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The Role of Vitamin C and Thyroxine Hormone (T_4) on the Growth of Asian Redtail Catfish (*Hemibagrus nemurus*) in the Recirculation System

Peran Vitamin C dan Hormon Tiroksin (T_4) terhadap Pertumbuhan Ikan Baung (Hemibagrus nemurus) pada Sistem Resirkulasi

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Abstract

This research was conducted in January-July 2021 at the Marine Science Technology Biology Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Riau. The purpose of the study was to see the effect of a combination dose of vitamin C and thyroxine hormone (T4) on the growth rate and survival of bream reared in a recirculation system. The method used was an experimental method using a factorial complete randomized design (CRD) with 2 factors and 3 replicates. The first factor is vitamin C, while the second factor is the dose of tyrrhosine hormone (T4) given during maintenance. The doses of vitamin C used in this study were; 0 mg/kg (V0), 500 mg/kg (V1), 1000 mg/kg (V2). Doses of thyroxine hormone (T4) used were doses; 0 mg/kg (H0), 4 mg/kg (H1), 6 mg/kg (H2), 8 mg/kg (H3). The Asian redtail catfish used were 8-10 cm in size and reared in a round container made of PE plastic with a diameter of 56 cm and a height of 48 cm, totaling 36 units. The pellets used were Hi-Provite 781-2 with 31% protein, with feeding done 3 times a day ad satation. The results showed that the addition of vitamin C and thyroxine hormone influenced the growth of Asian redtail catfish reared in the recirculation system. The combination of vitamin C 1000 mg/kg and thyroxine hormone 8 mg/kg feed gives the highest growth and survival, seen from the absolute weight growth rate of 12.97 g, specific growth rate of 1.93 g/day, and 95% survival. Water quality during rearing was favorable for the growth of Asian redtail catfish, with temperature ranging from 28-30^{o}C, pH 6.5-7.0, and DO 4.2-5.95 ppm.

Keywords: Vitamin C, Thyroxine Hormone (T_4), Recirculation

Abstrak

Penelitian ini dilaksanakan pada bulan Januari-Juli 2021 bertempat di Laboratorium Biologi Teknologi Ilmu Kelautan, Fakultas Perikanan dan Kelautan, Universitas Riau. Tujuan penelitian untuk melihat pengaruh dosis kombinasi vitamin C dan hormon tiroksin (T_4) terhadap laju pertumbuhan dan kelangsungan hidup ikan baung yang dipelihara pada sistem resirkulasi. Metode yang digunakan adalah metode eksperimen menggunakan rancangan acak lengkap (RAL) faktorial dengan 2 faktor dan 3 kali ulangan. Faktor pertama adalah vitamin C, sedangkan faktor kedua adalah dosis hormon tirkosin (T_4) yang diberikan selama pemeliharaan. Dosis vitamin C yang digunakan dalam penelitian ini, adalah dosis; 0 mg/kg (V0), 500 mg/kg (V1), 1000 mg/kg (V2). Dosis hormon tiroksin (T_4) yang digunakan adalah dosis; 0 mg/kg (H0), 4 mg/kg (H1), 6 mg/kg (H2), 8 mg/kg (H3). Ikan baung yang digunakan berukuran 8–10 cm dipelihara dalam wadah berbentuk bulat berbahan plastik PE dengan diameter 56 cm dan tinggi 48cm berjumlah 36 unit. Pelet yang digunakan yaitu Hi-Provite 781-2

dengan protein 31%, dengan pemberian pakan dilakukan sebanyak 3 kali sehari secara *at satation*. Hasil penelitian menunjukkan bahwa penambahan vitamin C dan hormon tiroksin memberikan pengaruh terhadap pertumbuhan ikan baung yang dipelihara pada sistem resirkulasi. Kombinasi vitamin C 1000 mg/kg dan hormon tiroksin 8 mg/kg pakan memberikan pertumbuhan dan kelulushidupan tertinggi, dilihat dari laju pertumbuhan bobot mutlak sebesar 12,97 g, laju pertumbuhan spesifik 1,93 g/hari, dan kelulushidupan 95%. Kualitas air selama pemeliharaan mendukung untuk pertumbuhan ikan baung, yaitu suhu berkisar antara 28-30^{o}C, pH 6,5-7,0, dan DO 4,2-5,95 ppm.

