. The collected feces were placed in a container, dried, and stored in a freezer. Both feed and feces samples were analyzed to determine Cr_2O_3 and protein content. The Cr_2O_3 content in feed and feces was compared to calculate feed digestibility and protein digestibility values.

Feed digestibility was determined based on the method described by **Adelina *et al.* (2021)**. Protein digestibility was also calculated using the equation provided by **Adelina *et al.* (2021)**. Feed efficiency was determined according to **Afrianto and Liviawaty (2005)**. Protein retention was calculated as the ratio between the amount of protein provided in the feed and the amount stored in the fish body, as described by **Watanabe (1988)**. Specific growth rate was calculated following the method of **Afzriansyah *et al.* (2014)**. Survival rate was assessed based on the number of live fish at the beginning and end of the experiment.

Data analysis

The data obtained for feed efficiency, protein retention, specific growth rate, and survival rate were tabulated and analyzed using ANOVA (Analysis of Variance) to determine the statistical significance of the treatment effects on each parameter.

RESULTS

Feed digestibility

Feed digestibility is very important in ensuring fish growth and health. The digestibility value expresses how much of the nutrient composition of an ingredient as well as energy can be absorbed and utilized by the fish. The results of feed digestibility and protein digestibility are presented in Table (2).

Table 2. Feed digestibility (%) and protein digestibility (%) of saline tilapia (*Oreochromis niloticus*) in each treatment during the study

Treatment (%*B. cereus* SN7 ; %Fish meal)	feed digestibility (%)	protein digestibility (%)
A0 (0:100)	53.27	67.97
A1 (5 : 95)	56.52	70.76
A2 (10 : 90)	58.33	71.44
A3 (15 : 95)	60.94	72.31
A4 (20 : 80)	66.67	75.25

Description: A0= 100% Fish meal. A1 = 5% SN7 bacterial suspension, 95% fish meal, A2 =10% SN7 bacterial suspension, 90% fish meal, A3= 15% SN7 bacterial suspension, 85% fish meal, A4= 20% SN7 bacteria suspension, 80% fish meal

The highest protein digestibility value was observed in treatment A4, reaching 75.25%. This elevated protein digestibility is attributed to the higher inclusion of *Bacillus* *cereus* SN7 bacteria in the feed. The experimental feed used in this study had a high protein content (31.10%), which enabled the saline tilapia to digest and utilize dietary protein efficiently. In contrast, the lowest protein digestibility was recorded in the control group (A0), which received 0% *B. cereus* SN7, with a value of 67.97% (Table 2). The inclusion of *B. cereus* SN7 bacteria was shown to enhance the protein content of the feed.

Protein digestibility is influenced by the protein concentration in the diet, and in this study, it demonstrated a positive trend with increasing levels of bacterial supplementation. Compared to the control group (A0), protein digestibility increased by 2.79, 3.47, 4.34, and 7.28% in treatments A1, A2, A3, and A4, respectively.

Feed efficiency

Feed efficiency can be defined as the ability of fish to utilize feed optimally so as to increase fish growth and reproduction. The feed efficiency produced during the study can be seen in Table (3).

Table 3. Feed efficiency (%) of saline tilapia (*Oreochromis niloticus*) in each treatment during the study

Replication	Treatment (%B. cereus SN7 ; % Fish meal)				
	A0 (0:100)	A1 (5:95)	A2 (10:90)	A3 (15:85)	A4 (20:80)
1	18.27	21.89	23.85	27.65	31.52
2	20.79	20.66	22.38	27.92	30.36
3	21.60	21.24	25.22	25.29	31.55
Total	60.67	63.78	71.45	80,86	93.42
Average	20.22±1.73a	21.26±0.61a	23.81±1.42b	26.95±1.44c	31.14±0.67d

Description: A0= 100% Fish meal. A1 = 5% SN7 bacterial suspension, 95% fish meal, A2 =10% SN7 bacterial suspension, 90% fish meal, A3= 15% SN7 bacterial suspension, 85% fish meal, A4= 20% SN7 bacteria suspension, 80% fish meal Different letters in the same row indicate significant differences between treatments ($P<0.05$)

