The Effect of Dietary Chromium on Growth and Survival Rate of Tilapia (Oreochromis niloticus)

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The Effect of Dietary Chromium on Growth and Survival Rate of Tilapia (*Oreochromis niloticus*)

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ABSTRACT

This research was conducted to determine the role of chromium (Cr^{+3}) on the growth and survival of tilapia (*O. niloticus*). This was carried out from May to July 2019 at the Fish Seed Center, Siwarak, Central Java. Tilapia with body weight of 5.97±0.28 g was used in this study and cultured for 42 days. Plastic containers with a volume of 200 L are used for rearing with a stocking density of 200 fish. During the experiment, the fish were fed twice a day, using the ad satiation method. Completely Randomized Design (CRD) with 4 dietary chromium treatments used, namely A (2 mg Cr^{+3} kg^{-1} diet), B (4 mg Cr^{+3} kg^{-1} diet), C (6 mg Cr^{+3} kg^{-1} diet), and D (8 mg $Cr^{+3}kg^{-1}$ feed). Experiment using 5 replications. Measurement of variables were consisting of total feed consumption (TFC), feed utilization efficiency (FUE), protein efficiency ratio (PER), protein digestibility, relative growth rate (RGR), and survival rate (SR). The results showed that dietary chromium had a significant effect ($P<0.05$) on TFC, FUE, PER, protein digestibility, and RGR values, but it had no effect on SR values ($P>0.05$). Treatment B showed the highest values for TFC (161.66±0.82 g), FUE (34.51±1.25%), PER (1.18±0.04%), protein digestibility (99.89%), and RGR (2.15±0.08% day^{-1}). The optimum dose of dietary chromium for maximum fish growth was 3.49 mg kg^{-1} diet.

Keywords: dietary chromium, growth, survival, tilapia.

ABSTRAK

Penelitian ini bertujuan untuk mengkaji peran kromium dalam pakan terhadap pertumbuhan dan kelngsungan hidup ikan nila (*O. niloticus*). Penelitian ini dilakukan pada bulan Mei hingga Juli 2019 di Balai Benih Ikan (BBI), Siwarak, Jawa Tengah. Ikan uji berbobot (5.97±0.28 g) dipelihara selama 42 hari dalam bak plastik bervolume 200 L dan kepadatan 200 ikan. Selama pemeliharaan, Ikan diberi pakan 2 kali per hari dengan metode *ad satiation*. Penelitian ini menggunakan rancangan acak lengkap (RAL) dengan 4 perlakuan Chromium pakan, yaitu A (2 mg Cr^{+3} kg^{-1} pakan), B (4 mg $Cr^{+3}kg^{-1}$ pakan), C (6 mg $Cr^{+3}kg^{-1}$ pakan), dan D (8 mg $Cr^{+3}kg^{-1}$ pakan). Tiap petcobana dilakukan 5 ulangan. Variabel yang diukur adalah total konsumsi pakan (TKP), efisiensi pemanfaatan pakan (EPP), rasio efisiensi protein (PER), kecernaan protein, laju pertumbuhan relatif (RGR), dan kelulushidupan (SR). Hasil penelitian menunjukkan bahwa kromium pakan memberikan pengaruh nyata ($P<0.05$) terhadap nilai TKP, EPP, PER, kecernaan protein, dan RGR, namun tidak berpengaruh ($P>0.05$) terhadap nilai SR. Perlakuan B menghasilkan nilai tertinggi untuk TKP (161.66±0.82 g), EPP (34.51±1.25%), PER (1.18±0.04%), kecernaan protein (99.89%), dan RGR (2.15±0.08% $hari^{-1}$). Dosis optimum kromium pakan untuk pertumbuhan maksimum ikan nila sebesar 3.49 mg kg^{-1}.

Kata-kata kunci: kromium pakan, pertumbuhan, kelulushidupan, ikan nila.

1. Introduction

Tilapia (*Oreochromis niloticus*) is one of the economically important freshwater fish in Indonesia. According to Subandiyono and Hastuti (2016), tilapia is classified into omnivorous fish. Amarwati et al (2015), said that omnivorous fish was able to digest dietary carbohydrates of 20-40%. Tilapia has a weakness as unable to utilize dietary

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carbohydrates more efficiently. Putra (2016), said that carbohydrate digestibility in fish was relatively low because the availability and activity of the amylase enzyme in the digestive tract of fish are quite low. The fish ability to digest carbohydrates is lower compared to terrestrial animals, and each type of fish have different capabilities.