Kata kunci: Vitamin C, Hormon Tiroksin (T_4), Resirkulasi

1. Introduction

Asian redtail catfish (*Hemibagrus nemurus*) is a type of public water fish that lives in lakes and rivers to the lower reaches of Sumatra and Kalimantan (Tang, 2003). Baung fish is one of the freshwater commodities with high economic value, where the price is quite high around IDR 50,000-60,000/kg (Saputra et al., 2017). This fish is favored by the public because it has thick meat and a distinctive taste. Asian redtail catfish enlargement cultivation business activities have been widely carried out, but in these cultivation activities there are obstacles such as slow growth of Asian redtail catfish and low survival rates.

Asian redtail catfish production has not been able to meet market demand which continues to increase every year (Wardani et al., 2018). The decline in Asian redtail catfish production is partly due to fluctuations in the quality of aquaculture water, causing physiological changes such as adaptation systems and decreased endurance. Unstable environmental conditions affect changes in aquatic organisms both directly and indirectly. Direct influence is mainly on changes in physical and chemical parameters, while indirect influence can occur on biological parameters (Braga et al., 2017).

One of the efforts to improve the immune system of fish is by providing vitamin C into the feed. Vitamin C is a water-soluble nutrient that functions as a catalyst in the process of food metabolism and fish physiology to maintain health, increase fish immunity against infection and as an antioxidant. Providing vitamin C in pelleted feed can increase the immune response of fish (Wirdona et al., 2019). The hormone thyroxine (T4) mixed or added to feed can help regulate metabolic processes and spur growth rates in fish and increase the speed of food absorption by fish (Yandra et al., 2020). The process of metabolism and growth in fish is also influenced by hormonal factors. The systematic work of hormones is to stimulate growth and as a catalyst for faster growth reactions (Dedi et al., 2018).

Recirculation system is a circulation system utilizing water that has been used in a cultivation unit and then flowed back into a treatment unit so as to reduce the use of water from outside the system. The recirculation system was developed to increase dissolved oxygen levels, reduce ammonia levels and organic waste produced by fish so that water quality can be maintained for recirculating fish life (Verawati, 2017). From the background explanation above, the author is interested in conducting research on "the role of vitamin C and thyroxine hormone (T4) on the growth and survival rate of baung fish (Hemibagrus nemurus) in the recirculation system".

2. Material and Method

2.1. Time and Place

This research was conducted from January to July 2021. The rearing of bream was carried out at the Marine Science Biotechnology Laboratory, Universitas Riau.

2.2. Methods

The method used in this research is an experimental method using a factorial complete randomized design (CRD) with 2 factors and 3 replications. The first factor was vitamin C, while the second factor was the dose of the hormone tyrrhosine (T_4) given during maintenance. The dose of vitamin C given in this study refers to Hidayat et al. (2017) in Asian redtail catfish with the best treatment is a dose of 1,000 mg/kg. The dose of vitamin C used in this study is with 3 dose treatments; 0 mg/kg (V0), 500 mg/kg (V1), 1000 mg/kg (V2).

While the dose of hormones (T_4) given in this study refers to Yandra et al. (2020) on Asian redtail catfishwith the best treatment is the dose of thyroxine 6 mg/kg. The dose of thyroxine hormone (T_4) used is with 4 dose treatments; 0 mg/kg (H0), 4 mg/kg (H1), 6 mg/kg (H2), 8 mg/kg (H3). For more details, the treatments that will be used in this study can be seen in Table 1.

