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Growth Performance of Tilapia and Catfish Fry Cultivated with Bio-Enzyme Supplementation and Its Agribusiness Perspective

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ABSTRACT

Tilapia and catfish are freshwater fish commodities that are widely cultivated by the community because of their relatively easy maintenance, low cost, and short time. The quality of the cultivation water environment is an important factor and influences the growth performance and life of these commodities. This study aimed to analyze the growth performance of tilapia and catfish fry cultivated with the addition or supplementation of bio-enzymes with different concentrations in the maintenance water. This study used an experimental method with three treatments: control **(**without bio-enzymes**)**, 500 ml/900 L or 0.6 ml/L bio-enzymes, and 1000 ml/900 L or 1.1 ml/L bio-enzymes. The results illustrate that bio-enzyme supplementation into tilapia fry ponds compared to the control treatment without bio-enzymes showed a higher contribution to weight growth than length growth. The opposite occurred for catfish fry, namely bio-enzyme supplementation into catfish fry ponds compared to the control without bio-enzymes showed a higher contribution to length growth than weight growth. Supplementation with 500 ml of bio-enzyme resulted in the highest absolute weight growth of tilapia fry, which was 16.95 g with a daily weight growth rate of 0.42 g/day and a specific weight growth rate of 3.35% and 100% survival rate. Supplementation with 500 ml of bio-enzyme resulted in the highest absolute length growth of catfish fry, which was 9.20 cm with a daily length growth rate of 0.23 cm/day and a specific length growth rate of 2.23% and 100% survival rate. In agribusiness perspective, only tilapia in consumption size **(**at 135 days old**)** treated with bio-enzymes **(**500 ml and 1000 ml**)** were recommended for sale, particularly in consumption size. Meanwhile, for catfish, only in fingerlings phase were decommended for selling with treatment bio-enzyme 500 ml.

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INTRODUCTION

Fish farming, known as aquaculture, is one of the leading fish food sources with the fastest growth in productivity worldwide **(Sumaila *et al.*, 2022; Serra *et al.*, 2024)**. Aquaculture stands as a vital provider of animal protein essential for human nutrition, with fish exhibiting rapid growth and offering optimal calorie-protein ratios for human consumption **(Melenchón, *et al.*, 2022)**. Freshwater fish farming has been widely developed by communities, both on a household and large scale **(Mzula *et al.*, 2021; Angermayr *et al.*, 2023)**. Among the freshwater fish commonly cultivated by the community are tilapia and catfish **(Febrianty , 2021; Nalle *et al.*, 2021)**.

The development of fish farming productivity is greatly influenced by water quality, which significantly supports fish growth performance **(Ajayi & Okoh, 2014; Tumwesigye *et al.*, 2022)**. Water quality, manifested in the form of physical, chemical, and biological parameters, affects the entire life cycle, including survival, growth, and reproduction **(Siegers *et al.*, 2019; Koniyo, 2020; Kulla *et al.*, 2020)**.

Aquaculture water quality is generally contaminated by organic matter from leftover feed and metabolic waste in the form of fish feces. One effort to maintain and improve water quality in fish farming is the addition of enzymes to the culture environment.

Bio-enzymes or Bioz are fermented products made from fruits or vegetables that are widely used for various purposes due to their probiotic microorganism content and bioactive compounds **(Ducatelle *et al.*, 2018)**. It is produced in 3 months fermentation process with ratio 1 : 3: 10 for sugar : waste : water **(Rasit *et al.*, 2019; Galintin *et al.*, 2021; Kurniawan *et al.*, 2024)**. Bio-enzymes are also known as ecoenzymes, garbage enzymes, terrazymes, fruit enzymes, flower enzymes, and so on **(Neupane & Khadka, 2019; Singh *et al.*, 2019)**. It is a fermentation product

One use of bio-enzymes is to accelerate the waste degradation process and improve environmental quality **(Ardianita *et al.*, 2023)**. However, several studies have shown that the use of bio-enzymes (ecoenzymes) in fish farming environments does not show a different effect on reducing ammonia, nitrate, and nitrite and does not result in good fish growth **(Kusumawati *et al.*, 2018; Bambang *et al.*, 2024)**. Based on the above description, this study was conducted to confirm previous studies by analyzing the growth performance of tilapia and catfish fry cultivated with the addition or supplementation of bio-enzymes with different concentrations in the maintenance water.

