The growth of tilapia (*Oreochromis niloticus*) fed a diet supplemented with *Curcuma xanthorriza* Roxb in a biofloc system

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Abstract. Tilapia (*Oreochromis niloticus*) is a freshwater fish commodity that is popular with consumers. Tilapia has good taste at an inexpensive price. To meet consumer demand, tilapia cultivation is carried out intensively by increasing the stocking density. High stocking densities can cause the accumulation of leftover feed and feces that settle to the bottom of the pond. The accumulation of leftover feed and feces can be harmful to fish because it produces ammonia and nitrite compounds. To anticipate this problem, cultivation with a biofloc system can be applied to maintain good water quality. Meanwhile, to optimize growth, additional dietary supplements such as *Curcuma xanthorriza* Roxb, which are growth promoters, can be given. The study used an experimental method with a completely randomized design (CRD), 4 treatments, 1 control, and 3 replications. First treatment (T1), consisted of cultivation with a biofloc system without curcuma diet; T2 had biofloc + a diet with 5.63 g curcuma kg^{-1} feed; T3 had biofloc + a diet with 3.75 g curcuma kg^{-1} feed; T4 had biofloc + a diet with 1.88 g curcuma kg^{-1} feed and T0 was the control, without biofloc and without a curcuma supplemented diet. The parameters observed were weight and length gain, specific growth rate (SGR), feed conversion ratio (FCR), and feed efficiency (FE), while the supporting parameters were water temperature and pH. The results showed that the diets with curcuma in the biofloc system had an effect on weight and length gain, SGR, FCR, and FE, but it was not significant ($p>0.05$). The optimum dose that resulted in higher growth was in T2. This shows that the use of the curcuma diet in the biofloc system has the potential to be used in tilapia cultivation.
Key Words: fish, floc, gain, growth, zingiberaceae.

Introduction. Tilapia (*Oreochromis niloticus*) is a sought commodity because it has several advantages such as good taste, easy to cultivate and the price is relatively low. Tilapia comes from the African continent, but can be cultivated easily. The demand for consumption of tilapia is high, so tilapia cultivation is carried out intensively. Intensive cultivation by applying high stocking densities can cause problems such as disease and slow growth. Disease is a limiting factor in fish farming, so it must be prevented. In the livestock and fishing industries, treatment can be carried out by administering antibiotics or other chemotherapy agents. Apart from treatment, prevention can be carried out by using immunostimulants to increase immunity. Immunity in fish and humans is obtained from non-specific (innate) and specific (acquired) immune processes and mechanisms to prevent attacks by pathogens (Fall & Ndong 2011). Disease prevention can be carried out by maintaining water quality through biofloc technology/systems. Meanwhile, increasing growth can be done by providing growth supplements to the feed. Biofloc is a technology for cultivating aquatic animals that can increase productivity. Research reports (Sukenda et al 2016) prove that catfish (*Clarias gariepinus*) farming with the biofloc system can increase growth through the addition of carbon sources. Molasses, tapioca flour, and wheat are carbon sources that can be added to the culture water media in the biofloc system to increase the immune response and growth performance of the fish, as well as reduce the abundance of *A. hydrophila* and the feed conversion ratio. Furthermore, according to

Ekasari (2009), biofloc works by converting inorganic nitrogen, especially ammonia, by heterotrophic microorganisms into microbial biomass, which can then be consumed by cultivated fish. The biofloc system is in great demand because it can maintain water quality and produce floc, which is used as additional food by farmed fish, thereby increasing the feed utilization efficiency. To optimize growth, apart from using biofloc technology to maintain optimal water quality, supplements can be added to the feed to further stimulate growth. The addition of natural or herbal supplements as growth promoters is safe to apply.

The use of herbs as fish growth supplements has been widely applied. One of the used materials is curcuma (*Curcuma xanthorriza* Roxb). *C. xanthorriza* is a herb used to stimulate fish growth. Fish fed the curcuma diets had better growth with increasing doses in the range of 4-12 g kg^{-1} feed (Prabowo et al 2017). According to Sari et al (2012), curcuma could also be administered by immersion apart from being added to the feed. Carp (*Cyprinus carpio* L.) immersion in a solution of *C. xanthorriza* with a concentration of 0.6 g L^{-1} can have survival rates of up to 100%, absolute weight gain of 12.48 g ind^{-1} and a daily growth rate of 2.39%. Apart from increasing growth, administering a curcuma solution through soaking can also increase immunity. Research on the use of herbs for fish growth has been widely reported, but there are still few combined treatments with the addition of herbal supplements + cultivation with a biofloc system. This study aims to find a combination of biofloc system with the addition of a curcuma supplemented diet on the growth of tilapia.