Table 1. Treatment doses of vitamin C and thyroxine hormone (T_4)

No.	Treatment Code	Description

1.	V H_{00}	No Vitamin C, No T_4
2.	V H_{01}	Without Vitamin C, Dosage T 4 /4 $^{mg}_{kg}$ Feed
3.	V H_{02}	Without Vitamin C, Dosage T_4 6 /$^{mg}_{kg}$ Feed
4.	V H_{03}	Without Vitamin C, Dose T_4 8 /$^{mg}_{kg}$ feed
5.	V H_{10}	Vitamin C 500$^{mg/kg}$, No T_4
6.	V H_{11}	Vitamin C 500$^{mg/kg}$, Dosage T_4 4 /$^{mg}_{kg}$ Feed
7.	V H_{12}	Vitamin C 500$^{mg/kg}$, Dosage T_4 6 /$^{mg}_{kg}$ Feed
8.	V H_{13}	Vitamin C 500$^{mg/kg}$, Dosage T 8 /4 $^{mg}_{kg}$ Feed
9.	V H_{20}	Vitamin C 1000$^{mg/kg}$, No T_4
10.	V H_{21}	Vitamin C 1000$^{mg/kg}$, Dosage T_4 4 /$^{mg}_{kg}$ Feed
11.	V H_{22}	Vitamin C 1000$^{mg/kg}$, Dosage T_4 6 /$^{mg}_{kg}$ Feed
12.	V H_{23}	Vitamin C 1000$^{mg/kg}$, Dosage T_4 8 /$^{mg}_{kg}$ Feed

2.3. Observation Parameters

Parameters measured were absolute weight growth, specific growth rate and survival rate. Absolute weight growth was calculated using the formula of Arifin et al. (2020), specific growth rate is calculated using the following formula:

$$Wm=Wt-Wo$$

Where: Wm = Absolute weight growth (g)
W_t = Average weight at the end of the study (g)
W_o = Average weight at the beginning of the study (g)

Specific growth rate measurements are calculated using the formula according to Monentcham et al. (2010), namely:

$$SGR = ((Ln\ Wt - Ln\ Wo)/t)) \times 100$$

Where: SGR = Specific growth rate (%/day)
Wt = Average weight of fish at the end of the study (g)
Wo = Average weight of fish at the beginning of the study (g)
T = Duration of study (days)

According to Effendie (2002), the survival rate can be calculated using the following formula:

$$SR = \frac{Nt}{No} x\ 100\%$$

Where : SR = Survival (%)
Nt = Number of fish at the end of the study (fish)
No. = Number of fish at the beginning of the study (fish).

2.4. Data Analysis

Data obtained from the measurement of absolute weight, specific growth rate, survival rate were tabulated into tables and analyzed statistically using the SPSS version 25 application if the treatment showed a significant difference where $p<0.05$, then the Student Newman-Keuls test was carried out to determine the difference of each treatment.

3. Result and Discussion

3.1 Growth Rate of Asian Redtail Catfish (Hemibagrus nemurus)

The absolute weight growth of Asian redtail catfish fed with vitamin C supplement and thyroxine hormone with different doses during 50 days of rearing gave an influence between treatments ($p<0.05$), which ranged from 7.25-12.97g. The measurement results of absolute weight growth of Asian redtail catfish during the study can be seen in Table 2.

Table 1. Absolute weight growth of Asian redtail catfish (*H.nemurus*)

Hormone (H) (mg/kg)	Vitamin (V) (mg/kg)			Average
	V0 (0)	V1 (500)	V2 (1000)	
H0 (0)	7,25±0,25^a	8,90±0,10^c	10,18±0,24^e	8,78±1,29^a
H1 (4)	8,30±0,10^b	9,83±0,34^e	11,87±0,24^g	10,00±1,56^b
H2 (6)	8,84±0,05^c	10,13±0,23^e	12,35±0,06^h	10,44±1,54^c
H3 (8)	9,38±0,13^d	11,23±0,23^f	12,97±0,23^i	11,20±1,45^d
Average	8,44±0,83^a	10,02±0,89^b	11,84±1,09^c	

Notes: Superscript in the same column and row indicates significant difference ($p<0.05$).

The provision of hormone T_4 in feed with different doses influenced the growth of absolute weight of Asian redtail catfish ($p<0.05$). The provision of hormone T_4 with a dose of 8 mg/kg feed gave the highest absolute weight

growth of 11.20 g with a percentage increase in fish weight of 91%, while the absolute weight growth of Asian redtail catfish without the provision of hormone T_4 gave the lowest growth of 8.78g.