Carbohydrates are organic compounds formed from three elements, namely carbon, oxygen, and hydrogen. According to Yanto et al (2018), carbohydrate is one of the main energy sources, so its existence is one of the most important factors in the body of fish. The energy that carbohydrate produced will be used for fish metabolism, and the rest will be used for growth. According to Tang et al (2018), metabolism in every fish is different depending on the needs of his body. Fish metabolism can also be influenced by the environment. If the utilization of non-protein sources (fats and carbohydrates) was less than optimal then the lack of energy may be taken from the results of protein conversion through the process of catabolism. So, the growth becomes less optimal. Subandiyono and Hastuti (2016), said that the fish growth occurs when the metabolic energy needs are met, and the remaining available energy is used for fish maintenance and growth.

The efforts that can be done to increase growth in tilapia is by adding chromium, to help increasing the digestibility of carbohydrates to maximize the role of protein for fish growth. Chromium is a micro-mineral that can help improve insulin performance so that glucose in the blood immediately enters the cell and used for energy metabolism. Fulfillment of metabolic energy can be done by adding energy derived from non-protein sources, so that protein can be used efficiently for growth. Subandiyono and Hastuti (2016), said that the chromium requirement of carnivorous fish was higher than herbivorous fish. According to Subandiyono (2004), chromium plays an important role on increasing the work of insulin in the body, so that chromium can increase utilization efficiency of fish feed. Carbohydrates can be used efficiently for metabolic energy, so that the role of protein can be used more optimally for growth. The aims of the research were to observe the role of chromium (Cr^{+3}) on the growth and survival rate of tilapia (O. niloticus). It was expected that with the addition of supplemental chromium the growth of tilapia will be optimal and can be positively correlated with the survival rate of tilapia.

2. Materials And Methods

Fish used for this study had an average body weight of 5.5-6.3 g /fish. The trial fish was obtained from the Fish Seed Center (BBI), Siwarak, Ungaran, Central Java. The fish used for study was raised for 42 days. The fish was acclimatized for a week, so the fish will not experience stress. The experimental feeds were given after the fish passed for 1 day with no feed given to empty its metabolism. The rearing container used 20 containers with 4 treatments each consisting of 5 replicates. The fish rearing was carried out in a plastic container has a volume of 200 L, with density of 1 fish each liter of water.

The experimental feed used was an artificial feed with the addition of chromium (Cr^{+3}) as follows, A (2 mg $Cr^{+3}kg^{-1}$ diet), B (4 mg $Cr^{+3}kg^{-1}$ diet), C (6 mg $Cr^{+3}kg^{-1}$ diet), and D (8 mg $Cr^{+3}kg^{-1}$ diet). Feeding was carried out using at satiation method twice a day, i.e. at 8:00 am and 16:00 pm. The results of proximate analysis of feed after the addition of chromium can be seen in Table 1.

The method used in this study was the experimental method. The experimental design used was a completely randomized design (CRD) with 4 treatments and 5 replicates. This study used the treatments with chromium doses as follows:

Table 1. Proximate Analysis of Feed Treatment

Treatments	Proximate Analysis					
	Water (%)	Protein (%)	Fat (%)	NFE (%)	CF (%)	Ash (%)
2 mg $Cr^{+3}kg^{-1}$ diet	7.96	28.85	9.99	37.66	4.70	10.84
4 mg Cr^{+3} kg^{-1} diet	11.76	29.25	13.80	32.45	3.29	9.45
6 mg Cr^{+3} kg^{-1} diet	11.70	28.50	12.91	34.05	4.43	8.41
8 mg Cr^{+3} kg^{-1} diet	10.94	28.85	13.82	33.69	3.75	8.95

Source: Chemistry Laboratory of Central Java Agricultural Research and Development Agency (2019)

A: Feed treatment with chromium of 2 mg $Cr^{+3}kg^{-1}$ diet.
B: Feed treatment with chromium of 4 mg $Cr^{+3}kg^{-1}$ diet.
C: Feed treatment with chromium of 6 mg $Cr^{+3}kg^{-1}$ diet.
D: Feed treatment with chromium of 8 mg $Cr^{+3}kg^{-1}$ died.