MATERIALS AND METHODS

This research was conducted at the Hatchery, Bangka Belitung University, from June to August 2025. The samples used in this study were 100 tilapia fry measuring 6-8 cm and catfish fry measuring 5-7 cm in each pond. Both types of samples were cultivated in concrete ponds measuring 2 m long, 1.5 m wide, and 0.6 cm high, filled with water to a depth of 30 cm.

The research treatment consisted of two, namely cultivation media without added bio-enzymes and cultivation media added bio-enzymes. Based on pre research, effectiveness of bio-enzyme supplementation into the cultivation media was carried out before fish maintenance with doses of 500 ml and 1000 ml in each pond containing 900 L of water or treatments of 0.6 ml/L and 1.1 ml/L. The test sample fish fry were maintained in the research pond for 40 days by being fed pellets *ad satiation*, namely feeding until the fish were full and stopped eating.

Fish sample measurements were conducted on 10% of the population in each treatment. The research parameters observed in fish were absolute weight growth (g), absolute length growth (cm), daily weight growth rate (g/day), daily length growth rate (cm/day), specific weight growth rate (%), specific length growth rate (%), and survival (%). The water quality parameters observed were pH, temperature ($^{\circ}$C), dissolved oxygen (DO) (ppm), total dissolved solids (TDS) (ppm), and electrical conductivity (EC) (mS/cm). The research data were analyzed descriptively and presented in tables and graphs.

RESULTS AND DISCUSSION

The results of the study showed that bio-enzyme supplementation into the pond compared to the control treatment without bio-enzyme can have an effect or no effect on the growth performance of fish fry. Bio-enzyme supplementation into tilapia fry ponds contributed more to higher weight growth than length growth. The opposite occurred for catfish fry, namely bio-enzyme supplementation into catfish fry ponds resulted in higher length growth than weight growth. Supplementation of 500 ml of bio-enzyme resulted in the highest absolute weight growth of tilapia fry, namely 16.95 g with a daily weight growth rate of 0.42 g/day and a specific weight growth rate of 3.35% and 100% survival. Supplementation of 500 ml of bio-enzyme resulted in the highest absolute length growth of catfish fry, namely 9.20 cm with a daily length growth rate of 0.23 cm/day and a specific length growth rate of 2.23% and 100% survival.

Growth of tilapia

Supplementation of bio-enzymes into the cultivation medium, namely the maintenance water in the tilapia fry pond resulted in higher weight growth of the fry at the end of the observation compared to the control treatment without bio-enzymes. However, the length growth of the tilapia fry reared in the pond with bio-enzyme supplementation was lower than the control treatment without bio-enzymes (Fig. 1). The absolute growth, daily growth rate, and specific growth rate of the tilapia fry are shown in Table (1). The research data also did not show any symptoms of disease in the fry reared, but there were 3 fish that died during maintenance in the 1000 ml bio-enzyme treatment, while in the other treatments no dead fry were found during maintenance (Table 1).

