Aceh Journal of Animal Science (2023) 8 (3): 121 - 128

Aceh Journal of Animal Science

Journal homepage: www.jurnal.unsyiah.ac.id/AJAS

Short communication

Productivity of comet goldfish (*Carassius auratus*) cultured in aquaponics system using fine bubbles (FBs)

Yuli Andriani*, Zahidah Zahidah, Drian Alif Anando, Rusky Intan Pratama

Department of Fisheries, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Sumedang, West Java 45363, Indonesia

ARTICEL INFO

Keywords:
Aquaponic
Comet goldfish
Fine bubbles
Growth
Survival rate

Received: 26 April 2023
Accepted: 11 June 2023
Available online: 12 October 2023

DOI:10.13170/ajas.8.3.31827

ABSTRACT

Water quality is an important factor in the process of fish farming. This study aims to determine the application of FBs pressure that can increase the productivity of comet goldfish *Carassius auratus* farming in an aquaponic system. The research was carried out from January to March 2022 at the Ciparanje Green House, Faculty of Fisheries and Marine Sciences, Padjadjaran University, Jatinangor. This study used a completely randomized design (CRD) experimental method with four treatments and three replications. The treatment used was the application of FBs pressure of 0 atm (A), 5.25 atm (B), 5.5 atm (C), and 5.75 atm (D). Maintenance of test fish for 30 days with ad satiation feeding. Observation of fish growth through sampling is done by taking fish 10% of the total population randomly in each pond. Data were analyzed using the F test at a 95% confidence level, followed by Duncan's multiple range test with a 95% confidence level, while water quality data were analyzed descriptively. The results showed that the specific daily growth rate of FBs 5.75 was 2.51%, the absolute length growth was 3.33%, the absolute weight growth was 1.70 g and the fish survival rate was 99.3%. It was concluded that the use of FBs in the aquaponic system can increase production of the system.

Introduction

Comet goldfish *Carassius auratus* is one of the most popular ornamental fish worldwide including in Indonesia (Nurlaili *et al.*, 2023). The beauty of color and fins are the main attraction of comet goldfish. In 2018-2020, the production of comet goldfish was 384,600 fish with prices reaching IDR 2,000/fish (BPS, 2020). One of the obstacles to increasing comet goldfish production is limited land and water supply (Amara *et al.,* 2021). Therefore, the aquaponic system can be applied to overcome these problems. Aquaponics is a technology that combines fish farming with vegetable crops, such as kangkong, Pak Choy, and lettuce, with the benefits of saving land and water. Aquaponics can reduce the amount of water used in aquaculture systems because it has a recirculation system with repeated use of water from fish rearing to plant media (Padli *et al.,* 2017).

In the aquaponic system, the dissolved oxygen content is the most important aspect so that aquaculture productivity is maintained. Dissolved oxygen in the rearing medium plays a role in the process of oxidation and reduction of organic and inorganic materials by nitrifying bacteria to reduce the pollution load in cultivation containers (Zidni *et al.*, 2019). Aquaponics requires a supplier of micro-sized air bubbles that have a large surface area so that they can maximize gas exchange and release oxygen into the water better than ordinary bubbles (Silaban *et al.,* 2012). Fine Bubbles (FBs) technology is a

* Corresponding author.
Email address: yuliyusep@gmail.com

Printed ISSN 2502-9568; Electronic ISSN 2622-8734

renewable technology that can be implemented in aquaponic activities because it can increase oxygen supply and fish productivity and the efficiency of the aquaponics system (Andinet *et al.,* 2016). FBs produce 150-200 nm bubbles to provide dissolved oxygen for a long time and under stable conditions (Hu *et al.,* 2018). The FBs aeration system can significantly increase the activity of Ammonia Oxidizing Bacteria (AOB) and Nitrite Oxidizing Bacteria (NOB) to accelerate biological activity in waters (Scabra *et al.,* 2021). An effective oxygen supply system is needed because it affects the growth performance of comet goldfish in aquaponics. Therefore, the purpose of this study was to determine the growth of comet goldfish fry using fine bubbles technology with various pressures as a supply of oxygen in an aquaponics system.