The high growth of absolute weight in the provision of hormone T_4 dose of 8 mg/kg of feed, this is because the addition of the hormone thyroxine with the right dose in the feed in addition to improving the metabolic system can also improve the quality of feed and the level of feed consumption that is utilized effectively and optimally by fish, so that the feed provided is actually utilized as the fish nutrient intake needed to produce faster growth. This is in accordance with the results of research by Susanti et al. (2016), giving thyroxine at a dose of 6 mg/kg of feed gives the best results on the growth of absolute weight of paweh (*Osteochillus hasselti* CV) of (5.12 ± 1.70 g). The low growth of absolute weight of Asian redtail catfish without the provision of hormone T4, this is because without the provision of hormone T4 in the feed can not increase the metabolism of fish in spurring the growth rate. The function of thyroxine hormone helps regulate fish metabolic processes and spur growth rate, increase appetite, increase body weight and increase the speed of food absorption.

The provision of vitamin C in feed with different doses influenced the growth of absolute weight of Asian redtail catfish ($p<0.05$). Giving vitamin C at a dose of 1000 mg/kg feed gave the highest absolute weight growth of 11.84 g with a percentage increase in fish weight of 127%, while the absolute weight growth of Asian redtail catfish without giving vitamin C gave the lowest growth of 8.44 g. The high growth of absolute weight with the provision of vitamin C at a dose of 1000 mg / kg of feed, this is because vitamin C can adsorb and can metabolize iron. This is according to Syatriani & Astrina (2010), one of the functions of vitamin C is absorption and metabolism of iron. Vitamin C reduces ferrous iron to ferrous in the small intestine so that it is easily absorbed to increase growth. According to Pakaya (2014), vitamin C is absorbed through the gastrointestinal tract, at the top of the small intestine by diffusion and then enters the blood circulation through the portal vein. Vitamin C is widely distributed in body tissues. When compared to the results of research by Farida et al. (2014) biawan (*Helostoma temmincki*) given vitamin C 200 mg/kg feed resulted in a significant increase in growth. Furthermore, research on the addition of vitamin C can significantly improve fish performance and growth (Abadi et al., 2018; Ghafarifarsani et al., 2022; Narra et al., 2015; Rahimnejad et al., 2021).

The low growth of absolute weight without the provision of vitamin C, this is because without the addition of vitamin C from the feed, it cannot increase the physiological response of fish in apportioning and metabolizing iron in the body, so that the resulting growth is lower than the treatment given vitamin C and the presence of vitamin C cannot be produced by the fish body itself, must be obtained from feed intake. This is according to research by Farida et al. (2014), biawan treatment without vitamin C resulted in lower growth compared to the treatment given vitamin C.

The specific growth rate of bream fed with vitamin C supplement and thyroxine hormone at different doses during 50 days of rearing gave an effect between treatments ($p<0.05$), which ranged from 1.29-1.93%. The measurement results of specific growth rate of Asian redtail catfish during the study can be seen in Table 3.

Table 3. Specific growth rate of Asian redtail catfish (*H. nemurus*)

Hormone (H) (mg/kg)	Vitamin (V) (mg/kg)			Average
	V0 (0)	V1 (500)	V2 (1000)	
H0 (0)	1,29±0,03^{a}	1,50±0,02^{c}	1,64±0,03^{e}	1,48±0,15^{a}
H1 (4)	1,42±0,02^{b}	1,60±0,04^{e}	1,82±0,03^{g}	1,62±0,17^{b}
H2 (6)	1,49±0,01^{c}	1,64±0,03^{e}	1,87±0,01^{h}	1,66±0,01^{c}
H3 (8)	1,55±0,02^{d}	1,76±0,03^{f}	1,93±0,02^{i}	1,75±0,02^{d}
Average	1,44±0,10^{a}	1,62±0,10^{b}	1,81±0,11^{c}	

Notes: *Superscript* in the same column and row indicates significant differences ($p<0.05$)

Based on Table 3, the combination of vitamin C + thyroxine hormone added to the feed gives an effect between treatments on the growth of absolute weight of Asian redtail catfish ($p<0.05$). The highest specific growth rate value of bream during maintenance is in the treatment of a combination of vitamin C + thyroxine hormone with a dose of vitamin C 1000 mg/kg and hormone T_4 8 mg/kg of feed, which is 1.93%. This shows that the dose of vitamin C and thyroxine hormone can increase the growth rate of Asian redtail catfish because the function of vitamin C and thyroxine hormone functions in increasing the body's metabolic processes so that rapid growth can develop normally and to support its survival.