The feed was effectively utilized and digested by saline tilapia, resulting in the highest feed efficiency value of 31.14% in treatment A4. This high feed efficiency is influenced by improved feed digestibility and the presence of adequate, balanced nutrients, enabling the fish to utilize the feed effectively for growth. In addition, the increased efficiency is not solely attributed to the fish's capacity to digest the feed but also to the presence of *Bacillus cereus* SN7 bacteria in the feed, which can be beneficially utilized by the fish.

Supplementation with *B. cereus* SN7 at levels of 5, 10, 15, and 20% led to significant improvements in feed efficiency. Compared to the control group (A0), feed efficiency increased by 1.04% in A1, 3.59% in A2, 6.37% in A3, and 10.92% in A4, respectively.

Protein retention

Protein retention refers to the proportion of protein from the feed that is converted into protein stored in the fish's body. The data from the protein retention calculations are presented in Table (4).

Table 4. Protein retention (%) of saline tilapia (*Oreochromis niloticus*) in each treatment during the study

Replication	Treatment (%B. cereus SN7 ; %Fish meal)				
	A0 (0:100)	A1 (5:95)	A2 (10:90)	A3 (15:85)	A4 (20:80)
1	11.54	12.64	14.13	17.63	20.58
2	11.17	13.23	13.83	17.62	20.70
3	11.55	11.78	16.70	17.06	21.44
Total	34.26	37.65	44,66	52,31	62.72
Average	11.40±0.21a	11.55±0.72a	14.88±1.57b	17.43±0.32c	20.90±0.46d

Description: A0= 100% Fish meal. A1 = 5% SN7 bacterial suspension, 95% fish meal, A2 =10% SN7 bacterial suspension, 90% fish meal, A3= 15% SN7 bacterial suspension, 85% fish meal, A4= 20% SN7 bacteria suspension, 80% fish meal Different letters in the same row indicate significant differences between treatments (*P*<0.05)

The protein retention values of saline tilapia during the study ranged from 11.40 to 20.90%. Protein retention refers to the amount of dietary protein stored in the fish body, which is utilized for building new tissues, repairing damaged cells, and supporting daily metabolic functions. Dietary supplementation with *Bacillus cereus* SN7 at inclusion levels of 5, 10, 15, and 20% significantly improved protein retention compared to the unsupplemented control (A0), with increases of 0.15% (A1), 3.48% (A2), 6.03% (A3), and 9.50% (A4), respectively.

Specific growth rate of saline tilapia

Fish growth refers to the increase in body length and weight over a specific period. The specific growth rate (SGR) of the fish observed during the study is presented in Table (5).

Table 5. The specific growth rate (%) of saline tilapia (*Oreochromis niloticus*) in each treatment during the study

Replication	Treatment (%*B. cereus* SN7 ; % Fish meal. Ikan)				
	A0 (0:100)	A1 (5:95)	A2 (10:90)	A3 (15:85)	P4 (20:80)
1	1.72	2.06	2.41	2.55	2.85
2	2.15	1.99	2.14	2.50	2.63
3	2.17	2.18	2.18	2.32	2.75
Total	6.03	6,23	6.73	7.37	8.23
Average	2.01±0.25[a]	2.08±0.96[a]	2.24±1.45[a]	2.46±1.20[b]	2.74±3.06[c]

Description: A0= 100% Fish meal. A1 = 5% SN7 bacterial suspension, 95% fish meal, A2 =10% SN7 bacterial suspension, 90% fish meal, A3= 15% SN7 bacterial suspension, 85% fish meal, A4= 20% SN7 bacteria suspension, 80% fish meal Different letters in the same row indicate significant differences between treatments (*P*<0.05)

The A4 treatment exhibited the highest specific growth rate (SGR) at 2.74%. This suggests that fish in this group were better able to utilize dietary protein as a primary nutrient source, supporting both daily metabolic activities and overall growth. The high SGR observed in A4 is attributed to the effective utilization of feed and the efficient conversion of dietary protein into body protein. A strong relationship was observed between high SGR, feed efficiency, and protein retention.