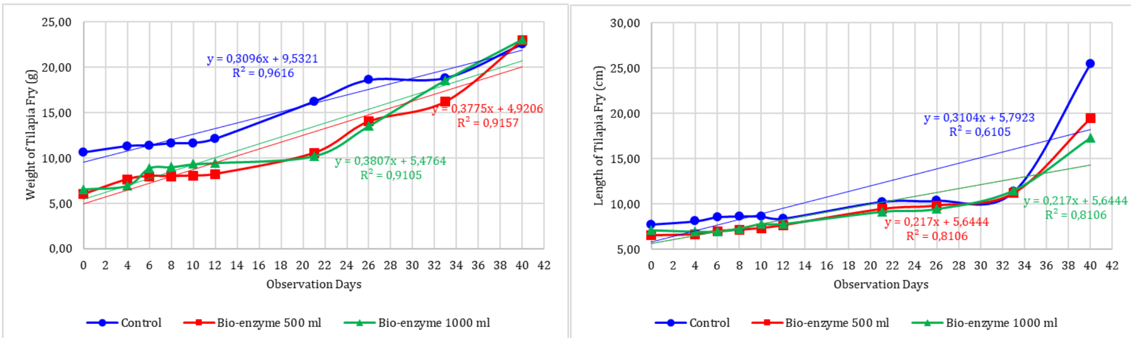

Fig. 1. Growth in weight and length of tilapia fry

Table 1. Calculation of growth and survival of tilapia fry

Parameter	Tilapia Fry		
	Control	Bio-enzyme	
		500 ml	1000 ml
Absolute weight gain (g)	11.94	16.95	16.47
Absolute length growth (cm)	17.75	12.98	10.20
Daily weight gain rate (g/day)	0.30	0.42	0.41
Daily length growth rate (cm/day)	0.44	0.32	0.26
Specific weight growth rate (%)	1.88	3.35	3.13
Specific length growth rate (%)	2.98	2.74	2.23
Survival rate (%)	100	100	97

Growth of catfish

Supplementation of bio-enzymes into the culture medium, namely the maintenance water in the catfish fry pond, resulted in lower weight growth of the fry at the end of the observation compared to the control treatment without bio-enzymes. However, the length growth of the catfish fry reared in the pond with bio-enzyme supplementation was higher than the control treatment without bio-enzymes (Fig. 2). The absolute growth, daily growth rate, and specific growth rate of the catfish fry were shown in Table (1). The research data also showed no symptoms of disease and no dead fry were found during the maintenance (Table 2).

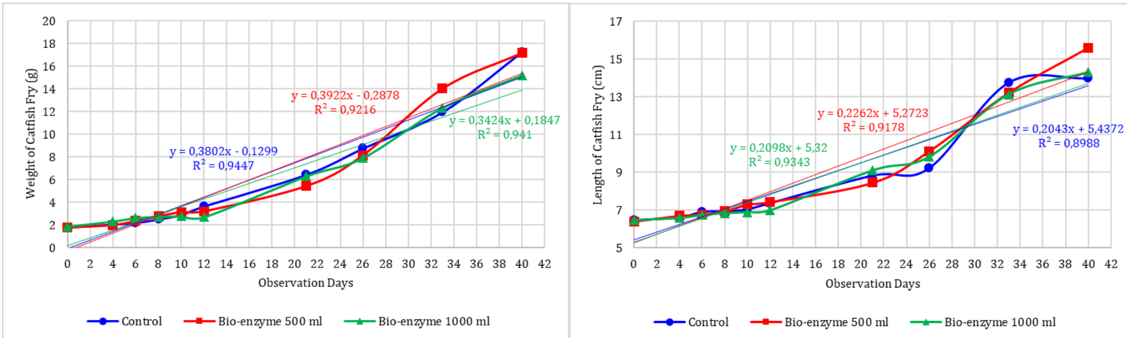

Fig. 2. Growth in weight and length of catfish fry

Table 2. Calculation of growth and survival of catfish fry

Parameter	Catfish Fry		
	Control	Bio-enzyme	
		500 ml	1000 ml
Absolute weight gain (g)	15.48	15.40	13.28
Absolute length growth (cm)	7.55	9.20	7.85
Daily weight gain rate (g/day)	0.39	0.39	0.33
Daily length growth rate (cm/day)	0.19	0.23	0.20
Specific weight growth rate (%)	5.65	5.69	5.23
Specific length growth rate (%)	1.94	2.23	1.99
Survival rate (%)	100	100	100

Water quality as a medium for cultivating tilapia and catfish fry

The results of water quality measurements used as a culture medium for the Nile fish and catfish fry—pH, temperature, DO, TDS, and EC—showed that all parameters were dynamic. This indicates that water quality fluctuates during cultivation and does not reflect a relationship between bio-enzyme supplementation in the culture medium and water quality.

Water quality in the tilapia fry rearing ponds showed a pH value that tended to be higher than that in the catfish fry ponds. The water temperature in the tilapia fry rearing ponds was relatively lower than that in the catfish fry ponds. Dissolved oxygen in the water in the tilapia fry ponds was relatively better than that in the catfish fry ponds. Total dissolved solids and electrical conductivity in the tilapia and catfish fry control ponds were relatively higher at certain times and relatively lower at other times compared to the TDS in the bio-enzyme treatment ponds.

