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Efek dosis vitamin C terhadap pertumbuhan dan kelangsungan hidup ikan sidat (*Anguilla bicolor*, McClelland, 1844)

Effects of vitamin C dosage levels on growth and survival rate of sidat fish (*Anguilla bicolor*, McClelland, 1844)

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Abstrak

Ikan sidat merupakan salah satu spesies yang memiliki nilai ekonomis tinggi, namun pertumbuhannya yang lambat dan tingkat kelangsungan hidup yang rendah menjadi masalah yang perlu diatasi melalui pengembangan teknologi budidaya yang efektif. Penelitian ini bertujuan untuk menganalisis pengaruh dosis vitamin C terhadap pertumbuhan dan kelangsungan hidup ikan sidat (*Anguilla bicolor*). Penelitian dilakukan di UPR. Mina Mandiri, Kecamatan Beutong, Kabupaten Nagan Raya, selama periode Agustus hingga Oktober 2023. Metode yang digunakan adalah Rancangan Acak Lengkap dengan empat taraf perlakuan dan tiga kali ulangan, yakni 0, 200, 300, dan 400 mg/kg pakan. Hasil analisis ANOVA menunjukkan bahwa dosis vitamin C memiliki pengaruh signifikan terhadap pertumbuhan dan kelangsungan hidup ikan sidat (P<0,05). Berdasarkan uji lanjut Duncan menunjukkan perbedaan signifikan antar perlakuan pada parameter pertumbuhan, namun tidak ada perbedaan yang signifikan pada kelangsungan hidup. Dosis pemberian 200 mg/kg pakan menunjukkan hasil tertinggi dan optimal dalam peningkatan pertumbuhan serta kelangsungan hidup ikan sidat.

Kata kunci: Ikan sidat; pertumbuhan; teknologi budidaya; vitamin

Abstract

Eel is a species with high economic value, but its slow growth and low survival rate are problems that need to be addressed through the development of effective cultivation technology. This study aimed to investigate the effects of vitamin C dosage on the growth and survival of eels (*Anguilla bicolor*). This study was conducted at the UPR. Mina Mandiri, Beutong District, Nagan Raya Regency, during the period August to October 2023. The method used was a completely randomized design with four treatment levels and three replications, namely 0, 200, 300, and 400 mg/kg feed. ANOVA results showed that the dose of vitamin C had a significant effect on the growth and survival of eels (P < 0.05). Further tests using Duncan's method showed significant differences between treatments in growth parameters, but there was no significant difference in survival. The 200 mg/kg feed dose showed the highest and optimal results in terms of increasing the growth and survival of eel fish.

Keywords: Culture technology; eel; growth; vitamin C

1. Introduction

The eel (*Anguilla bicolor*) is a catadromous fish commonly found in fresh and estuarine waters (Sugianti and Krismono, 2013). The life cycle of an eel consists of five stadia: larvae (*Leptocephalus*), fry (*glass eel*), elver, yellow eel, and silver eel. (Kusuma *et al.*, 2021; McKinnon, 2006). Eel fish have a high economic value, as can be seen from the high demand in international and local markets, which causes its need to increase. (Noor & Abidin, 2019). The vast market potential of eel fish is expected to improve the community economy. However, the development of eel fish farming still faces several obstacles, such as slow growth, low survival, and diseases that can cause death. (Harun *et al.*, 2023). Perdana and Chilmawati (2016)

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mentioned that improving cultivation technology by improving the rearing environment and nutrition is necessary. Further, Abdan *et al.* (2017) stated that one of the efforts to improve nutrition is the application of vitamin C in feed.

Vitamin C is an organic compound essential for food metabolism and fish physiology (Ishak and Wahana, 2020). Fish cannot synthesize vitamin C; therefore, they require an external intake of vitamin C (Hasri *et al.*, 2023). According to Hardy (2002), Vitamin C deficiency can cause various health problems in fish, such as weakened body energy, incomplete bone growth, and even death. Vitamin C is a free-radical antidote that protects fish cells from damage (Murmu and Shrivastava, 2011). According to Dubey (2013), free radicals, such as water pollutants, can naturally form in the fish body or come from the environment. Cellular damage caused by free radicals can lead to various health problems, such as slow growth, low feed efficiency, and decreased immunity (Biller and Takahashi, 2018; Romanova *et al.*, 2023). Based on the results of the present study, vitamin C can improve growth, feed efficiency, and fish endurance. This has been proven in various studies, such as Sunarto (2008). Fitriani and Akmal (2020) showed that providing, which shows that giving vitamin C to betok fish can increase daily growth rate and feed efficiency and increase the resistance of betok fish to environmental stress.