Vitamin C with different doses added to the feed on the specific growth rate of Asian redtail catfish ranged from 1.44-1.81%. The addition of vitamin C to the feed influenced the specific growth rate during rearing ($p<0.05$). The highest specific growth rate was 1.81% by giving vitamin C at a dose of 1000 mg/kg feed. When compared with the results of Abadi et al. (2022), giving vitamin C at a dose of 400 mg/L to catfish (*Clarias* sp), resulted in the highest specific growth rate of 0.148 g/day.

The high specific growth rate in the treatment of vitamin C at a dose of 1000 mg/kg feed, this is because the addition of vitamin C can increase growth to be more significant. According to Adeoye et al. (2016) the increase in growth that occurs in fish is due to increased enzyme performance so that the absorption of nutrients becomes better. This also means that the use of protein as an energy source goes well due to the role of vitamin C which can improve the physiological functions of fish, improve growth and blood conditions of fish.

The provision of thyroxine hormone in feed with different doses influenced the specific growth rate of Asian redtail catfish ($p<0.05$). The provision of hormone T_4 at a dose of 8 mg/kg feed gave the highest absolute weight growth of 1.75% while the absolute weight growth of Asian redtail catfish without hormone T_4 gave the lowest growth of 1.48%. The addition of vitamin C + thyroxine hormone in combination gives an effect on the absolute weight of bream raised optimally, vitamin C and thyroxine hormone are able to work together to stimulate an increase in metabolic and physiological rates, so that appetite increases as a result of rapid cell division and the formation of new cells and to support the survival of fish.

Vitamin C has many functions in relation to cellular respiration and enzyme action. The role of vitamin C is the oxidation of phenylalanine to tyrosine, reduction of ferric ions to ferrous in the digestive tract so that iron ions are easily absorbed, converting folic acid to folinic acid (in the active form) and playing a role in the formation of steroid hormones from cholesterol (Fujaya, 2004). Vitamin C is a catalyst in the process of food metabolism and fish physiology to maintain health (Khan et al., 2017).

Lovell (1979) states that vitamin C deficiency in feed shows symptoms of low feed efficiency and slow growth. High feed efficiency indicates efficient use of feed so that some of the food substances are broken down to meet energy needs and the rest is used for growth, resulting in high fish growth. In addition, thyroxine hormone (T_4) mixed or added to feed can help regulate metabolic processes and spur growth rates in fish and increase the speed of food absorption by fish (Yandra et al., 2020). The hormone thyroxine can increase the activity of protease and lipase in the digestive tract so as to increase protein and fat metabolism in the body. Protease is an enzyme that hydrolyzes protein into amino acids and simple peptides, while lipase is an enzyme that hydrolyzes fat into glycerol and fatty acids which will then be absorbed through the intestinal.

3.2. Survival Rate of Asian Redtail Catfish

The survival of Asian redtail catfish reared with the addition of different doses of vitamin C and thyroxine hormone in each treatment on the feed affects the survival ranging from 70-95% ($p<0.05$). The highest survival rate during maintenance is in the treatment of a combination of vitamin C 1000 mg/kg feed + thyroxine hormone 8 mg/kg feed, which is 95%. While the lowest value in the treatment without the addition of vitamin C and thyroxine hormone with 70% survival rate. The results of the measurement of the survival rate during the study can be seen in Table 4.

Table 4. Survival rate of Asian redtail catfish (*H.nemurus*)

Hormone (H) (mg/kg)	Vitamin (V) (mg/kg)			Average
	V0 (0)	V1 (500)	V2 (1000)	
H0 (0)	70,00±0,00^{a}	76,67±2,89^{bcd}	88,33±2,89^{f}	78,33±8,29^{a}
H1 (4)	71,67±2,89^{ab}	78,33±2,89^{cde}	90,00±0,00^{fg}	80,00±8,29^{ab}
H2 (6)	73,33±2,89^{abc}	80,00±5,00^{de}	96,67±2,89^{fg}	81,67±8,66^{b}
H3 (8)	75,00±0,00^{abcd}	83,33±2,89^{e}	95,00±0,00^{g}	84,44±8,82^{c}
Average	72,50±2,61^{a}	79,58±3,96^{b}	91,25±3,11^{c}	

Notes: *Superscript* in the same column and row indicates significant differences ($p<0.05$)

The addition of 1000 mg/kg vitamin C and 8 mg/kg thyroxine hormone gave the highest survival rate of 95.00%. This shows that the combination of vitamin C and thyroxine hormone can increase the immune system and metabolic rate of fish. When compared to bream given control feed (without the addition of vitamin C and thyroxine hormone) resulted in a survival rate of 70.00%.