Materials and Methods

This research was carried out from January to March 2022 at the Ciparanje Green House, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Jatinangor. Water quality tests were carried out at the Laboratory of Aquatic Resources, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran. 1200 comet goldfish fry used as test fish in the study measuring 8-11 cm came from fish farmers in Tanjungsari, Sumedang. This study used a Completely Randomized Design (CRD) with each of the four treatments repeated three times. The treatment used is the application of FBs pressure in fish-rearing tanks:
A: Control (without FBs pressure)
B: FBs with a pressure of 5.25 atm
C: FBs with a pressure of 5.5 atm
D: FBs with a pressure of 5.75 atm

Research procedure

Fish acclimatization

Comet goldfish fry were first acclimatized in a fiber tub for seven days before starting the study. Fish acclimatization is carried out so that the fish can adapt to the new environment and can adjust when the experiment is carried out. The stocking density of fish in each rearing tank is 100 fish, in a pond measuring 70 cm x 70 cm x 70 cm as many as 12 units. Feeding was given three times a day using the ad satiation method, namely feeding the fish until they were full every 07.00, 11.00, and 16.00 WIB.

Aquaponic installation preparation

Installation of a recirculation system is installed with separate fish and plant containers made of multilevel iron shelves. The water in the fish-rearing tanks is channeled into the plant containers using a 4” PVC pipe. The water from the water spinach outlet comes out of the 4” PVC pipe and enters the FBs container. The water that has been pumped from the FBs generator will be returned to the fish-rearing tank by a 1/2” PVC pipe with a pump.

Figure 1. Aquaponic installation used this study

Seeding water spinach

The husk charcoal is put into the tray until it is full and then flushed. Ground water spinach plant seed are sown in each hole on the tray. Sowing was carried out in the Ciparanje Inland Fisheries Area, Faculty of Fisheries and Marine Science, Universitas Padjadjaran. The tray containing plant seed is then covered using husk charcoal then flushed with water, then stored in a shady place. Watering is done in the morning and evening. After the 10-day-old plant seed were transferred to a plastic cup (filled with three plant seeds) and then placed in an aquaponics installation

Research implementation

Maintenance is carried out for 30 days. Fish were fed three times a day using commercial feed PF 1000. Feeding was done at 07.00, 09.00, and 15.00 West Indonesia Time. The method of feeding the fry uses ad satiation, namely feeding the fish until they are full.

Water quality parameters measured included dissolved oxygen (mg/L), temperature (℃), and pH. Water samples for water quality testing came from water in rearing tubs, water spinach outlets from each rearing tank, as well as water in pump containers and FBs that had passed biofiltration for each treatment. However, specifically for the dissolved oxygen concentration parameter, samples were taken from the outlet of the FBs hose, except without FBs (pumps), the sample water was taken from the pump container. The parameters used in measuring water quality are listed in Table 1.

Table 1. Device/methods and time of measurement of observation parameters

Parameter	Unit	Device	Measurement Time
Dissolved Oxygen	(mg/L)	DO Meter	Every week
Temperature	(℃)	Thermometer	Every week
pH	-	pH meter	Every week

Fish growth

Fish growth was measured by weighing the weight of the initial and final samples, then measuring the total length of the fish. The specific growth rate is calculated using the following formula:

$$\alpha\ (\%) = \left[t \sqrt{\frac{\overline{\omega}\ t}{\overline{\omega} o}} - 1 \right] \times 100$$

Where, α= Specific Growth Rate (%), ϖ t= The average weight of fish at the t-time of rearing, ϖ o= Average weight of fish at the start of rearing (grams), t= Length of maintenance time (days)

The survival rate of comet goldfish fry was calculated based on Muchlisin *et al.* (2016) as follows:

$$\text{Survival rate } (\%) = (\text{No} - \text{Nt})/\text{No} \times 100$$

Where, Nt is the number of fish dead during the study, No is the number fish at the start of the study.

Observation of fish growth using sampling is done by taking fish 10% of the total population randomly in each pond. Fish growth was observed by weighing and measuring the body length of the fish every seven days through sampling. After that, adjustments were made to the amount of feed given for the following week. Every day observations are made for the survival of fish by recording the number of dead fish.