Material and Method. This research used tilapia juveniles (7-9 cm) fed with a diet supplemented with curcuma in a biofloc cultivation system. The materials used for biofloc are EM4 probiotics, molasses, and salt. The study used an experimental method with a completely randomized design (CRD) using 4 treatments, 1 control, and 3 replications. The treatments in this research were the following: T0 - control (without biofloc and without adding supplements); T1 - biofloc; T2 - biofloc + diet with 5.63 g curcuma kg^{-1} feed; T3 - biofloc + diet with 3.75 g curcuma kg^{-1} feed; T4 - biofloc + diet with 1.88 g curcuma kg^{-1} feed. The biofloc dose applied was in accordance with the results of research conducted by Rijal et al (2020), by providing 3.93 mL of EM4 probiotics and 15.7 mL of molasses in 20 L of maintenance media water. During the research, no water changes were carried out. In this research, the quality parameters of the water measured were pH and temperature at the beginning and end of the research. The pH and temperature were measured using a pH meter and a water thermometer. The feed used in this study was commercial pellets from P.T. Matahari Sakti, Surabaya, Indonesia. The pellets contain 39% protein, 5% fat, 8% fiber, 12% ash and 10% moisture content. Fish were reared in containers with 20 L of water, 15 tilapia per container. The fish were reared for 60 days. The feed given is 3% of the biomass weight per day, with a frequency of administration 2 times a day, in the morning at 8.00 a.m. and in the afternoon at 17.00 p.m. The following parameters were determined in the study (Fuchs et al 2015):

$$W = Wt - Wo$$

Where: W - weight gain (g); Wt - final weight (g); Wo - initial weight (g).

To determine fish biomass, weighing was carried out with an analytical balance to an accuracy of 0.01 g, every 10 days on all fish 6 times until the research was completed (60 days).

$$L = Lt - Lo$$

Where: L - length gain (cm); Lt - final length (cm); Lo - initial length (cm).

The total length was determined for all fish using a ruler (mm). Fish length measurements were only carried out at the beginning of the study (day 0) and the end of the study (day 60).

$$FE = \frac{Wt - W0}{F} X\, 100$$

Where: FE - feed efficiency (%); F - feed intake; Wt - final weight (g); Wo - initial weight (g).

$$FCR = \frac{F}{Wt - W0}$$

Where: FCR - feed conversion rate; F - feed intake (g); Wt - final weight (g); Wo - initial weight (g).

$$SGR = \frac{LnWt - LnW0}{t} X\ 100\%$$

Where: SGR - specific growth rate (%); Wt - final weight (g); Wo - initial weight (g); t - time (day).

The results were analyzed using the analysis of variance (ANOVA) at a confidence level of 95% (α=0.05), with the help of the SPSS software. If significant differences were observed, to determine the significance between treatments, the Duncan Multiple Range Test (DMRT) was employed at a confidence level of 95%.

Results and Discussion. Fish growth parameters during the 60 days of study are presented in Table 1.

Table 1

Weight and length gain (Wt, Lt), specific growth rate (SGR), feed conversion ratio (FCR) and feed efficiency (FE) of tilapia (*Oreochromis niloticus*) at the end of the experiment

Treatment	*Wt (g)*	*Lt (cm)*	*SGR*	*FCR*	*FE (%)*
T0	$13.7^{ab}\pm1.86$	$6.1^{b}\pm0.56$	$3.2^{ab}\pm0.21$	$5.3^{a}\pm2.33$	$21.4^{a}\pm8.27$
T1	$13.3^{ab}\pm1.83$	$5.9^{b}\pm0.10$	$3.2^{ab}\pm0.04$	$4.3^{a}\pm1.00$	$24.0^{a}\pm4.94$
T2	$14.9^{b}\pm1.87$	$6.4^{b}\pm0.30$	$3.3^{b}\pm0.13$	$5.2^{a}\pm1.65$	$20.7^{a}\pm7.11$
T3	$13.5^{ab}\pm1.78$	$6.2^{b}\pm0.34$	$3.1^{ab}\pm0.23$	$4.7^{a}\pm0.98$	$21.9^{a}\pm5.11$
T4	$11.6^{a}\pm1.73$	$5.7^{a}\pm0.20$	$3.0^{a}\pm0.10$	$6.0^{a}\pm0.96$	$16.7^{a}\pm2.50$