The addition of vitamin C is needed by the fish body to increase metabolism, resistance to environmental changes and disease (Suwirya et al., 2008). According to Hidayat (2012), the provision of the hormone thyroxine can increase, so that the better the metabolism in the fish body, the appetite increases, the fish body's resistance to the surrounding environment will be better so that fish mortality is smaller. The addition of vitamin C with different doses in feed has an effect between treatments ($p<0.05$). The highest survival rate of bream in the addition of vitamin C 1000 mg/kg feed, which is 91.25%. While without the addition of vitamin C, which is 72.50%. This shows that the addition of vitamins can increase the immune system of fish, so as to increase fish survival. According to Mudiarti et al. (2019), vitamin C deficiency will not only reduce growth but will also increase mortality. The absence of vitamin C in the feed will increase the mortality rate. This is thought to be due to the function of vitamin C, which is to increase the body's resistance to stress during maintenance.

The provision of thyroxine hormone in feed with different doses influenced the survival rate of bream, which ranged from 70-75% ($p<0.05$). The provision of T4 hormone at a dose of 8 mg/kg feed gave the highest survival rate, which was 84.44%. It is suspected that the provision of thyroxine hormone can increase fish metabolism in the formation of energy, so that the energy needed by fish is fulfilled. According to Heraedi et al. (2018), the provision of thyroxine hormone can increase the metabolic rate of the fish body in the process of converting food substances into energy or ATP, so that the body's resistance to the environment will also increase because the energy needs of the feed are met.

3.3. Water Quality

Water quality is a limiting factor for the type of biota cultivated in a water body. Temperature plays an important role in determining the growth of cultured fish. Water quality measured during the study were temperature, pH, and DO. Water quality during the study is presented in Table 5.

Table 5. Water quality during the study

No.	Parameters	Beginning of Research	End of Research	Water quality standards (Tang, 2003)
1	Temperature (°C)	29-31	28-30	27-33°C
2	pH	6,5	7,0	4-9
3	DO (ppm)	5,2-5,95	4,2-4,75	1-9 ppm

Based on Table 5. it can be seen the results of water quality measurements during the rearing period of bream. The temperature value in the research container ranged from 28-31^{0}C. Optimal water temperature will increase fish feeding activity, thus accelerating growth (Primaningtyas et al., 2015). The pH of the water medium for rearing mackerel during the rearing period ranged from 6.5-7.0 The pH value of cultured water can still be tolerated by fish in accordance with Tang (2003) which states that a good pH value for mackerel is 5-9. Dissolved oxygen values during the study ranged from 4.2-5.92 ppm. This range of DO values is still within the tolerance of good values for fish. Priadi & Sundari (2019) stated that the oxygen concentration that can support the life of organisms in the waters is 4-6.8 ppm.

4. Conclusions

The addition of vitamin C and thyroxine hormone influenced the growth and survival of bream reared in the recirculation system. The combination of vitamin C 1000 mg/kg and thyroxine hormone 8 mg/kg feed gave the highest growth rate of bream, such as absolute weight growth of 12.97 g, specific growth rate of 1.93 g/day, and 95% survival rate. Water quality during rearing was favorable for bream growth, with temperature ranging from 28-30oC, pH 6.5-7.0, and DO 4.2-5.95 ppm.

5. Suggestion

It is recommended to use a combination of vitamin C 1000 mg/kg and thyroxine hormone 8 mg/kg feed so that the growth and survival of bream can be improved.

6. References

Abadi, A.S., Hariati, A.M., Sanoesi, E. (2018). Effect of add vitamins C in spesific growth rate of red rainbow fish (*Glossolepsis incisus* Weber). *Jurnal Airaha*, 7(2).