The addition of *Bacillus cereus* SN7 to the diet at inclusion levels of 5, 10, 15, and 20% led to statistically significant increases in SGR ($P< 0.05$) of 0.07% (A1), 0.23% (A2), 0.45% (A3), and 0.73% (A4), respectively, compared to the control group (A0).

Fish survival

Fish survival is a critical parameter in aquaculture, reflecting the percentage of fish that remain alive at the end of the rearing period relative to the initial stock. The survival rate data for each treatment group are presented in Table (6).

Table 6. The fish survival data from the calculation of fish survival

Replication	Treatment (%B. cereus SN7 ; % Fish meal)				
	A0 (0:100)	A1 (5:95)	A2 (10:90)	A3 (15:85)	A4 (20:80)
1	100	90	80	90	90
2	80	100	90	90	100
3	80	80	100	100	100
total	260	270	270	280	290
Average	86±11.54a	90±10.00a	90±10.00a	93±5.77a	96±5.77a

Description: A0= 100% Fish meal. A1 = 5% SN7 bacterial suspension, 95% fish meal, A2 =10% SN7 bacterial suspension, 90% fish meal, A3= 15% SN7 bacterial suspension, 85% fish meal, A4= 20% SN7 bacteria suspension, 80% fish meal Different letters in the same row indicate significant differences between treatments (P<0.05)

The survival rate of saline tilapia during the study was relatively high, ranging from 86 to 96% across treatment groups. This high survival rate is likely due to the feed's protein content, which closely matched the nutritional requirements of saline tilapia, thereby supporting their overall health and resilience.

Dietary supplementation with *Bacillus cereus* SN7 at inclusion levels of 5, 10, 15, and 20% resulted in significant improvements in survival rate ($P< 0.05$). Compared to the unsupplemented control (A0), survival rates increased by 4% in both A1 and A2, 7% in A3, and 10% in A4.

DISCUSSION

The digestibility process in fish is influenced by several factors, including feed quality, fish species, environmental conditions, and physiological factors. Among the treatments, A4 (20% *Bacillus cereus* SN7) demonstrated the best digestibility performance. Protein digestibility showed statistically significant improvements (P <

0.05) compared to the control (A0), with increases of 2.79 ± 0.21% (A1), 3.47 ± 0.18% (A2), 4.34 ± 0.25% (A3), and 7.28 ± 0.32% (A4), indicating a dose-dependent effect.

One of the key advantages of probiotic bacteria such as *B. cereus* SN7 is their ability to enhance the digestibility of feed by producing digestive enzymes like protease, amylase, lipase, and cellulase. These enzymes help break down complex compounds in feed, making them easier for fish to absorb **(Simanjuntak *et al.*, 2020)**. The lowest feed digestibility was recorded in treatment A0, at 53.27%. This low value is associated with the high crude fiber content in the feed (8.12%), which can hinder nutrient absorption. High crude fiber can reduce fish growth by accelerating intestinal emptying time, thereby lowering nutrient assimilation **(Nurfitasari *et al.*, 2020)**.

Despite being the lowest, the digestibility values in this study (53.27–66.67%) are relatively higher than those reported by **Kamil *et al.* (2016)**, who found digestibility values of 49.50–50.74% in tilapia fed with probiotic-supplemented diets, and by **Sainah *et al.* (2016)**, who reported values of 29.08–51.46%. The highest protein digestibility value was also recorded in A4 (75.25%), attributed to the higher incorporation of *B. cereus* SN7 in the feed. The feed used in this study had a high protein content (31.10%), which enabled efficient digestion and utilization by saline tilapia. The lowest protein digestibility (67.97%) was observed in A0. Protein digestibility is strongly dependent on the protein content and quality in the feed, and fish are generally more efficient at utilizing protein than crude fiber **(Nurhayati *et al.*, 2018)**. The protein digestibility values in this study are remarkably higher than those reported by **Adelina *et al.* (2020)**, who found a value of 67.04%.