Weight gain, length and daily growth rate (SGR). Based on the results of the study, the addition of curcuma dietary supplements in tilapia cultivation using biofloc technology can increase growth as evidenced by the increase in weight and length and higher SGR compared to control in T2.

Research conducted on *Osteochilus vittatus* in the addition of *Curcuma longa* to the biofloc system cultivation can increase growth in weight and length, SGR, FCR and FE at an optimal dose of 1.125 g of curcuma kg^{-1} feed (Purbomartono et al 2022). Biofloc technology maintains water quality by converting ammonia and nitrite into elements that are safe for aquaculture cultivation, minimizing water changes (Avnimelech et al 2008). The results of other studies indicate that the growth of Larasati tilapia (*O. niloticus* strain Larasati) cultivated with biofloc technology is better than in conventional methods. This is due to the biofloc technology being able to maintain the dynamics of water quality within the normal range during cultivation, such as oxygen between 4-5 mg L^{-1} and ammonia from 0.01 to 0.015 mg L^{-1}. The Larasati strain of tilapia produced in the biofloc system showed good quality, normal hematological conditions and optimal fish performance. The results of this research show that biofloc technology with the addition of curcuma supplements through feed (diet) can support success in fish cultivation. The results of this research are similar to those reported by Purbomartono et al (2022) using turmeric flour (*Curcuma longa*) in cultivating *O. vittatus*. Turmeric flour diet (*Curcuma longa*) in *O. vittatus* using a biofloc system can increase growth. Turmeric flour supplementation of 1.125 g kg^{-1} feed is the optimal dose in increasing weight and length gain, daily growth rate, conversion ratio and feed efficiency. This proves that turmeric (*Curcuma longa*) flour supplementation through feed has the potential to be applied to fish farming using a biofloc system. Supported by the research results of Basuki et al (2013), the growth of the Larasati tilapia reared using the biofloc system was better than in conventional methods.

In this research, good water quality within the biofloc system and the addition of curcuma diet resulted in increased growth. *C. xanthorriza* contains the bioactive compound curcumin, which functions to support growth. *C. longa* and *C. xanthorriza* contain curcumin compounds (Sinurat et al 2009). Curcumin functions in regulating fat metabolism in the digestive tract. The cholagogum activity of curcumin is able to stimulate the bile glands to secrete more bile, which will help in the processes of digestion, breakdown and emulsifying of fats (Alappat & Awad 2010).

Growth in farmed fish through the supplementation of *C. xanthorriza* is common practice among farmers. However, the results of research on *C. xanthorriza* diets have not always presented significant increases in growth. The results of Prabowo et al (2017) on milkfish (*Chanos chanos*) with an optimal dose of 12 g of curcuma per kg of feed showed an insignificant weight gain. Meanwhile, goldfish (*Carassius auratus*) have significant increases in weight and length at a dose of 5 g per kg of feed (Monoarfa et al 2020). This shows that *C. xanthorriza* can be used as a growth promoter, but has a moderate to strong effect depending on fish species and dosage.

Insana & Wahyu (2015) reported that the addition of curcuma supplements to tilapia at higher doses (50 g kg^{-1}) feed could increase weight and length growth, as well as survival up to 100%. In this study, the growth of tilapia increased, but not significantly, at a dose of 5.63 g curcuma kg^{-1} feed, even though it had been supported using biofloc technology. This is strongly suspected to occur because the dose of curcuma supplement was relatively small.

Feed conversion ratio (FCR) and feed efficiency (FE). Feed conversion and efficiency in tilapia cultivation in this study resulted in optimal FCR and FE values in the biofloc treatment without the addition of *C. xanthorriza* (T1) supplements. According to Hastuti & Subandiyono (2014), biofloc technology has been widely applied in aquaculture activities. Biofloc technology applies the basic principle of dissolved nitrogen assimilation by heterotrophic bacteria by managing the C:N ratio in the water. The heterotrophic bacterial biomass then forms threads or aggregates called flocs. Floc does not only contain bacteria, but is composed of microalgae and zooplankton, which are trapped by organic particles. The role and function of biofloc is not just to improve water quality by converting ammonia and nitrites, but to form floc biomass that can be used as additional feed.

