Feed Digestibility and Growth Performance of Saline Tilapia *(Oreochromis niloticus)* with the Use of Single Cell Protein of *Bacillus cereus* Consortium Bacteria *)* as a Substitute for Fishmeal

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Abstract

Feed digestibility values indicate the composition of nutrients that can be absorbed and used for growth. One that can be used to improve feed digestibility is the use of single cell proteins. One of them is Bacillus cereus. **This study aims** to determine the effect of utilization of *Bacillus cereus* bacterial consortium in feed on feed digestibility, protein, feed efficiency, growth of saline tilapia *(Oreochromis niloticus)*. **The research method** was a completely randomized design (CRD) with 5 treatments and 3 replicates. The test feed used were T0 (feed without Bccb), T1 (feed with 5% Bccb), T2 (feed with 10% Bccb), T3 (feed with 15% Bccb), T4 (feed with 20% Bccb). The size of saline tilapia was 4-6 cm and the average weight was 2.00 ± 0.30g. Fish were kept in an aquarium with a capacity of 80L and a stocking density of 10 $^{fish/m3}$. Feeding test 10% of the weight of the fish, the frequency of feeding 3 times a day, namely 08.00, 12.00 and 17.00 WIB. **Result**.The best result was the use of 15% *B. cereus* bacterial consortium which resulted in feed digestibility of 77.27%, protein digestibility of 84.69%, feed efficiency of 31.77±1.51, protein retention of 20.39±0.69, specific growth rate of 2.69±0.02, and fish survival of 96.67±5.77. The water quality of the rearing medium was 27.9-28.9°C, pH 6-7.5, DO 4-5 mg/l, and salinity 17 ppt.

Key words: *Bacillus cereus* bacterial consortium; Saline Tilapia; Feed; protein, digestibility.

Introduction

The saltwater tilapia (Oreochromis niloticus) is one of the most widely cultivated fish species in the world. Its rapid growth and ability to adapt to various environmental conditions make it a prime choice in the aquaculture industry. The saltwater tilapia commodity (O. niloticus) is a species of tilapia that is tolerant to brackish and marine waters with salinities reaching 15-20 ppt, enabling it to be cultivated in both freshwater and brackish environments (Dewi et al., 2018). One of the primary challenges in tilapia farming is the need for high-quality feed, particularly in terms of protein content. Fishmeal, while an excellent source of protein, often suffers from price fluctuations and supply limitations, necessitating the search for more sustainable alternatives (Ghosh et al., 2021; Le et al., 2022).

The increasing demand for tilapia commodities correlates with the intensification of aquaculture, impacting the need for fish feed as a limiting growth factor. Feed requirements for aquaculture fish constitute approximately 60-70% of total production costs, making the development of sustainable feed from local raw materials essential and a challenge for farmers (Sarker et al., 2018). According to Feliatra et al. (2022), in order to reduce feed supply costs, it is crucial to identify alternative local sources of protein that are of good quality and more affordable. This way, efficiency in reducing production costs, particularly for feed, can be achieved.

One promising alternative is the use of single-cell protein (SCP) derived from microorganisms, including bacteria. Bacillus cereus has been identified as a potential protein source that can provide additional benefits, such as improved feed digestibility and enhanced fish health (Moghadam et al., 2020; Barboza et al., 2023). The use of bacterial consortia, including B. cereus, can enhance feed utilization efficiency and improve growth performance by leveraging more affordable and sustainable resources (Akhmedova et al., 2021). The Bacillus cereus utilized in this study is a potential isolate from heterotrophic bacteria. This bacterium possesses the ability to inhibit the growth of pathogenic bacteria such as Vibrio sp. and Aeromonas sp. The single-cell protein derived from Bacillus cereus can serve as a high-protein feed for fish (Feliatra et al., 2018). The protein produced by this bacterium, also known as single-cell protein (SCP), contains a high protein content of 50%-65% and is easily digestible, making it a viable alternative protein source for fish feed to replace relatively expensive raw materials such as fishmeal (Purwaningtyas, 2019).

Digestibility of feed is a key factor influencing the growth performance of fish. Recent studies have shown that the addition of single-cell protein (SCP) to feed can enhance nutrient digestibility and improve the hematological profile of fish, which is crucial for optimal growth (Ali et al., 2022). However, there remains a gap in understanding the specific effects of Bacillus cereus as a fishmeal substitute on the growth performance of saltwater tilapia. Therefore, this study aims to evaluate the digestibility of feed and growth performance of saltwater tilapia fed diets supplemented with single-cell protein from a Bacillus cereus consortium. The results of this research are expected to provide new insights into the development of more sustainable alternative feeds for aquaculture.