Other research conducted by Abdan *et al.* (2017) also showed that adding vitamin C to commercial feed significantly affected absolute weight growth, absolute length growth, specific growth rate, survival, and feed conversion in swordfish (*Tor* sp.). Other studies have also shown positive effects of vitamin C administration in fish, such as in catfish (*Clarias* sp.) (Abadi *et al.*, 2022), snakehead fish (*Channa striata*) (Alfisha *et al.*, 2020), and carp (*Cyprinus carpio*) (Komalasari *et al.*, 2018). Based on the reported positive effects, it is crucial to research vitamin C applications in eels (*Anguilla bicolor*). This study aimed to improve the technology of eel farming through feeding, considering that vitamin C can provide significant benefits to growth, feed efficiency, and fish endurance.

2. Materials and Methods

2.1. *Time and place*

This research was conducted at the Mina Mandiri People's Hatchery Unit (UPR), Lhok Seumot, Beutong District, Nagan Raya Regency, from August to October 2023.

2.2. *Tools and materials*

The tools used in this study included nets, stationery, shovels, digital thermometers, cameras, digital scales (accuracy: 0.01 g), pH meters, vitamin C (ascorbic acid), eels (elver stadia), and artificial feed with a 40% protein content.

2.3. *Research design*

This study used a completely randomized experimental design with four treatments and three replicates, as described by Abdan *et al.* (2017):

Treatment A : 0 mg/kg feed
Treatment B : 200 mg/kg feed
Treatment C : 300 mg/kg feed
Treatment D : 400 mg/kg feed

2.3. *Research procedures*

2.4.1. *Preparation of containers and fish samples*

The working procedure in this study began with containers in cages with a size of 60 × 60 × 80 cm, with as many as 12 units. These containers were cleaned using detergent to sterilize them from fungi and bacteria that may be attached. After cleaning, the containers were rinsed and dried in the sun for 3 hours. The containers were then placed in a round tarpaulin pond and aerated for 24 hours before introducing the sample fish. The eel fish fry used in this study was obtained from natural catches and had undergone a domestication process at UPR Mina Mandiri. For the stocking of test fish, referring to previous research by Diansyah *et al.* (2014), which is 4g/L

2.4.2. *Preparation of test feed*

The feed used in this study was a commercial feed with a protein content of 40%. The test feed was substituted with vitamin C according to the specified treatment. Subsequently, sufficient water was added to the test feed and stirred until a paste was formed. This process was performed to achieve optimal consistency. The processed feed was then given to the fish twice daily, at 08.00 and 17.00 WIB *ad libitum.*

2.4.3. *Data collection*

Data were collected seven times on days 0, 10, 20, 30, 40, 50, and 60. Growth data were obtained by weighing the weight of fish during the sampling period, whereas observations of the weight of dead fish were made daily to calculate the survival rate of fish.

Water quality control was performed in several steps. First, feces were removed using a shovel to clean the remaining feed during rearing. Subsequently, the water was changed according to the volume of water wasted. Water quality measurements were carried out in the morning and evening every time sampling was done, which was carried out in the 08.00-16.00 WIB time range. The parameters measured included temperature, pH, ammonia concentration (NH_3), and dissolved oxygen (DO).

2.3. *Parameters*

2.3.1. *Growth*

Weight gain was calculated using the following formula of Effendie (1979):

$$PBM = Wt - Wo \qquad (1)$$

Where, W: Weight gain (g), Wt: Biomass weight at the end of the study (g), Wo: Biomass weight at the beginning of the study (g).

2.3.2. *Specific growth rate (SGR)*

The specific growth rate (SGR) is the difference in each weight in one sampling period and was calculated using the formula of Marzuqi *et al.* (2012):

$$SGR = \frac{Ln\ Bt - Ln\ B0}{t} x\ 100\% \qquad (2)$$

Where, LPS = Specific growth rate, Wo = Average initial weight (grams), Wt = Average final weight (grams), t = Time (days)

2.3.3. *Feed efficiency (EP)*

Feed efficiency is the amount of feed utilized by fish. A high feed efficiency value indicates a good level of feed utilization. The feed efficiency was calculated using the formula of Afrianto and Liviawaty (2005):

$$EP = \frac{(\mathrm{Wt}+D)-Wo}{(\mathrm{F})}\ \mathrm{x}\ 100 \qquad (3)$$

Where, EP = Feed Efficiency (%), F = Feed Conversion (%), D = Dead Fish

2.3.4. *Survival rate*

Survival was calculated using the following *equation* proposed by Effendie (1979):

$$SR = Nt/N0 \times 100 \quad (4)$$

Where Nt = number of fish at the end of rearing (fish), N0 = number of fish at the beginning of rearing (fish)

2.4. Data analysis

Data obtained from each treatment were analyzed using analysis of variance (ANOVA). If this study indicated a significant effect, Duncan's test was conducted to evaluate the differences between treatments and to determine the optimal treatment. Statistical analysis was performed using the software SPSS (version 26.0).