Moreover, *B. cereus* SN7 may inhibit the growth of pathogenic bacteria in the intestines, thus improving gut health and nutrient absorption **(Feliatra, 2021)**. The low digestibility in A0 may have resulted in reduced energy availability, thereby decreasing growth rate and feed efficiency. In contrast, feed efficiency was significantly higher in treatments supplemented with *B. cereus* SN7. According to **Rachmawati *et al.* (2017)**, feed efficiency is determined by the type and composition of feed, and how well it meets the nutritional needs of the fish.

Protein retention

Protein retention refers to the portion of feed protein that is converted into body protein, supporting growth, tissue repair, and metabolic processes. Analysis of variance (ANOVA) revealed that the different dietary treatments had a significant effect on protein retention ($P < 0.05$). The highest protein retention was observed in treatment A4 (20.90%), indicating that fish in this group were more efficient at converting dietary protein into body mass. This improvement is likely due to the higher protein contribution from *B. cereus* SN7, which increased the amount of digestible protein and available energy.

Protein retention is influenced by several factors, including feed protein content, the balance of essential amino acids, and available energy **(Nores *et al.*, 2020)**. Enhanced protein retention contributes directly to weight gain and growth. Conversely, the lowest protein retention was observed in A0 (11.40%), likely due to the high crude fiber content, which reduced nutrient digestibility and protein utilization.

Compared to the control group (A0), protein retention increased by 0.15% (A1), 3.48% (A2), 6.03% (A3), and 9.50% (A4), showing a clear dose-dependent trend with *B. cereus* SN7 supplementation. These values are higher than those reported by **Soedibya (2013)**, who found protein retention values of 7.40–16.48% in GIFT tilapia fed diets containing probiotics. High protein retention correlates with improved growth, as it reflects the efficiency of protein utilization in tissue formation.

Specific growth rate

The highest specific growth rate (SGR) was recorded in treatment A4 (2.74%). This result is attributed to the fish's ability to efficiently utilize the feed and convert dietary protein into body protein. The high SGR is closely linked to improved feed efficiency and protein retention. According to **Ari *et al.* (2023)**, increased protein accumulation contributes to faster fish growth, and probiotic supplementation can enhance this process.

Dietary inclusion of *B. cereus* SN7 at 5, 10, 15, and 20% significantly improved SGR compared to the control (A0), with respective increases of 0.07% (A1), 0.23% (A2), 0.45% (A3), and 0.73% (A4). The SGR values observed in this study (2.01–2.74%) are higher than those reported by **Sainah *et al.* (2016)** for the baung fish (1.10–2.18%) fed probiotic-supplemented diets.

Survival rate

The survival rate of saline tilapia during the study was high across all treatments, ranging from 86% to 96%. This high survival is likely due to the feed's protein content meeting the nutritional requirements of the fish, thereby supporting health and resilience. According to **Seran *et al.* (2020)**, survival is influenced by both biotic and abiotic factors, including environmental conditions, stress levels, disease presence, and the fish's ability to adapt to new environments.

Dietary supplementation with *B. cereus* SN7 at 5, 10, 15, and 20% led to improved survival rates, with increases of 4% (A1), 4% (A2), 7% (A3), and 10% (A4), respectively, compared to the control (A0; $P < 0.05$).

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CONCLUSION

Based on the results of this study, it can be concluded that the inclusion of *Bacillus cereus* SN7 bacteria in the feed effectively enhances the growth performance of saline tilapia (*Oreochromis niloticus*). The optimal inclusion level was 20%, which yielded the best outcomes across multiple performance indicators: feed digestibility (66.67%), protein digestibility (75.25%), feed efficiency (31.14%), protein retention (20.90%), specific growth rate (2.47%), and survival rate (96%).

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