Data analysis

The research data were analyzed based on the parameters measured in the study. The effect of treatment on water quality (DO, temperature, and pH) was analyzed descriptively and presented in tables and graphs. The effect of the treatment given on the specific daily growth rate, growth in length and absolute weight, and survival of comet goldfish was analyzed using variance with the F test at a 95% confidence level. If there is a significant difference between the treatments, then the test is continued with Duncan's multiple range test with a 95% confidence level.

Results

The use of FBs significantly increases growth, survival rate and water quality in comet fish cultivation. FBs improve the quality and quantity of oxygen in water by reducing the size of oxygen particles so the availability of dissolved oxygen which will affect the increase in growth and physiological conditions of fish. When fish are in good health, more energy in the body will be used for growth. The optimal water quality value will support metabolic activity in fish so that a lot of energy is produced and this energy can be used for growth.

The results of dissolved oxygen measurements showed that the dissolved oxygen value in the fish-keeping containers (Figure 2a) ranged from 6.96 – 7.96 mg/L, at the water spinach outlet (Figure 2b) ranged from 6.77 – 7.71 mg/L, and in the pump containers and FBs (Figure 2c) ranged from 7.13 – 7.94 mg/L. Changes in dissolved oxygen values during the research can be seen in Figure 2.

Figure 2a showed the dissolved oxygen value in the comet fry-rearing container decreased in the fourth week in treatments A, B, and C. The highest average dissolved oxygen value in the comet seed rearing container was in treatment D at 7.83 mg/L and the lowest was in treatment A was 6.96 mg/L, then treatment B was at 7.63 mg/L and treatment C was 7.73 mg/L.

The treatment using the FBs application had a higher average dissolved oxygen value compared to the treatment without FBs (control). Figure 2c shows that the average value of dissolved oxygen is higher in the FBs container with treatment D (pressure 5.75 atm) which is equal to 7.83 mg/L.

Based on the results of observations during the study, it was shown that the water temperature in the fish-rearing container (Figure 3a) ranged from 24.4 – 26.5 ℃, at the water spinach outlet (Figure 3b) ranged from 24.6 – 26.5 ℃, as well as in the pump container and FBs (Figure 3c) ranged from 25.1– 26.2 ℃. This range is still in normal conditions with a range that can still be tolerated by fish and plants. In this research, temperature fluctuations do not interfere with the comet fry metabolism.