Cultivation with a biofloc system can significantly reduce total ammonia-N and nitrite-N (Hwihy et al 2021). In addition to reducing ammonia and nitrite in the water, biofloc treatment results in significantly increased final weight of fish, better FCR values and reduced volume of maintenance water. Even though the biofloc system does not always produce significant differences in fish hematology, blood biochemistry and hepatosomatic index (HSI), it is more important that it can improve the stability of water parameters and fish growth performance, and at the same time reduce the volume of water exchange.

In aquaculture, fish can be exposed to stress. Oxidative stress is a condition that refers to an imbalance between the production of reactive oxygen species (ROS) and endogenous and exogenous antioxidants due to poor water quality. ROS production in normal physiological conditions of the fish will not cause stress. Even in homeostatic conditions, ROS molecules also play a role in maintaining immune defenses, so that they can prevent the entry of pathogenic infections. However, if homeostasis is not achieved, high ROS levels can damage lipids, proteins and DNA (Biller & Takahashi 2018). ROS is very important for modulating the immune system, although it is known that the production of immune compounds in fish is limited by oxidative stress (Biller & Takahashi 2018).

C. xanthorriza in this study reduced FCR and increased FE compared to control, although not significantly. This is in accordance with the results of Amer et al (2022), where curcumin was added to feed up to a concentration of 400 mg kg^{-1} to obtain maximum growth, optimal immune response, antioxidant function and normal intestinal histology in Nile tilapia. Prolonged administration of curcumin at high concentrations (600 and 800 mg kg^{-1}) is not recommended, because it can stimulate tissue inflammation. Curcumin helps digestive performance, so it can increase growth. The capacity and ability of the digestive tract is better and absorption of nutrients increases, making the utilization of nutrients more efficient and effective (Jia et al 2022). The increase in growth is also associated with the improvement in most of the gut histomorphometry profiles in curcumin-treated fish. El-Hakim et al (2020) reported that curcumin supplementation of 200 mg kg^{-1} diet for *O. niloticus* can inhibit growth. Sruthi et al (2018) reported that curcumin supplementation of 0.5% and 1% could increase weight gain, SGR, and decrease FCR in *Oreochromis mossambicus* through the activation of protease, lipase, and α-amylase enzymes in the intestine.

Water quality. Good water quality can affect the growth rate of fish being cultivated. Sub-optimal water quality can slow down the growth rate because unfavorable water conditions cause fish not to eat. The water quality of tilapia rearing with the addition of curcuma diet in the biofloc system is presented in Table 2.

Table 2

Water quality in tilapia (*Oreochromis niloticus*) cultivation with *Curcuma xanthorriza* Roxb supplementation for 60 days in the biofloc system

Treatment	*pH*	*Temperature (°C)*
T0	7.8-8	25-27
T1	7.6-8	25-27
T2	7.6-8.3	25-26
T3	8-8.2	26-27
T4	8.5-8.6	25-26

From the results of water quality observations during the research, the pH value was between 7.6-8.6. This pH is considered suitable for fish culture. According to Boyd (2015), a pH value between 6.8-8.5 is suitable for aquaculture activities. The results of temperature measurements during the research ranged from 25-27°C, within the normal range for fish cultivation. According to Sulistyo et al (2016), a temperature in the range of 22-30°C is good for the life and growth of fish. A similar opinion was expressed by Asniatih et al (2013), who noted that the optimal temperature for raising fish is between 25-30°C.

Conclusions. Based on research data and analysis, it can be concluded that the addition of *C. xanthorriza* to Nile tilapia diets while using the biofloc cultivation system resulted in better, but not significant growth in weight and length, SGR, FCR and FE. The optimal dose of *C. xanthorriza* in the biofloc system for tilapia which resulted in better growth was achieved in T2, with the biofloc system + the addition of 5.63 g of curcuma kg^{-1} feed. Fish cultivation using biofloc technology combined with the provision of a curcuma diet has the potential to be used in fish cultivation.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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