Abadi, A., Romboisano, N.W., Lalaem, Y.M., Hismayasari, I.B., Puspitasari, A.W. (2022). Peningkatan laju pertumbuhan spesifik ikan lele (*Clarias* sp) dengan suplementasi vitamin C pada pakan. *Journal of Fish Nutrition*, *2*(1): 89-100.

Adeoye, A.A., Yomla, R., Jaramillo-Torres, A., Rodiles, A., Merrifield, D.L., Davies, S.J. (2016). Combined effects of exogenous enzymes and probiotic on Nile tilapia (*Oreochromis niloticus*) growth, intestinal morphology and microbiome. *Aquaculture*, 463: 61-70.

Arifin, O.Z., Prakoso, V.A., Suhud, E.H., Subagja, J. (2020). Growth performance of domesticated asian redtail catfish (*Hemibagrus nemurus*) fingerlings at different stocking densities. *Indonesian Aquaculture Journal*, 15(1): 1-6.

Braga, E.S., Azevedo J.S., Oliveira A.L., Favaro D.I.T. (2017). Trace elements and nuclear abnormalities in fish species of two brazilianestuarine regions an attempt to increase the matrix for environmental monitoring. *Journal of Aquaculture and Marine Biology*, 6(2): 1-11.

Dedi, D., Irawan, H., Putra, W.K.A. (2018). Pengaruh Pemberian hormon tiroksin pada pakan pellet megami terhadap pertumbuhan benih ikan kerapu cantang (*Epinephelus fuscoguttatus-Lanceolatus)*. *Intek Akuakultur*, 2(2): 33-48.

Effendie, M.I. (2002). *Biologi Perikanan*. Yogyakarta. Yayasan Pustaka Nusantara. p163.

Farida, H., Hasan, H., Dayanti, F. (2014). Pengaruh vitamin C dalam pakan terhadap pertumbuhan dan sintasan benih ikan biawan (*Helostoma temmincki*). *Jurnal Ruaya Fakultas Perikanan dan Ilmu Kelautan Universitas Muhammadiyah Pontianak*, 3(1): 41-47.

Fujaya, Y. (2004). *Fisiologi ikan dasar pengembangan teknik perikanan*. Rineka Cipta. Jakarta. p179.

Ghafarifarsani, H., Hoseinifar, S.H., Javahery, S., Yazici, M., Van Doan, H. (2022). Growth performance, biochemical parameters, and digestive enzymes in common carp (*Cyprinus carpio*) fed experimental diets

supplemented with vitamin C, thyme essential oil, and quercetin. *Italian Journal of Animal Science*, 21(1): 291–302.

Heraedi, A., Prayitno, S.B., Yuniarti, T. (2018). The Effect of different thyroxine hormone (T_4) concentration on the growth, survival, and pigment development of pink zebra fish larvae (*Brachydanio reiro*). *Omni-Akuatika*, 14(2): 21–28

Hidayat, R. (2012). Enlargement of selais (*Ompok hypopthalmus*) with fish meal containing thyroxine (T_4) Hormones. Fakultas Perikanan dan Ilmu Kelautan. Universitas Riau. Riau.

Khan, K.U., Zuberia, A., Nazirb, S., Ullaha, I., Jamila, Z., Sarwara, H. (2017). Synergistic effects of dietary nano selenium and vitamin C on growth, feeding, and physiological parameters of mahseer fish (*Tor putitora*). *Aquaculture Reports*, 5(1): 70-75.

Lovell, R.T. (1979). Factor effecting valutary food comsumption by channel catfish. pp 563- 571. In Proceding of Southestry Association of Fish and Wild Life. Agency Squthesqestery Coop. N.Y.

Monentcham, S.E., Pouomogne, V., Kestemont, P. (2010). Influence of dietary protein levels on growth performance and body composition of afican bonytongue fingerlings *Heterotis niloticus*. *Aquaculture Nutrition*, 16(2): 144–152.