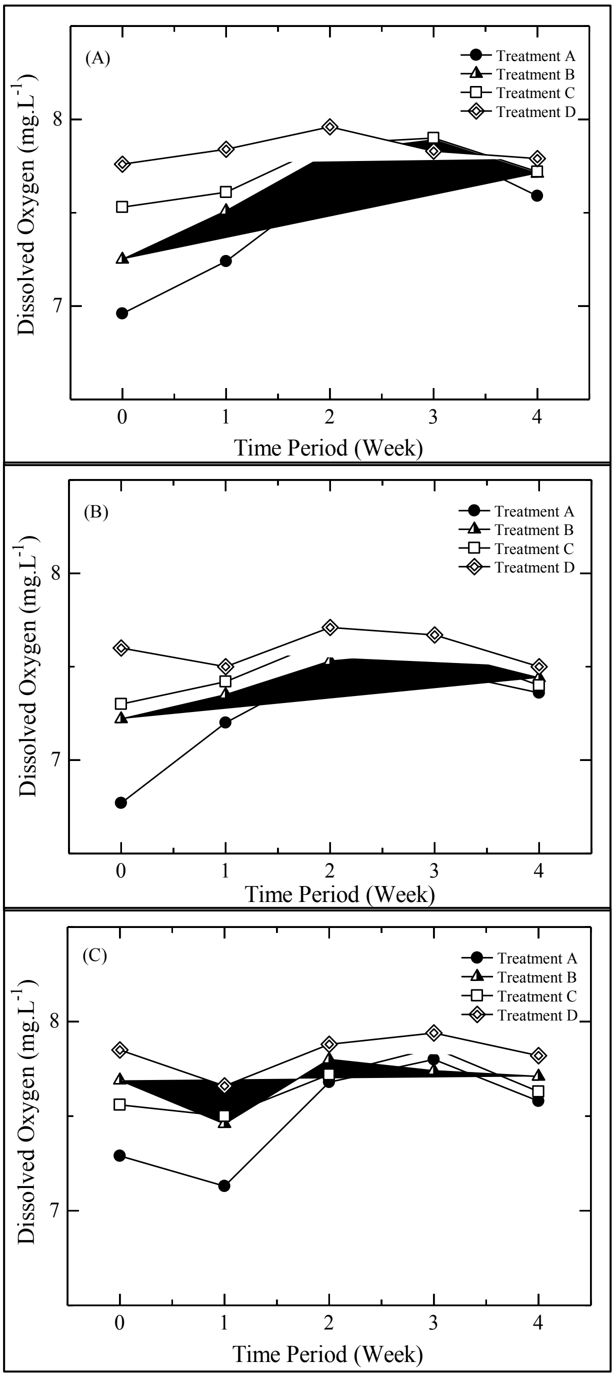

Figure 2. Changes in DO value during research on fish rearing containers (A), water spinach outlet (B), and pump container and FBs (C).

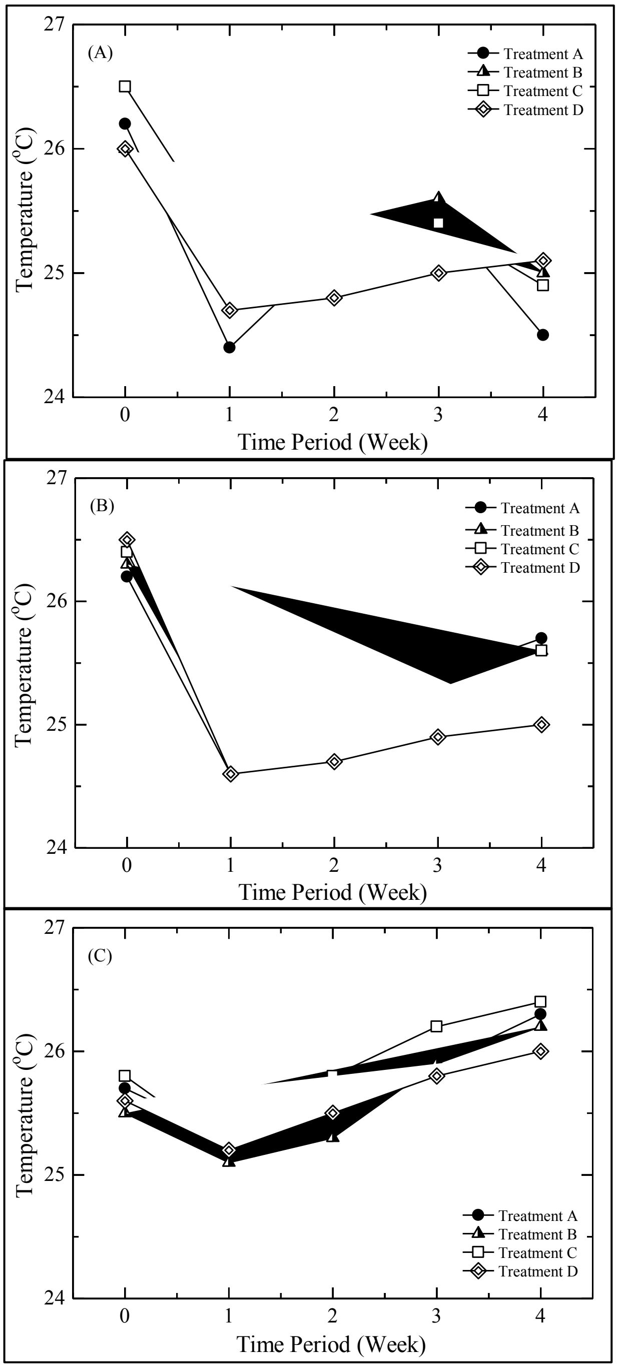

Figure 3. Temperature changes during research on fish rearing containers (A), water spinach outlet (C), and pump container and FBs (C).