The water quality in the tilapia fry pond had the highest pH value in the 500 ml bio-enzyme treatment, the highest temperature in the 1000 ml bio-enzyme treatment, the highest DO in the 500 ml bio-enzyme treatment, and the highest TDS and EC in the control treatment. The water quality in the catfish fry pond had the highest pH value in the 500 ml bio-enzyme treatment, the highest temperature in the control treatment, and the highest DO, TDS, and EC in the control treatment. The water quality conditions and comparison between the water quality in the tilapia and catfish fry ponds are shown in Figs. (3, 4).

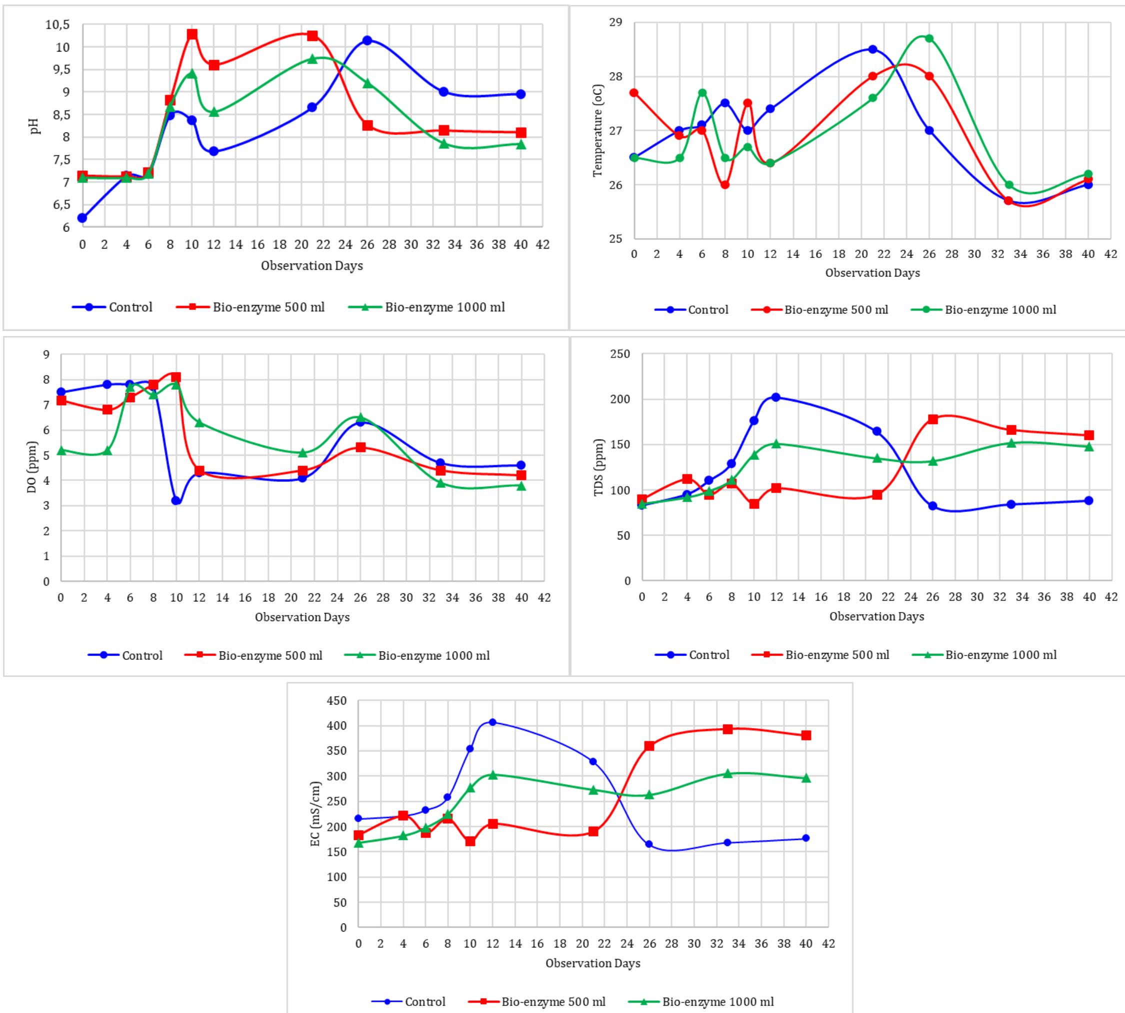

Fig. 3. Water quality as a medium for tilapia cultivation

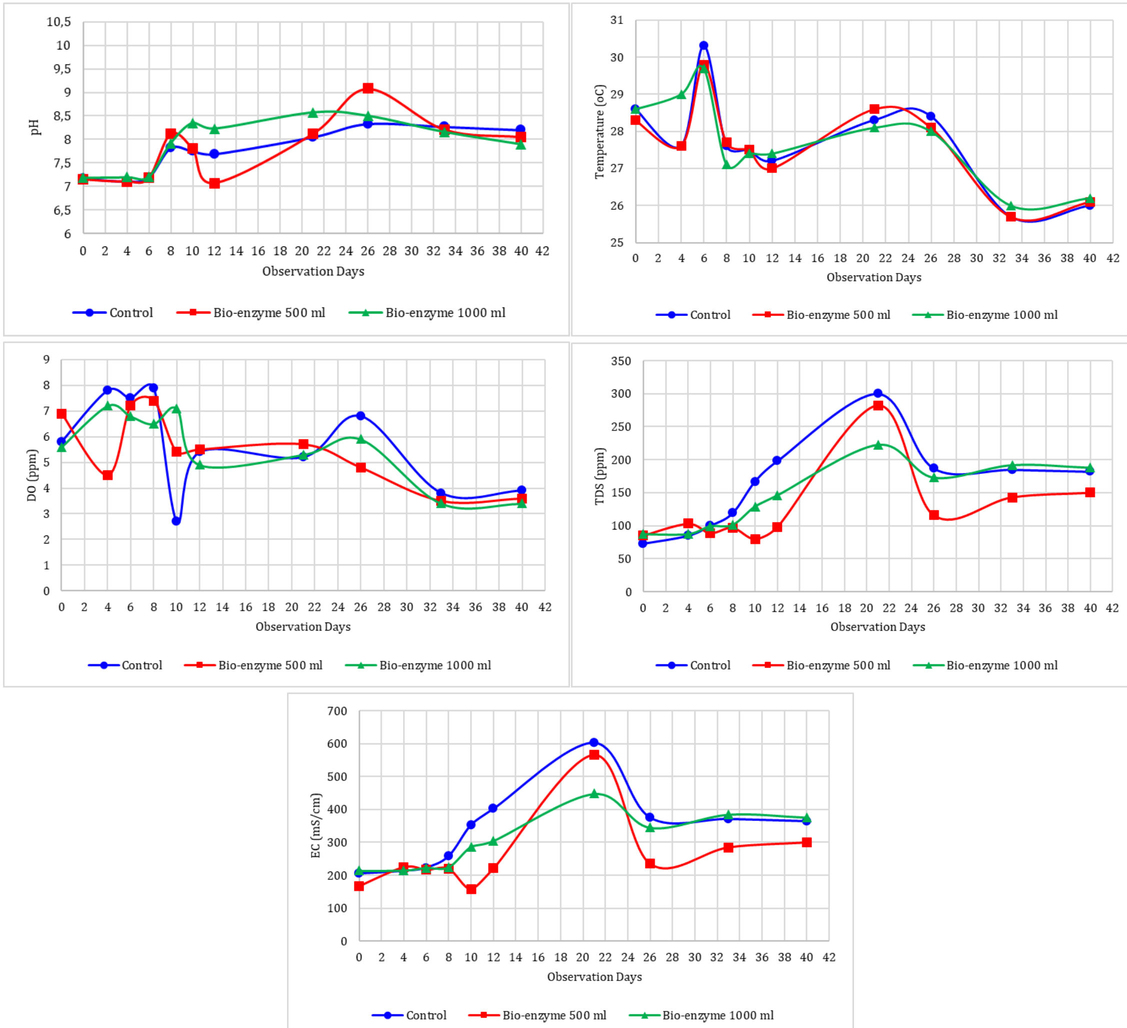

Fig. 4. Water quality as a medium for catfish cultivation

Sikku *et al*. (2023) conducted a study on the application of 5-15 ml/L of ecoenzyme (bio-enzyme) in tilapia fry (3 cm in length) cultivation pond maintained for 45 days. The absolute weight produced ranged from 0.98-1.76 g with a specific weight growth rate ranging from 2.33-4.19%. The water pH value during maintenance ranged from 7.6-9.1. When compared with the specific weight growth rate in this study which ranged from 3.13-3.35% (Table 1), then supplementation with a high concentration of bio-enzyme (15 ml/L) resulted in a better specific weight growth rate than the low concentration (0.6-1.1 ml/L) in this study. However, at a concentration of 5-10 ml/L in the study by **Sikku *et al*. (2023)** showed a lower value (2.33-2.98%) compared to the treatment in this study. Thus, there is no linear pattern that shows that the higher the concentration of bio-enzyme given, the higher the growth of tilapia fry.