Mudiarti, L., N. Kursistiyanto. (2019). Pemanfaatan asam askorbat dalam perekayasaan pakan untuk meningkatkan pertumbuhan dan kelulushidupan benih ikan kerapu macan (*Ephinephelus fuscoguttatus*). *Eksakta: Jurnal Ilmu-Ilmu MIPA*, 19(2): 169-181.

Narra, M.R., Rajender, K., Reddy, R., Rao, J.V., Begum, G. (2015). The role of vitamin C as antioxidant in protection of biochemical and haematological stress induced by chlorpyrifos in freshwater fish Clarias batrachus. *Chemosphere*, 132:172–178.

Pakaya, D. (2014). Peranan Vitamin C. *Jurnal Ilmiah Kedokteran*, 1(2): 45-54.

Priadi, B., Sundari, S. (2019). Pertumbuhan dan sintasan ikan baung (*Hemibagrus nemurus*) (Valenciennes, 1840) hasil domestikasi. *Buletin Teknik Litkayasa Akuakultur*, 17(1): 19-21

Primaningtyas, A.W., Hastuti, S., Subandiyono. (2015). Performa produksi ikan lele (*Clarias gariepinus*) yang dipelihara dalam sistem budidaya berbeda. *Journal of Aquaculture Management and Technology*, 4(4): 51-60.

Rahimnejad, S., Dabrowski, K., Izquierdo, M., Hematyar, N., Imentai, A., Steinbach, C., Policar, T. (2021). Effects of vitamin C and E supplementation on growth, fatty acid composition, innate immunity, and antioxidant capacity of rainbow trout (*Oncorhynchus mykiss*) fed oxidized fish oil. *Frontiers in Marine Science*, 8.

Saputra, A., Tarsim, T., Elisdiana, Y. (2017). Pengaruh perendaman benih ikan baung (*Hemibagrus nemurus*) pada umur yang berbeda dalam hormon pertumbuhan rekombinan (Rgh) dengan dosis yang berbeda terhadap pertumbuhan dan kelulushidupan. *Jurnal Sains Teknologi Akuakultur*, 1(2):119-126.

Susanti, N.M., Sukendi, S., Syafriadiman, S. (2016). Efektivitas pemberian hormon tiroksin (T_4) terhadap pertumbuhan ikan pawas (*Osteochillus hasselti CV)*. *Jurnal Perikanan dan Kelautan*, 21(2): 26-31.

Suwirya, K., Marzuqi, M., Giri, N.A. **(**2008). *Informasi nutrisi ikan untuk menunjang pengembangan budidaya laut*. Balai Besar Riset Perikanan Budidaya Laut Gondol. 8.

Syatriani, S., Astrina, A. (2010). Konsumsi makanan dan kejadian anemia pada siswi salah satu SMP di Kota Makassar. *Jurnal Kesehatan Masyarakat Nasional*, 4(8): 251-254.

Tang, U.M. (2003). *Teknik budidaya ikan baung*. Kanisius. Yogyakarta.

Verawati, Y. (2017). Pengaruh perbedaan padat penebaran terhadap pertumbuhan dan kelangsungan hidup benih ikan gurami (*Osphronemus gouramy*) pada sistem resirkulasi. *Jurnal Mina Sains*, 1(1): 6-12.

Wardani, R., Nugroho, F., Arief, H. (2018). Hubungan produksi dan permintaan ikan baung (*Mystus Nemurus*) di Desa Sungai Paku Kecamatan Kampar Kiri Kabupaten Kampar Provinsi Riau. *Jurnal Online Mahasiswa (JOM) Bidang Perikanan dan Ilmu Kelautan*, 5(2):1-11.

Wirdona, M., Riauwaty, M., Syawal, H. (2019). Pemberian pakan yang diperkaya vitamin C untuk meningkatkan imunitas ikan nila (*Oreochromis niloticus*). *Jurnal Online Mahasiswa (JOM) Bidang Perikanan dan Ilmu Kelautan*, 3(2): 1-8.

Yandra, E., Tang, U.M., Syawal, H. (2020). Efektivitas pemberian hormon tiroksin (T_4) dan photoperiode terhadap pertumbuhan ikan baung (*Mystus nemurus*). *Jurnal Ruaya: Jurnal Penelitian dan Kajian Ilmu Perikanan dan Kelautan*, 8(2):153-162.