Discussions

Water temperature can affect dissolved oxygen because if the water temperature decreases, the solubility of dissolved oxygen increases (Mubarak *et al.,* 2010). The use of FBs can produce oxygen bubbles in large numbers and very small sizes compared to ordinary aeration (Serizawa, 2017). The oxygen bubbles from the FBs last longer in the water maximally if the water temperature is low. The low temperature can keep the oxygen bubbles in the water longer. According to Patty (2018) low water temperature has lower dissolved oxygen mobility towards the surface and will last in water for a long time compared to high-temperature conditions.

The results of measuring the degree of acidity (pH) during the study showed the degree of acidity (pH) in fish-keeping containers (Figure 4a) ranged from 6.98 to 8.07. At the water spinach outlet (Figure 4b) it ranges from 7.23 to 7.84 and at the pump container and FBs (Figure 4c) it ranges from 7.29 to 7.83. The pH value of fish-rearing media, water spinach outlet media, as well as pump containers, and FBs decreased in the fourth week. Fluctuations in the pH value of the water spinach outlet media are due to the activity of nitrifying bacteria and plants in maintaining the pH value. The process of nitrifying bacteria naturally lowers the pH in aquaponic systems, while aquatic plants work on photosynthesis and root respiration and remove carbonic acid and increase the pH value (FAO, 2014).

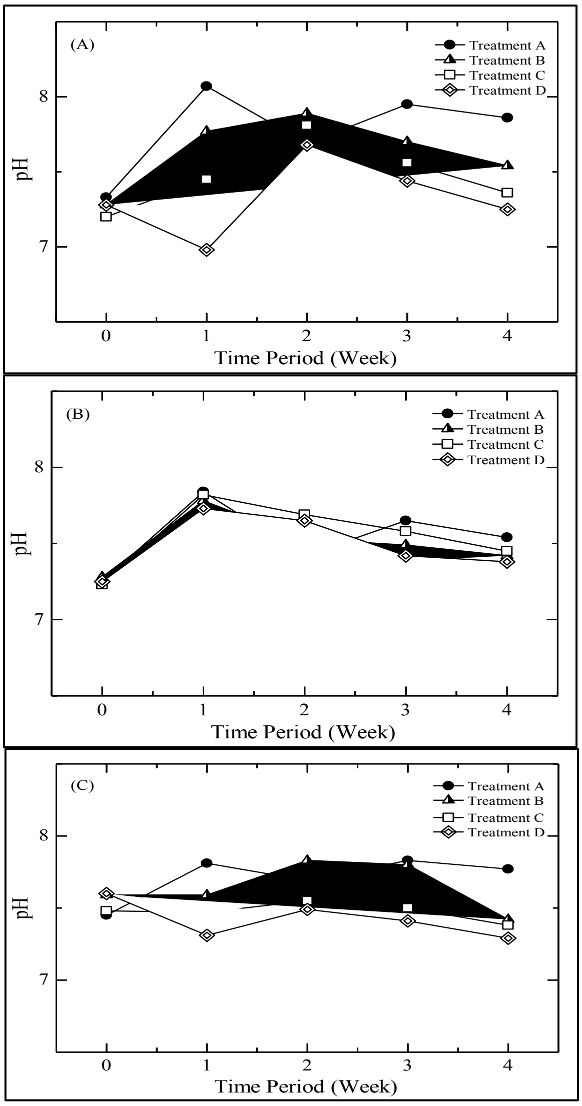

Figure 4. Changes in pH value during research on fish rearing containers (A), water spinach outlet (B), and pump container and FBs (C)

Table 2. Results of Duncan's multiple test analysis of specific growth rate, growth in length, and absolute weight of comet goldfish fry

Treatment	Fish Growth		
	SGR (%)	**AL (cm)**	**AW (g)**
A (Control)	1.32± 0.01[a]	2.36±0.05[a]	0.57± 0.07[a]
B (pressure 5.25 atm)	1.97±0.08[b]	2.89±0.10[b]	1.03±0.10[b]
C (pressure 5.5 atm)	2.01±0.05[b]	3.00±0.08[b]	1.41± 0.05[c]
D (pressure 5.75 atm)	2.51±0.10[c]	3,33±0.24[c]	1.70± 0.02[d]

Note: a number followed by the same superscript letter vertically indicates there is not a significant difference according to Duncan's test at the 95% level of confidence. SGR =Specific Growth Rate; AL = Absolute Length; AW = Absolute Weight