Bio-enzyme research has also been conducted on catfish fry cultivation. The results of **Kusumawati *et al.* (2018)** research show that the addition of bio-enzymes to catfish fry ponds maintained for 4 weeks **(**approximately 28 days**)** has a length of 5.9-8.0 cm with a weight of 2.01-4.32 g from a length of 5.1-5.8 cm and a weight of 1.12-1.22 g on day 0. Meanwhile, the results of measurements on the 26th day of this study have shown that the weight and length data were 8.76 g and 9.22 cm, respectively, in the control treatment; 8.14 g and 10.12 cm in the 500 ml bio-enzyme treatment **(**0.6 ml/L**)**; and 7.90 g and 9.82 cm in the 1000 ml bio-enzyme treatment **(**1.1 ml/L**)** (Fig. 4). This difference may be caused by the contribution of bio-enzymes in the research of **Kusumawati *et al.* (2018)** found lower pH and DO values, ranging from 5.85 to 6.89 and DO from 2.95 to 3.71 ppm in the fourth week of culture. This study, however, found pH values ranging from 8.33 to 9.08 and DO from 4.8 to 6.8 ppm. Based on SNI 6484.4:2014, water quality for catfish fry culture has a pH of 6.5 to 8 and DO > 3 ppm.

The description shows that specifically, the contribution of bio-enzyme supplementation to the growth performance of tilapia fry was better than that of catfish fry (Tables 1, 2). This was in line with the statement by **Herliwati *et al*. (2024)** that the addition of bio-enzymes can improve water quality, which can impact the survival of catfish fry. However, the addition of bio-enzymes to the cultivation water medium only affected the growth of tilapia and not catfish. Similar conditions were also found in the results of research by **Mado *et al.* (2023)** and **Natsir *et al.* (2024)**, who found increased growth of tilapia with the application of bio-enzymes to the cultivation water medium. However, according to **Kusumawati *et al.