2.1 Method of Collecting Data

a. Total Feed Consumption

Feed is given with at satiation method (feeding the fish bit by bit until the fish was full), the rest of the feed that was not consumed was weighed again. The weight of the initial feed was reduced by the remaining feed that was not consumed was said to be the final result of the Feed Consumption Rate (Pereira et al ,2007).

b. Feed Utilization Efficiency

The formula used to calculate the Feed Utilization Efficiency (FUE) according to Tacon (1987):

10

$$\text{EFU} = \frac{Wt-W0}{F} \times 100\%$$

where:

FUE	=	Feed utilization efficiency (%)
Wt	=	Total weight of fish at the end of the study (g)
W0	=	Total weight of fish at the beginning of the study (g)
F	=	Total weight of feed given during rearing (g).

c. Protein Efficiency Ratio

The formula used to calculate the Protein Efficiency Ratio (PER) according to Tacon (1987):

$$\text{PER} = \frac{Wt-W0}{Pi} \times 100\%$$

where:

PER	=	Protein Efficiency Ratio (%)
Wt	=	Total weight of fish at the end of the study (g)
W0	=	Total weight of fish at the beginning of the study (g)
Pi	=	Weight of feed consumed x% protein content in feed (g)

d. Protein Digestion

Calculation of the formula for protein digestion according to Subandiyono and Hastuti (2016) was as follows:

Feed Protein Digestion =

$$100 - (100 \times \frac{\%\ \text{Indicator inside feed}}{\%\ \text{Indicator insinde feces}} \times \frac{\%\ \text{Feces Nutrient}}{\%\ \text{Feed Nutrient}})$$

e. Relative Growth Rate

The formula used to calculate the relative growth rate (RGR) according to Subandiyono and Sri Hastuti (2014) and De Silvia and Anderson (1995) was as follows:

$$\text{RGR} = \frac{Wt-W0}{W0 \times t} \times 100\%$$

where:

RGR	=	Relative growth rate (%/day)
Wt	=	Total weight of fish at the end of the study (g)
W0	=	Total weight of fish at the beginning of the study (g)
t	=	Length of culture (days) .

f. Survival Rate

The formula used to calculate the survival rates (SR) according to Dauda et al (2018) was as follows:

$$\text{SR} = \frac{Nt}{N0} \times 100\%$$

where:

SR = Survival rate (%)
Nt = Total of fish at the end of study (Fish).
N0 = Total of fish at the beginning of study (Fish).

g. Water Quality

Water quality data measured include pH, DO (dissolved oxygen), temperature, and ammonia. Water quality measurements were carried out 2 times a day at 6:00 am and 16:00 pm. Measurements of DO and ammonia were performed at the beginning, middle, and end of the study. The DO, temperature, and pH were measured by a water quality checker (YSI 550A).

2.2. Data Analysis

Data generated from the study include TFC, FUE, PER, protein digestibility, RGR, SR then analyzed using analysis of variance (ANOVA) with SPSS 22.0 software. The data that has been collected were tested by normality test, homogeneity test, additive test, and analysis of variance (ANOVA). If the analysis of variance (ANOVA) results obtained have a significant effect ($P<0.05$), then the Duncan test was performed to determine the mean value between treatments. Water quality data used descriptive analysis.

3. Results and Discussion

The results of analysis of variance that have been done show that the addition of chromium to artificial feed has significantly effect (P<0.05) on Total Feed Consumption (TFC), Feed Utilization Efficiency (FUE), Protein Efficiency Ratio (PER), and Relative Growth Rate (RGR). The addition of chromium had no significantly effect (P>0.05) on the survival rate (SR) (Table 2).

3.1. Total Feed Consumption

The addition of chromium to artificial feed had a significant effect (P<0.05) on the total feed consumption (TFC) of tilapia (*O. niloticus*). The addition of chromium resulted in different levels of feed consumption for each treatment A, B, C, and D of 160.03±1.32, 161±0.82, 152.67±2.20 and 148.04±1.34 g. The value of feed consumption in treatments A and treatment B was not significantly different, whereas in treatments C and D decreased, the addition of chromium increased the level of feed consumption at certain concentrations. Adding chromium to fish feed can reduce the stress level of fish, this can be seen through the behavior of feeding before using treatment feed. Fish that are fed using non-chromium (commercial) feed tend to be more aggressive than chromium-treated feed. Stress levels can affect the appetite of fish. Hastuti (2004), states that stress levels will affect appetite and feed consumption, intestinal absorption and metabolic rate. Another thing that is thought to affects the level of feed consumption is the addition of chromium will affect glucose levels in the blood. According to Subandiyono (2004), an increase in chromium to 6.6 ppm Cr^{+3} in gourami fish resulted a delay in decreasing blood glucose levels, such as in fish that consume feed without chromium. Hastiadi and Farida (2019), stated that the level of blood glucose affects the level of feed consumption. Akbar et al (2011), say that blood glucose content changes, before being fed is the lowest point, and after being fed increases, then after the peak point is reached, there will be a decrease with increasing time after being fed.