Methodology

This study was conducted from July to October 2024. All stages of the research, from feed preparation to the maintenance of test fish, were carried out at the Fish Nutrition Laboratory, Department of Aquatic Cultivation, while the bacterial isolates were prepared at the Marine Microbiology Laboratory, Department of Marine Science, Universitas Riau.

Test Fish and Bacteria

The test subjects consisted of 150 healthy, active saltwater tilapia (Oreochromis niloticus) juveniles measuring 4-6 cm in length and averaging 2.23±0.72 g in weight. The bacterial consortium used comprised five strains of Bacillus cereus: B. cereus SN7, B. cereus SP4, B. cereus S5, B. cereus Xmb051, and B. cereus BF2, all of which are maintained in the Marine Microbiology Laboratory, Faculty of Fisheries and Marine Science, Universitas Riau.

The bacterial growth medium consisted of 50 ml of sago wastewater, 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., 2021). The modified sterilized sago wastewater medium was supplemented with pasteurized egg white, incubated in a water bath shaker at 63-66 °C for 4 hours. The Bacillus cereus consortium was then inoculated, and bacterial growth was monitored for 12 hours. Subsequently, the bacteria were harvested and prepared for use as fish feed.

Preparation of Test Feed

The formulation and composition of the test feed are presented in Table 1. The ingredients were weighed according to the fish's requirements. Mixing was conducted gradually, starting with the smallest quantities to ensure homogeneity among all components. The consortium of B. cereus was incorporated during the mixing process with other raw materials in proportions according to the treatments. Water, previously boiled, was added slowly while stirring until the mixture could be formed into lumps. The raw materials were then molded into pellets, which were dried under sunlight. The test feed was analyzed for proximate composition, with the results presented in Table 1

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

Material	Protein material	Treatment (% *Bccb* & : % Fish meal)				
		TO (0:100)	T1 (5:95)	T2 (10:90)	T3 (15:85)	T4 (20:80)

BccB	56,5	0,00	5,00	10,00	15,00	20,00
Fish meal	49,35	50,00	45,00	40,00	35,00	30,00
ILM	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
Mix vitamins.	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
Total		100,00	100,00	100,00	100,00	100,00
Proximate Analysis Results						
Protein		29,4	29,85	30,55	30,78	31,10
Fat		8,55	8,35	8,10	7,92	7,70
Crude 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

ILM = Indigofera leaf meal
BCCB = Bacteria concortium *Bacillus cereus*
T0= 100% Fish meal. T1 = 5% BCCB suspension of 95% fish meal, T2 =10% BCCB suspension of 90% fish meal, T3= 15% BCCBsuspension, 85% fish meal, T4=20% BCCB suspension, 80% fish meal.

Feeding of Test Fish

This study was conducted in water with a salinity of 17 ppt. Following acclimatization, the test fish were adapted for 15 days to adjust to the salinity of 17 ppt. The test feed was administered three times daily at 08:00, 12:00, and 17:00 WIB, amounting to 10% of the total fish biomass. Every 14 days, sampling was performed to weigh all fish in order to adjust the amount of feed provided. Fish survival was monitored daily through direct observation. The test feeding was conducted for a duration of 56 days.

Collection of Fish Feces for Digestibility Measurement

Measurement of feed digestibility was carried out by adding Cr_2O_3 to each test feed as much as 0.5 g. Collection of feces after the fish are fed by pipetting the feces at the bottom of the aquarium immediately after the fish release feces. Then the feces were put into a container, dried and put in the freezer. The collected feces were analyzed for Cr_2O_3 and protein content. Cr_2O_3 content in feed and feces was compared to obtain feed digestibility and feed protein digestibility values. Feed Digestibility According to Adelina et al (2021), protein digestibility protein is calculated by the equation proposed. Protein retention is a comparison between the amount of protein given through feed and the protein stored in all parts of the body. (Watanabe1988). Specific growth and survival rate number of fish at the beginning and end of the study that are alive can provide information about fish survival (Afzriansyah et al, 2014).