3. Results and Discussion

This study evaluated the growth performance and survival rate of eels in response to various doses of vitamin C (0, 200, 300, and 400 mg/kg). The findings show a significant increase in eel growth over time. Analysis of the treatment results revealed that treatment B (200 mg/kg feed) achieved the highest growth compared to the other treatments, whereas treatment A (no vitamin C) showed the lowest length gain. A sustained increase in length was observed in treatments B, C, and D, especially on days 40, 50, and 60, indicating a positive impact of vitamin C dosing (Figure 1). The results of the analysis of variance (ANOVA) test showed that the administration of vitamin C with different doses had a significant effect on the growth and survival of fish ($P < 0.05$). Duncan's Multiple Range Test indicated significant differences between treatments on growth parameters. However, there was no difference in survival, with the optimal results observed for treatment B (200 mg/kg feed) (Table 1).

During the study period, the water quality for all three parameters remained within favorable ranges for eel fish (Table 2). Observations showed that the administration of vitamin C did not affect the water quality in the experimental containers.

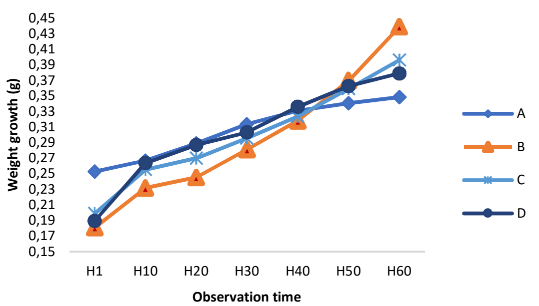

Figure i. Growth chart of eels (*Anguilla bicolor*) during the study.

Success in fish farming can be recognized by optimal fish growth, which is reflected in increased body weight. An increase in the number and size of fish bodies causes growth. A good feed quality is critical for optimal fish growth (Putri *et al.* 2022). One way to improve feed quality is to add Vitamin C (Abdan *et al.*, 2017; Alfisha *et al.*, 2020). Fitriani and Y. Akmal, 2020).

Dosing 200 mg/kg of feed with vitamin C was the most effective in improving eel growth. This finding indicates that vitamin C plays a critical role in eel growth, primarily through its contribution to iron absorption and metabolism (Hallberg *et al.* 1989). Vitamin C modifies ferrous iron to its ferrous form in the small intestine, making absorption easier and positively affecting the growth process (Lynch and Cook, 1980). Murota (2020) states that vitamin C absorption occurs through the gastrointestinal tract, especially in the upper segment of the small intestine, and then enters the bloodstream through the portal vein. The same thing was stated by Sivaramakrishnan *et al.* (2023), who stated that vitamin C can increase iron absorption from the gut, which plays a role in oxygen circulation in the body and collagen formation.

Vitamin C plays a significant role in supporting fish growth because of its ability to maintain iron atoms in a reduced state and maintain the activity of hydroxylase enzymes in the biosynthesis of collagen, hydroxyproline, and hydroxylin (Akiyama and Tan, 1991; Chugaeva *et al.*, 2023). These enzymes play a crucial role in the formation of the body skeleton, particularly in the cartilage tissue of fish (Sunarto *et al.*, 2008). Furthermore, Duque *et al.* (2022) stated that vitamin C is essential for the formation of L-carnitine in various body tissues. Chen *et al.* (2022) stated that L-carnitine in farmed fish can improve growth and feed utilization efficiency. In addition, L-carnitine can reduce the harmful effects of high fat on fish growth, such as increased lipid hydrolysis, lipid utilization, and decreased lipid peroxidation (Harpaz, 2005). Next, Sunarto (2008) added that vitamin C can prevent abnormal fat metabolism, such as decreased levels of long-chain fatty acids and impaired fat utilization by the body when fish are not eaten.