The results of study shows that the known factors that influence the level of consumption of tilapia feed include stress levels and the rate of glucose in the blood. Fish fed with the addition of chromium treatment tend to be calmer. Hastuti (2004) said that the addition of chromium can reduce cortisol levels, cortisol is a hormone that can control stress. Furthermore, Hastuti (2004) said that the mechanism of suppression of post-stress glucose and cortisol levels was thought to be related to insulin activity caused by Cr^{+3}-yeast. The addition of chromium will affect the level of glucose in the blood. The addition of chromium in the range of 4 mg/kg gives an effect on increasing the rate of glucose flow into the blood and offset the absorption of glucose into cells for use as energy. The increase in the rate of glucose flow into cells is caused by the increase in insulin performance. According to Ivandari et al (2019), energy needs can be met if glucose in the blood can enter the cell immediately, and this depends on insulin performance. The balance pattern will be followed by a decrease in glucose which causes the fish to feel hungry.

3.2. Feed Utilization Efficiency

The addition of chromium to artificial feed had a significantly effect (P<0.05) on the efficiency of tilapia (*O. niloticus*) feed

Table 2. Results of Total Feed Consumption (TFC), Feed Utilization Efficiency (FUE), Protein Efficiency Ratio (PER), Protein Digestibility, Relative Growth Rate (RGR), and Survival Rate (SR))

Biological Variables	Treatments			
	A (2 mg/kg)	B (4 mg/kg)	C (6 mg/kg)	D (8 mg/kg)
TFC (g)	160.03±1.32^c	161.66±0.82^c	152.67±2.20^b	148.04±1.34^a
EFU (%)	30.49±0.77^c	34.51±1.25^d	26.73±0.73^b	24.42±1.64^a
PER (%)	1.06±0.03^c	1.18±0.04^d	0.94±0.03^b	0.85±0.06^a
Protein Digestibility (%)	99.62	99.89	99.88	99.78
RGR (%/day)	1.90±0.04^c	2.15±0.08^d	1.69±0.03^b	1.49±0.11^a
SR (%)	94.00±5.48^a	94.00±5.48^a	92.00±4.47^a	94.00±5.48^a

Note: Variable values on the same line with different superscript letters show significantly different values (P<0.05).

utilization. The highest value of feed utilization efficiency (FUE) was in treatment B (34.51±1.25%), followed by treatment A (30.49±0.77%), treatment C (26.73±0.73%), and treatment D (24.42±1.64%). The value of FUE in treatment B is higher than treatment A, C, and D. The addition of chromium affects the level of FUE, this happened because chromium is able to make the fish calm so that energy is not much wasted for basal metabolism. Non-excessive energy expenditure can maximize energy for growth. According to Budiasih (2016), the role of trivalent chromium is to help the process of glucose metabolism with the help of insulin activity so that glucose immediately enters the cell membrane and can be converted into energy. The remaining energy will be stored in the form of glycogen and fat. The best value of FUE is obtained from treatment B with a dose of 4mg/kg.

Feed utilization is said to be efficient if the feed is used well for growth. Centyana et al (2014) said that feed efficiency will always be positively correlated with growth, if fish are able to utilize feed maximally, the resulting growth will be fast. According to Setiyowati (2017), the efficient use of feed is when the feed consumed can be used efficiently for growth. Rambo et al (2018) state that feed efficiency is the ratio between the amount of feed eaten and the body weight produced.