Water Quality Measurement

The parameters of water quality measured during the study included salinity, temperature, pH, and dissolved oxygen (DO). These measurements were taken at the beginning, middle, and end of the study.

Data Analysis

The data obtained, including feed efficiency, protein retention, specific growth rate, and fish survival rate, were tabulated. The data were then analyzed statistically using ANOVA (Analysis of Variance) to determine the effects of the treatments on the measured parameters.

Result and discussion

Feed Digestibility and Protein Digestibility

The results of the analysis of feed digestibility and protein digestibility in each treatment and replication are presented in Table 2.

Table 2. Feed digestibility (%) and feed protein digestibility (%) in each treatment

Treatment (% BCCB : % Fish meal)	Cr_2O_3 feed (%)	Cr_2O_3 feces (%)	Protein feed (%)	Protein feces (%)	Feed diges tibility (%)	Protein digestibility (%)
T0 (0 : 100)	0,5	1,96	30,46	19,32	74,49	83,82
T1 (5 : 95)	0,5	2,03	30,65	19,70	75,37	84,17
T2 (10 : 90)	0,5	2,10	30,89	20,40	76,19	84,24
T3 (15 : 85)	0,5	2,20	31,08	20,57	77,27	84,96
T4 (20 ; 80)	0,5	2,14	31,25	20,43	76,64	84,73

BCCB = Bacillus cereus Consortium bacteria
T0= 100% Fish meal. T1 = 5% BCCB suspension of 95% fish meal, T2 =10% BCCB suspension

of 90% fish meal, T3= 15% BCCBsuspension, 85% fish meal, T4=20% BCCB suspension, 80% fish meal.

The Effect of Single-Cell Protein on Digestibility and Feed Efficiency in Saltwater Tilapia (Oreochromis niloticus)

The results of the study indicated that the feed digestibility values for tilapia ranged from 74.49% to 77.27%, while the protein digestibility values ranged from 83.82% to 84.96%. The highest feed digestibility and protein digestibility were observed in the treatment T3 (pelleted feed containing 15% Bacillus cereus consortium), at 77.27% and 84.96%, respectively. This increase in digestibility may be attributed to the improved availability of single-cell protein in the feed, which aids in the digestion process and nutrient utilization by the fish.

According to Hanipa et al. (2017), fish are more efficient in digesting protein compared to fat or carbohydrates. Furthermore, single-cell protein is characterized by high protein content and essential amino acids, as well as important B-complex vitamins for fish (Rais, 2017). Sjofjan et al. (2020) added that the balanced nutritional composition of single-cell protein makes it easily digestible, effectively meeting the nutritional needs of fish. Research by Sarker et al. (2023) indicates that the use of bacteria as probiotics in feed can enhance digestive efficiency and nutrient absorption in fish.

Although an increased proportion of bacteria in the feed tends to elevate protein levels, observations from treatment T4 showed lower feed and protein digestibility compared to T3. This can be explained by competition between the bacteria and fish for nutrients, which intensifies with the increased bacterial quantity (Apriyan, 2021). This finding is consistent with Mukromin's (2022) research, which noted that excessive proportions of probiotics in feed can lead to decreased digestive efficiency.

The highest feed digestibility and protein digestibility achieved in this study, at 77.27% and 84.96%, respectively, are considered favorable compared to previous studies. Mukromin (2022) reported a feed digestibility of 59.30% and protein digestibility of 84.10% in catfish (*Hemibagrus nemurus*) fed probiotic diets. These results are also superior to those found by Sitanggang (2021), who recorded feed digestibility of 75.50% and protein digestibility of 84.30% in nilem fish (*Osteochilus hasselti*).

In accordance with findings by Andriani (2019), higher feed digestibility correlates with increased protein utilization by fish for growth. The ability of fish to digest feed is significantly influenced by the type and amount of crude fiber present in the feed. Moreover, Feliatra et al. (2022) demonstrated that high-quality feed, including a balanced protein proportion, is crucial for achieving optimal growth in fish.

Feed Efficiency in Saltwater Tilapia (Oreochromis niloticus)

Feed efficiency for juvenile saltwater tilapia is detailed in Table 3.