* (2018)** and **Bambang *et al.* (2024)**, catfish growth did not change with the same application. This is possible because catfish have a tolerance to less than ideal waters **(Hidayati *et al*., 2021)**, so that when water quality improves, its metabolism does not affect. Meanwhile, tilapia experience increased metabolism when quality improves, resulting in better growth. Tilapia fry experience increased growth and survival when oxygen and ammonia levels are more appropriate **(Islami *et al*., 2017)**. When compared to the pH, DO, and TDS conditions (Figs. 3 and 4), it can be seen that supplementing bio-enzymes into the culture medium results in better water quality for tilapia fry cultivation than for catfish fry. Furthermore, Figs. (3 and 4) also show that the total dissolved solids in catfish fry ponds were higher than in tilapia fry ponds. High dissolved solids can hinder the growth performance of fish fry.

Rahman *et al*. (2020) explained that total dissolved solids are organic and inorganic substances dissolved in water that can be a factor causing water turbidity. According to **Damayanti (2014)**, increased TDS concentrations in water can originate from feed waste and accumulated metabolic waste such as fish feces. According to **Al Zamzami *et al*. (2019)**, the length of maintenance time can contribute to an increase in dissolved organic matter, one of which comes from feed waste and fish feces. Furthermore, various studies have revealed that the presence of nitrogen waste can produce ammonia, nitrate, and nitrite compounds that can cause oxygen depletion, disease, and even death in fish **(Munguti *et al*., 2021; Li *et al*., 2023; Mustafa *et al*., 2024; Kurniawan *et al*., 2025)**.