3.3. Protein Efficiency Ratio

The addition of chromium to artificial feed had a significant effect ($P<0.05$) on the protein efficiency ratio (PER) of tilapia (*O. niloticus*). The value of PER of each treatment is significantly different, the value of PER for each treatment A, B, C, and D was 1.06±0.03, 1.18±0.04, 0.94±0.03 and 0.85±0.06%. The highest value was in treatment B followed by treatments A, C, and D. The protein content contained in the feed from the results of sequential laboratory tests were A (28.85%), B (29.25%), C (28.50%) and D (28.85%), from these results the highest value of feed protein was in treatment B. The addition of chromium affects the protein efficiency ratio, the suppression of the catabolism process causes the amount of protein that enters the body of the fish to be higher. Chromium plays an important role in increasing the efficiency of carbohydrate utilization, so that the energy produced is sufficient for the metabolic process, resulting in a suppression of the catabolism process. The process of catabolism occurs when energy in the body of the fish is not sufficient so that the fulfillment of that energy is produced from the protein degradation from the body of the fish. The best value for Protein Efficiency Ratio is obtained from the treatment B with a dose of 4 mg/kg. According to Sulasi (2005), protein efficiency ratios are used to find out how much amount of protein enters the fish's body.

3.4. Feed Protein Digestion

Protein digestibility for each treatment A, B, C, and D was 99.62, 99.89, 99.88, and 99.78%, respectively. Digestion value between treatments was not significantly different. Feed digestibility is influenced by enzyme activity found in the digestive tract. The metabolic process will take place when the nutrients have been digested and absorbed. Fish have better protein digestibility compared to carbohydrates. So, the protein provided was almost completely absorbed. According to NRC (1993), fish protein digestibility in general was 75-95%. Afzriansyah et al (2014), showed that the best digestibility is 95%. Arief et al (2015), said that high digestibility will occur when more nutrients are absorbed in the fish's body. When fish was able to make optimum use of its feed, optimal growth will occur.

Protein digestibility is the amount of protein that enters and can be absorbed by the digestive tract of fish. Factors affecting the level of protein digestibility are the level of protein content of feed ingredients and the amount of protein that enters the digestion. Ridwan and Andi (2014), said that the factors that influence nutrient digestibility include protein content and protein feed ratio, fish activity, fish size and environmental conditions. The ingredients and the amount of protein used for the study are the same, so that the digestibility value of the protein is not significantly different. According to Agustono (2014), feed digestion means how much nutrients can be absorbed by the digestive tract of the fish's body, the greater the digestibility value of a feed, the more feed nutrients that can be utilized by the fish. Factors that affect the level of feed digestibility are the quality of the feed. The better the quality of feed the better the level of digestibility. Rahmatia (2016), said that the level of digestibility depends on the composition of the feed ingredients, the nutritional content of the feed, and the activity of digestive enzymes in the digestive system of fish.

3.5. Relative Growth Rate

The addition of chromium to artificial feed had a significant effect ($P<0.05$) on the relative growth rate (RGR) of tilapia (*O. niloticus*). The relative growth rates for each treatment A, B, C, and D were 1.90±0.04, 2.15±0.08, 1.69±0.03, and 1.49±0.11%/day, respectively. The best relative growth value is obtained from the treatment B with a dose of 4 mgCr^{+3}/kg of feed. This value is carried out by regression test to produce an optimal dose of 3.49 mgCr^{+3}/kg of feed. The addition of chromium can increase relative growth up to 2.15±0.08%/day. It is thought that the addition of chromium can increase the efficiency of carbohydrate utilization in feed, so that the role of protein can be maximized for growth. The efficiency of carbohydrate utilization is caused by the role of insulin from the addition of chromium. According to Subandiyono (2004), the addition of chromium increases insulin performance so that it can accelerate the rate of blood glucose flow into cells, glucose will be immediately utilized for energy needs. Isa et al (2015) said that trivalent chromium is one of the roles of GTF (Glucose Tolerance Factor), which plays a role in carbohydrate metabolism by increasing insulin activity. Non-protein substances (fats, carbohydrates) were utilized maximally for metabolic energy requirements without taking the role of proteins to spend metabolic energy, so that proteins can be used more efficiently for growth. Chromium of 3.49 mg/kg can function optimally in tilapia.

The results of the laboratory test showed that the protein value contained in the feed was 29.25%. The highest protein value in treatment B compared to other treatments. A higher protein content can contribute to a high growth value. In addition, the role of chromium at a dose of 4mg/kg can increase the efficiency of carbohydrates, so that the energy needs of metabolism can be fulfilled without protein degradation in the body. The role of protein can be used more optimally for growth. According to Akbar et al (2011), the addition of chromium can stimulate insulin performance, so that glucose in the blood can enter the cells immediately to produce energy.