Tabel 3. Efisiensi Pakan (%) pada setiap perlakuan selama penelitian

Replication	Treatment (% bccb : % fish meal)				
	T0 (0:100)	T1(5:95)	T2(10:90)	T3(15:85)	T4(20:80)
1	20,69	23,58	23,96	31,27	25,60
2	20,07	22,73	26,53	31,76	23,89
3	18,72	22,36	25,07	32,30	27,11
Total	59,48	68,66	75,56	95,32	76,59
Average	19,83±1,00^{a*}	22,89±0,62^{b}	25,19±1,28^{c}	31,77±1,51^{d}	25,53±1,61^{c}

bccb = *Bacillus cereus* Consortium bacteria
T0= 100% Fish meal. T1 = 5% BCCB suspension of 95% fish meal, T2 =10% BCCB suspension of 90% fish meal, T3= 15% BCCBsuspension, 85% fish meal, T4=20% BCCB suspension, 80% fish meal.
*Different letters on the same line indicate there is significant difference between treatments (P<0.05)

Table 3 shows that the feed efficiency obtained in this study ranged from 19.83% to 31.77%. Treatment T3 exhibited the highest feed efficiency at 31.77%, which was significantly different from the other treatments ($P < 0.05$). This increase in feed efficiency can be attributed to the feed's ability to be digested and utilized optimally by the fish. The high feed digestibility in treatment T3 supports more efficient nutrient utilization, resulting in a significant increase in fish body weight.

An important factor influencing feed utilization efficiency is the type and composition of the feed that aligns with the nutritional requirements of the fish, including energy, protein, carbohydrates, fats, vitamins, and minerals (Raudah, 2017). The feed containing single-cell protein, such as Bacillus cereus in this study, was found to have a high protein content, thus meeting conventional protein needs with better digestibility compared to other materials. This finding is consistent with Sarker et al. (2023), who stated that single-cell protein contains B-complex vitamins and essential amino acids beneficial for fish growth.

The enhancement of feed utilization efficiency is also influenced by the quality of the artificial feed provided. Water quality, fish age, and the feed ingredients used are factors contributing to feed efficiency (Zulkhasyni et al., 2023). In this study, the feed efficiency obtained (31.77%) was higher than that reported by Rachmawati et al. (2022), which recorded feed efficiency of 25.09% in tilapia (Oreochromis niloticus) fed probiotic diets. Additionally, research by Akmal et al. (2021) demonstrated a feed efficiency of 22.21% in freshwater pomfret fed probiotic diets.

Thus, the use of single-cell protein from Bacillus cereus as a substitute for fish meal in the diet of saltwater tilapia not only enhances feed efficiency but also contributes to improved fish growth, taking into account a balanced and high-quality nutritional composition.

Protein Retention in Saltwater Tilapia (Oreochromis niloticus)

The data regarding the calculation of protein retention in saltwater tilapia raised over 56 days can be seen in **Table 4**.

Table 4. Protein Retention (%) in each treatment during the study

Replication	Treaitment (%Bccb : % fish meal)				
	T0(0:100)	T1(5:95)	T2(10:90)	T3(15:85)	T4(20:80)
1	10,70	12,35	15,50	20,43	15,94
2	10,71	13,82	15,77	19,68	15,86
3	11,21	13,63	16,17	21,06	15,73
Total	32,62	39,80	47,44	61,16	47,53
Average	10,87±0,29[a] *	13,27±0,79[b]	15,81±0,37[c]	20,39±0,69[d]	15,84±0,10[c]

* Different letters on the same line indicate there is significant difference between treatments ($P<0.05$)

Table 4 shows that protein retention across all treatments ranged from 10.87% to 20.39%. Treatment T3 (containing 15% single-cell protein from Bacillus cereus) exhibited the highest protein retention at 20.39%. This increase can be attributed to the presence of single-cell protein in the feed, which is more readily utilized by the fish. This finding aligns with the higher protein digestibility and feed efficiency observed in this treatment compared to the others. The increased protein retention in the fish indicates that the fish are capable of optimizing feed protein for metabolic and growth needs.

Sukran (2018) noted that protein retention values are influenced by the fish's ability to effectively utilize protein from the feed. In treatment T0 (0% B. cereus), the lowest protein retention was recorded at 10.87%. This decrease is likely due to the absence of B. cereus in the feed, which contributes to difficulties in digestion and nutrient utilization.

The results of this study indicate that a protein retention of 20.39% is higher than the findings of Dewi et al. (2022), who reported a protein retention of 18.55% in catfish fed diets supplemented with commercial probiotics. Additionally, research by Akmal et al. (2021) documented a protein retention of 14.62% in freshwater pomfret given probiotic diets. This suggests that tilapia have a superior ability to utilize feed protein when supplemented with 15% probiotics from the B. cereus consortium, thereby enhancing body protein storage.