Relatively low bio-enzyme concentrations were considered ineffective in reducing waste contamination, particularly in catfish fry ponds. This is visually confirmed by the cloudier and more odorous water in catfish fry ponds compared to tilapia fry ponds. This is thought to inhibit the growth of catfish fry in rearing ponds. **Kusumawati *et al*. (2018)** explained that administering bio-enzymes at low concentrations does not significantly reduce ammonia and nitrite concentrations. This contributed to the slow growth of catfish fry.

Higher bio-enzyme concentrations, duration, and frequency of bio-enzyme administration need to be tested for their effectiveness in improving the quality of aquaculture water and its effect on optimal growth for fish fry. This is in line with **Putri *et al*. (2024)**, who stated that the longer the time and the higher the eco-enzyme dosage, the higher the effectiveness in reducing waste contamination as indicated by the biological oxygen demand (COD) and total suspended solids (TSS) in the environment. **Yatma *et al*. (2024)** also revealed that increasing the eco-enzyme dosage used was able to significantly reduce the dissolved solids (TDS) content and improve water quality. Furhtermore, water quality and nutrient contribute to fish morphological and its growth **(Mustikasari *et al*., 2020; Serdiati *et al*., 2024)**.

Discussion about Agribusiness Perspective of Bio-Enzyme Supplementation for Aquaculture

From an agribusiness perspective, bio-enzyme supplementation in aquaculture presents a high-potential growth sector that aligns with key trends: sustainable food production, environmental regulation, and consumer preference for clean-label seafood. Strategic investment in research and development, production, and farmer outreach can unlock long-term profitability and ecological benefits.

Perspective in agribusiness opportunities, including market potential, value addition, product development and diversification, challenges from an agribusiness viewpoint, and investment and agribusiness models. In Indonesia **(**and many other countries**)** tilapia and catfish are major freshwater/pond-aquaculture species. Grower demand is strong for both local consumption and export. A value proposition; higher growth/lower feed cost/improved survival is very attractive to fish farmers, in particular tilapia and catfish. Use the enzyme supplementation in aquaculture can improve output and profit. In other hand, enzyme supplementation can reduce feed costs **(**better feed conversion ratio or FCR**)**, improves animal health and survival rates — leading to higher yields and profits, reduces environmental impact, enhancing the farm's market reputation and compliance with green regulations **(Varshini & Gayathri, 2023)**.

Using bio-enzymes in aquaculture offers several agribusiness advantages, making them an increasingly attractive input in sustainable fish farming. The benefits using bio-enzymes in aquaculture from an agribusiness perspective:

Improved Productivity and Profitability

Enhanced Feed Conversion Ratio **(**FCR**)** where bioenzymes help fish and shrimp digest feed more efficiently, reducing feed costs — a major operational expense. Faster growth rates where enzymes promote better nutrient absorption, accelerating growth and reducing time to market. Lower mortality rates where enzymes improve gut health and immunity, reducing disease outbreaks.

Profitability of this research result can be calculated with assumption referring to Tables (1 and 2). Tilapia and catfish fish fry were cultivated 45 days for fingelings size and 135 days for consumption size with survival rate 100%. The potential economic value of selling of fish fry and consumption sizes is shown in Table (3).

The economic value of selling tilapia at the fingerling phase or consumption size, as presented in Table (3), indicats that only tilapia treated with bio-enzymes were recommended for sale. The potential of selling price from bio-enzyme-supplemented fish was higer than normal price at local market. Consumption size with treatment bio-enzyme 500 ml had potential of selling price 52,000 IDR and bio-enzyme 1000 ml had potential of selling price 47,565 IDR compared price at local market 35,000 IDR. Meanwhile, selling of fingerlings phase of bio-enzyme-supplemented tilapia was not recommended due to the size of fish fry treated with bio-enzymes was not better than the control.

For catfish, the control and bio-enzyme treatment of 500 ml and 1000 ml of enzyme did not show significant differences. Even though, fingerlings phase (at 45 days old) treated with bio-enzyme 500 ml had potential of selling price 495 IDR, higher than price at local market (300 IDR). Thus, selling of fingerlings phase of bio-enzyme-supplemented catfish (500 ml bio-enzyme) was recommended.