3.6. Survival Rate

The addition of chromium in artificial feed had no significant effect (P>0.05) on the survival rate (SR) of tilapia (*O. niloticus*). The survival values for each treatment A, B, C, and D were 94.00±5.48, 94.00±5.48, 92.00±4.47, and 94.00±5.48%, respectively. The addition of chromium to feed does not affect the survival rate of tilapia. The deaths that occurred during the study were due to an imperfect acclimatization process. Acclimatization carried out in the study lasted for 7 days. According to Djunaedi et al (2016), the acclimatization process carried out in his research lasted for 5 weeks, acclimation time is adjusted by the ability of fish to adapt to the new environment. The longer the acclimatization process, the better, because fish have been able to adapt to the new environment. Then it will make it easier for fish to live and eat comfortably. According to Setiyowati et al (2017), the acclimatization process is one of the factors affecting the survival rate during rearing. Haetami (2015) said that the adaptability of the new environment can affect the survival rate of fish to its sustainability.

The survival rate value of 92-94% is still in good range. Based on BSN (2009), the minimum percentage for the survival rate of fish seed values is 75%. In accordance with the study of Aryansyah et al (2007), that the survival rate in the study is ranged from 93-100%. According to Djunaedi et al (2016), high survival rate was around 83-89%. Study by Khairunnisa et al (2019), the survival rate was around 96.67-100%. The relatively good survival value was affected by the existence of external support namely water quality during rearing was in the optimal range. On the other hand, the number of stocking fish was still relatively low, namely 1 fish / liter. During the fish rearing there was no competition for space, oxygen competition, and competition for feed.

Table 3. Values of Water Qualities of Tilapia (O. *niloticus*)

Treatments	Water Quality Parameter Range Values			
	Temperature (°C)	pH	DO (mg/l)	Ammonia (mg/l)
A	25-31	7	4.30-6,75	0.0011-0.0028
B	25-31	7	4.15-6.40	0.0015-0.0036
C	25-31	7	4.10-6.35	0.0017-0.0044
D	25-31	7	4.50-6.40	0.0010-0.0030
Optimum	25-32*	6.5-8.5*	≥3*	<0.02*

Note: *SNI 2009

3.7. Water Quality

According to the study on tilapia (*O. niloticus*) showed that the water quality during maintenance was still in good conditions. The value of water qualities in the parameters of oxygen, temperature, ammonia, and pH were 4.52-7.65 mg/l, 26-31°C, 0.0010-0.0044 mg/l, and 7, respectively. Water quality is one of the most important roles in fish life because water is a living medium. Panggabean et al (2016), stated that water quality was a determining factor in the success of aquaculture, this is because water is a living medium for fish. According to Saputra et al (2013), proper water quality for tilapia (*O. niloticus*) was pH 6.5-7.3, dissolved oxygen 2.89-4.01 mg/l, temperature 27-30°C, and ammonia 0.002-0.132 mg/l.

Water quality management during rearing was carried out by giving aeration to the culture media to increase the supply of oxygen. The presence of oxygen in the waters is very minimal, so there need for additional aeration. On the other hand, tilapia does not have other respiration devices such as catfish, so the presence of oxygen in water must be sufficient for its survival. Islami et al (2017), states that maintaining water quality can be done by means of a water dispensing system (siphon) and the use of aeration. Replacing the water and siphoning is done to reduce the presence of ammonia caused by the remnants of feed and result fish secretion. Feces, urine and accumulated food waste will cause ammonia which is andgerous for fish. According to Norjanna et al (2015), fish produce waste from the remnant of feed and also from metabolism that contains lots of ammonia.

Based on the observation of water quality of several parameters, the result was still classified in the optimal range. Some parameters of water quality measured include temperature, dissolved oxygen (DO), pH, and ammonia. The results of water quality measurements were presented in Table 3.

4. Conclusions

The addition of chromium in artificial feed given to tilapia (*O. niloticus*) had a significantly effect ($P<0.05$) on the TFC, FUE, PER, protein digestibility, and RGR variables, but had no significantly effect ($P>0.05$) on the SR variable. The optimal dose was obtained at 3.49 mg $Cr^{+3} kg^{-1}$ diet and it can increase growth of 2.15 % day^{-1}.

Suggestion

It is necessary to add dietary chromium to tilapia (*O. niloticus*) feed of 3.49% to obtain maximum growth and survival. Furthermore, it is recommended for future research to test glucose levels and test the body protein ratio of tilapia (O. niloticus) to determine the metabolic role of dietary chromium.

Authors contributions

Subandiyono and Sri Hastuti participated in revising the manuscript

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9