Recent studies have shown that the use of probiotics can improve growth performance and feed efficiency across various fish species (Wang et al., 2023; Abid et al., 2022). Therefore, the addition of single-cell protein from B. cereus not only enhances protein retention but also has the potential to improve the growth performance of saltwater tilapia.

Specific Growth Rate of Saltwater Tilapia (*Oreochromis niloticus*)

The specific growth rates of the saltwater tilapia fry obtained over the 56-day period can be observed in **Table 5**. This growth reflects the benefits of incorporating single-cell protein from B. cereus in the feed, which contributes to enhanced growth performance in the fish.

This study demonstrates that the utilization of B. cereus as a protein source in saltwater tilapia feed not only enhances growth but also positively affects feed performance. The significant growth increase observed in treatment T3 can be attributed to better nutrient availability and the optimization of the digestive process, supported by findings from Wang et al. (2020) and Abid et al. (2022) regarding the effectiveness of probiotics in improving fish growth.

Table 5. Specific growth rate for each treatment during the study

Replication	Treatment (% Bccb : % fish meal)				
	T0(0:100)	T1(5:95)	T2(10:90)	T3(15:85)	T4(20:80)
1	2,17	2,30	2,10	2,64	2,43
2	1,95	2,13	2,40	2,74	2,18
3	1,81	2,05	2,38	2,70	2,39
Total	5,93	6,49	6,89	8,08	7,00
Average	1,98±0,18^{a*}	2,16±0,07^{ab}	2,30±0,09^{b}	2,69±0,02^{c}	2,33±0,07^{b}

* Different letters on the same line indicate there is significant difference between treatments ($P<0.05$)

Table 5 demonstrates that the specific growth rate of saltwater tilapia ranged from 1.98% to 2.69%. The highest specific growth rate was observed in treatment T3, where fish were fed with 15% consortium bacteria of Bacillus cereus. The addition of probiotic bacteria in the feed contributed to improved feed efficiency and protein retention, resulting in the best specific growth rate compared to other treatments. This indicates the active role of bacteria in the fish's digestive tract, facilitating better utilization of the feed.

The low specific growth rate in treatment T0 (0% B. cereus) is likely due to the absence of probiotic bacteria, leading to suboptimal utilization of nutrients in the feed for growth. Research by Zainuddin et al. (2021) supports this finding by showing that the inclusion of probiotic bacteria in the feed can accelerate fish growth compared to feeds without probiotics. Meanwhile, the specific growth rate in treatment T4 was lower than in T3, likely due to an excessive amount of probiotic bacteria, resulting in competition between fish and bacteria for nutrient utilization. According to Mulyadi (2011), an excess of decomposing bacteria can disrupt the digestion and absorption processes, thereby reducing fish growth efficiency.

The highest specific growth rate recorded in this study, at 2.69%, is superior to the findings of Fajri et al. (2015), who reported a specific growth rate of 2.05% in catfish (Hemibagrus nemurus) fed with probiotics. Similarly, Sari et al. (2018) noted a specific growth rate of 0.97% in gourami (Osphronemus gouramy) when given probiotic feed. Recent studies indicate that the use of probiotics in fish feed significantly enhances growth and health (Hossain et al., 2021; Bahauddin et al., 2022).

The survival rates of saltwater tilapia across all treatments during the study can be observed in **Table 6**.

Table 6. Survival rates in each treatment during the study

Replication	Treatment (% Bccb :% Fish meal)				
	T0(0:100)	T1(5:95)	T2(10:90)	T3(15:85)	T4(20:80)
1	80	80	100	100	90
2	90	100	90	90	100
3	100	100	90	100	90
Total	270	280	280	290	280
Average	90±10,00^{a*}	93,33±11,54^{a}	93,33±5,77^{a}	96,67±5,77^{a}	93,33±5,77^{a}

* Different letters on the same line indicate there is significant difference between treatments ($P<0.05$)

Table 6 indicates that the survival rate of saltwater tilapia fry over the 56-day maintenance period ranged from 90% to 96.67%. The high survival rates across all treatments suggest that feed supplemented with the Bacillus cereus consortium bacteria is well utilized by saltwater tilapia to sustain their life. This finding aligns with Andriyan (2018), who noted that a good survival rate for fish typically falls between 73.5% and 86.0%.