Weight of catfish fry in the control treatment was bigger than the bio-enzyme treatment so that the addition of bio-enzymes had no effect on fry growth. As well as the weight of the fish, the addition of bioenzymes did not result in significant weight gain compared to the control treatment. Therefore, selling of fingerlings phase and also consumption size of bio-enzyme-treated fish were not recommended

Table 3. Economic value of tilapia and catfish in fingerlings and consumption size

Fish (Phase or Size)	Comparing Between Control and Bio-enzym Supplementation (500 ml and 1000 ml)		Price (IDR) in local market in Bangka, Indonesia	Potential of Selling Price (IDR)	Selling Recommendation of Bio-enzyme-supplemented Fish
	Weight (g)	Length (cm)			
Tilapia					
Fingerlings phase (at 45 days old)	5.01 x 100 fishes	Control > Treatment	200/fish	No	Not recommended for selling in fingerlings phase
	4.53 x 100 fishes				
Consumption size (at 135 days old)	15.03 x 100 fishes	-	35,000/kg (35/g)	52,000	Recommended for selling in consumption size (treatment bio-enzyme 500 ml)
	13.59 x 100 fishes			47,565	Recommended for selling in consumption size (treatment bio-enzyme 1000 ml)
Catfish					
Fingerlings phase (at 45 days old)	Control > Treatment	1.65	300/fish	495	Recommended for selling in consumption size (treatment bio-enzyme 500 ml)
		0.3		90	Not recommended for selling in fingerlings phase
Consumption size (at 135 days old)	-	4.95 x 100 fishes	23,000/kg (23/g)	11,385	Not recommended for selling in consumption size
		0.9 x 100 fishes		2,070	

Reduction in Input Costs

Less dependency on antibiotics and chemicals where enzymes can reduce disease pressure naturally. Better water quality management where bioenzymes help degrade organic waste and ammonia, reducing the need for chemical water treatments.

Sustainable Branding & Market Access

Eco-friendly production where enzyme use aligns with growing consumer demand for sustainable and antibiotic-free aquaculture. Certification ready where farms using bioenzymes can more easily meet organic or eco-certification standards.

Waste Reduction and Circular Economy

Utilization of agricultural byproducts where some bioenzymes are produced using agri-waste (e.g., fruit peels, crop residues), supporting circular bioeconomy models. Efficient waste breakdown where help manage sludge and organic waste, reducing environmental impact.

New Revenue Streams

Local production of bioenzymes wher farmers or agri-entrepreneurs can engage in low-cost production of bioenzymes using fermentation, creating micro-enterprises. Diversification for agro-industries where companies in biotech, agriculture, or food waste management can expand into aquaculture support services.

Regulatory and Environmental Compliance

Supports green policies where use of bioenzymes aligns with government and international sustainability goals in aquaculture. Reduces pollution where better water quality means less eutrophication and contamination of surrounding ecosystems.

CONCLUSION

The addition or supplementation of bio-enzymes to tilapia and catfish fry ponds produced different contributions. Bio-enzyme supplementation to tilapia fry ponds compared to the control treatment without bio-enzymes showed a higher contribution to weight growth than to length growth. The opposite occurred for catfish fry, namely bio-enzyme supplementation to catfish fry ponds compared to the control without bio-enzymes showed a higher contribution to length growth than to weight growth. The results of water quality measurements as a medium for cultivating tilapia and catfish fry, namely pH, temperature, DO, TDS, and EC showed that all parameters were dynamic. This means that water quality fluctuates during cultivation and does not reflect the relationship between bio-enzyme supplementation to the cultivation medium and water quality. In agribusiness perspective, using bio-enzymes in aquaculture offers several agribusiness advantages, making them an increasingly attractive input in sustainable fish farming. However, based on the economic value, only tilapia in consumption size (at 135 days old) treated with bio-enzymes (500 ml and 1000 ml) were recommended for sale, particularly in consumption size. Meanwhile, for catfish, only in fingerlings phase were decommended for selling with treatment bio-enzyme 500 ml.

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CONFLICTS OF INTEREST

All the authors declare no conflict of interest.

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