Feed efficiency in this study was significantly different (Table 1). This indicates that vitamin C at an appropriate dose can increase feed efficiency. (C.-m. Xu *et al.*, 2022) reported that vitamin C administration can effectively improve coho salmon's growth performance and feed efficiency (*Oncorhynchus kisutch*). Similar results were also reported in Vundu fish (*Heterobranchus longifilis)* (Ibiyo *et al.*, 2006), On tilapia (*Oreochromis niloticus*) (Ibrahim *et al.*, 2020; Komalasari *et al.*, 2018; Pangestyastuti, 2017), Mahseer fish (*Tor* sp.) (Abdan *et al.*, 2017), Catfish (*Pangasius hypopthalmus*) (Husin *et al.*, 2017) black tetra fish (*Gymnocorymbus ternetzi*) (Dhewantara *et al.*, 2023).

The survival rate obtained from this study (Table 1) showed that treatments B (200 mg/kg feed) and C (300 mg/kg feed) were the highest and best, respectively. This can be attributed to vitamin C, which maintains immunity and fish health levels. According to Perera and Bhujel (2021), vitamin C can boost the immune system of fish, thus protecting them from diseases. Research Hoang (2021) mentioned that Vitamin C supplementation can increase the survival rate of golden trevally fish (*Gnathanodon speciosus*) at a dose of 200 mg. Mellisa *et al.* (2021) also reported that a dose of 300 mg of vitamin C increased the growth and survival of lemeduk fish (*Barbonymus schwanenfeldii*).

Table 1
Growth, feed efficiency and survival of eels during the study.

Treatment	Parameters			
	Growth Absolute weight (gr)	Specific growth rate (%)	Feed efficiency (%)	Survival rate (%)
A (0 mg/kg feed)	0.10±0.01[a]	1.25±0.18[a]	3.22±0.91[a]	90.00±2.89[a]
B (200 mg/kg feed)	0.26±0.02[c]	2.04±0.24[b]	8.13±0.40[b]	96.67±8.66[a]
C 300 mg/kg feed)	0.20±0.05[b]	1.76±0.15[b]	7.37±2.59[ab]	96.67±5.77[a]
D 400 mg/kg feed)	0.19±0.02[b]	1.80±0.01[b]	6.57±0.83[ab]	93.33±7.64[a]

Notes: The same superscript in the same column is not significantly different

Table 2
Water quality during the research.

Parameters	Sampling Kualitas Air			
	Awal (H0)	Pertengahan (H30)	Akhir (H50)	Baku Mutu (Harianto *et al.*, 2021; Mulyani *et al.*, 2021)
Temperature(°C)	25,4	26,6	26,6	22 -26
pH	7,44	7,40	7,42	7,0-8,0
Dissolved oxygen (mg/l)	5	6	4	>3

The need for vitamin C in fish is influenced by the species, age, body size, growth rate, surrounding environment, and metabolism (Darias *et al.*, 2011; Lovell, 1989). Excessive vitamin C has a pro-oxidant effect, causing increased oxidative stress owing to the pro-oxidant activity of dehydroascorbic acid, an ascorbic acid metabolite (C. M. Xu *et al.*, 2022). This increase in oxidative stress results in decreased growth causes bleeding in the gills and internal organs of fish, and even leads to death (Trichet *et al.*, 2015). Although Vitamin C does not function as an energy provider, it plays an essential role as a catalyst in the internal metabolic processes of fish, which can support average growth, survival, and reproduction (Watanabe, 1988).

The conditions of the water used strongly influence the sustainability of aquaculture. Based on Table 2, the water quality in this study remained within the optimal range, following previous studies by Harianto *et al.* (2021) and Mulyani *et al.* (2021), which includes a temperature of about 25.6-26.6°C, a pH between 7.44-7.46, and a dissolved oxygen (DO) content of about 4-6 mg/L.

4. Conclusion

The results showed that variation in vitamin C dose significantly affected the growth and survival of eels (Anguilla bicolor). A dose of vitamin C 200 mg/kg feed produces the highest growth increment and survival of the fittest compared to other doses. Statistical analysis showed that different vitamin C doses significantly affected the growth and survival parameters of eel fish. The water quality in the experimental containers was maintained within the optimal range throughout the study period following the recommended water quality standards. Although the dosage of vitamin C positively affected fish growth, there was no significant effect on water quality. Therefore, the results of this study provide recommendations for dosing vitamin C at a dose of 200 mg/kg feed, which is the most effective dose for improving the growth and survival of eel fish in aquaculture.

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