Environmental factors, such as water quality and fish handling, significantly impact survival rates. According to Mustofa et al. (2018), improper handling can lead to stress in fish, which in turn diminishes their health and increases mortality risk. Recent research by Chatzifotis et al. (2021) demonstrated that the inclusion of probiotics in feed, such as B. cereus, can enhance fish resilience to environmental stressors, thereby contributing to improved survival rates.

Furthermore, research by El-Matbouli et al. (2022) asserts that the use of probiotics in fish farming not only enhances survival rates but also overall health by modulating gut microbiota and strengthening the immune system of the fish. These findings support the hypothesis that the inclusion of B. cereus consortium bacteria in the feed for saltwater tilapia is beneficial not only for survival but also potentially enhances fish resilience to suboptimal environmental conditions.

Water Quality

The parameters measured for water quality during the tilapia maintenance included temperature, pH, dissolved oxygen (DO), and salinity, assessed at the beginning, midpoint, and conclusion of the study. The water quality values are presented in **Table 7**.

Table 7. Results of water quality measurements during the fish maintenance study.

Parameters	Range			Quality standar INS 2009
	Beginning	Middle	End	
Temperatur (°C)	28-29	27,9-28,9	28-28,9	27-29
pH	6-7	6-7,5	7-7,3	6-8,5
Dissolved oxygen (mg/l)	4,09-5,67	4,33-5,02	4,12-5,53	2,4-6
Salinity (ppt)	17	17	17	17-20

INS=Indonesian national standards

Table 7 illustrates that the water quality conditions during the 56-day maintenance period for saltwater tilapia were generally favorable for supporting the life and growth of the fish. Throughout the study, water temperature remained relatively stable, ranging between 28-29°C. Temperature plays a crucial role in the metabolic processes of fish. An increase in water temperature can enhance metabolic rates due to increased feed consumption, thereby promoting fish growth. Conversely, lower temperatures can slow digestion and metabolic processes, leading to stunted growth in fish (Khan et al., 2021).

The pH levels during the study ranged from 6 to 7.5, which falls within the acceptable range for fish productivity of 6 to 8.5. Higher concentrations of carbon dioxide result in lower pH levels. According to Supriatna et al. (2020), the decomposition of organic materials by microorganisms releases CO2, which can decrease both oxygen concentration and pH levels in the water. **Table 7** also indicates that the dissolved oxygen (DO) measurements ranged from 4.09 to 5.67 mg/l. According to Siregar et al. (2017), DO levels between 3.05 and 5.03 mg/l are still tolerable for tilapia.

The survival of tilapia is also influenced by their osmoregulatory capacity. While tilapia are typically freshwater fish, they are euryhaline and can adapt to higher salinity levels. The suitable salinity range for tilapia is between 0-35 ppt, with an optimal range for growth being 0-30 ppt. Although tilapia can survive in salinities of 31-35 ppt, their growth tends to be slower under these conditions (Putro et al., 2018; Zainuddin et al., 2021).

Conclusion

This research shows that the utilization of *B. cereus* consortium bacteria in saltwater tilapia feed significantly enhances the specific growth rate, as evidenced by increased feed efficiency and protein retention. These findings open opportunities for broader application of probiotics in aquaculture to enhance fish productivity and health.

The results of this study indicate that the addition of probiotic bacteria in saltwater tilapia feed not only improves survival rates but may also serve as an effective strategy for enhancing fish health and growth. The use of probiotics presents a promising alternative in aquaculture, particularly in increasing fish resistance to stress and improving gut microbiota balance, ultimately contributing to the overall success of fish farming.

Feed using 15% B. cereus consortium bacteria can be utilized well by saline tilapia which results in feed digestibility of 77.27%, protein digestibility of 84.96%, feed efficiency of 31.77%, protein retention of 20.39%, specific growth rate of 2 .69%, and survival 96.67%.

Authors' Contributions

Each author's contribution is as follows, Feli Feliatra; conceptualize, investigate, and methodological analysis. Ummi Mardhiah Batubara: investigate, curate and analysis data. Nursyirwani; analysis and reviewed the manuscript. Adelina; investigate and laboratory analysis. Tanti Gusmadelpa: manuscript template check and methodology analysis. All authors discussed and contributed to the final manuscript.

Conflict of Interest

The authors declare that they have no conflict of interests.

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