Table 3. Results of Duncan's multiple test analysis of comet goldfish fry survival

Treatment	Survival rate (%)
A (Control)	74.7±4.93[a]
B (pressure 5.25 atm)	82.0±2.65[b]
C (pressure 5.5 atm)	88.7±1.15[c]
D (pressure 5.75 atm)	99.3±0.58[d]

Note: a number followed by the same superscript letter vertically indicates there is not a significant difference according to Duncan's test at the 95% level of confidence. SR =Survival rate/Life sustainability

Aceh Journal of Animal Science

Journal homepage: www.jurnal.unsyiah.ac.id/AJAS

Changes in pH affect the physiology of fish, including stunted growth rates, fish are sensitive to bacteria and parasites, and water will be toxic to fish. Changes in pH slowly will cause excess mucus in the fish's integumentary system so that it becomes whitish and is easily exposed to bacteria (Meegoda, 2018). The pH value can also affect the toxicity of a chemical compound. A high pH value in water can cause ammonia to not be ionized so that ammonia levels increase which is toxic to fish (Irawan *et al.*, 2019). The pH value during the research did not occur with a high fluctuation range for each treatment so it did not affect the survival of the comet goldfish.

The growth of the fish observed during the study was the specific growth rate and the absolute length and weight of the comet fry. Based on the results of observations, it appears that the treatment of various pressures of FBs resulted in different growth in comet goldfish. The values of daily growth rate, absolute length growth, and highest weight of comet fry were in treatment D (5.75 atm pressure) of 2.51%, 3.33 cm, and 1.70 grams. The results of Duncan's Multiple Test analysis of specific growth and absolute length of comet fry can be seen in Table 2. Results of Duncan's Multiple Test analysis daily growth rates showed that the comet fry treatment A (control) was significantly different from the Fine Bubbles B, C, and D treatments. The daily growth rate of treatment B and treatment C showed no significant difference, but treatment A significantly lower than treatment B,C and D. The results of Duncan's Multiple Test on the absolute length growth of comet fry showed that treatment A (control) was significantly different in Fine Bubbles B, C, and D. Meanwhile, the absolute length growth in treatment B (pressure 5.25 atm) and treatment C (pressure 5.5 atm) did not show a significant difference.

The use of increasing FBs pressure can increase the daily growth rate of comet fry during the study. The quality and quantity of oxygen bubbles produced by FBs are better than oxygen bubbles in the control treatment (without FBs) so that FBs technology can increase the availability of dissolved oxygen which will affect the increase in growth and physiological conditions of fish. When fish are in good health, more energy in the body will be used for growth. The optimal oxygen value will support metabolic activity in fish so that a lot of energy is produced and this energy can be used for growth (Ebina *et al.*, 2013).

At the beginning of the study, the stocking density of comet goldfish fry was 100 fish/tub, after being reared for 30 days the survival rate of comet fry in each treatment was different. The results showed that the highest comet seed survival rate was obtained in treatment D at 99.3%, followed by treatment C at 88.7%, then treatment B at 82%, and the lowest survival rate of comet fry was in treatment A at 74.7 %. The results of the F-Test analysis of diversity showed that there were significant differences between treatments on the survival of comet fry. The results of Duncan's Multiple Test analysis for the survival of comet fry can be seen in Table 3.

The analysis was continued using Duncan's Multiple Test at the 95% confidence level and the results showed that the survival of comet fry in treatment A (control) was significantly different in the Fine Bubbles B, C, and D treatments.

The low survival value of comet fry in treatment A (74.7%) apart from the absence of the addition of FBs also because the comet fry was attacked by the fungus *Saprolegnia* sp. thus making the fish's metabolism decrease. Saprolegnia fungi thrive at low temperatures, most *Saprolegnia* sp. can develop (minimum) at water temperature between 0 – 5ºC, moderate growth at 5 – 15ºC, optimum growth at 15 -30ºC, and decreased at 28 – 35ºC (Diana *et al.*, 2017). The temperature drops during research with reference SNI-8110 (BSN, 2015). This causes the fish to become stressed so they are susceptible to disease.

* Corresponding author.
Email address: yuliyusep@gmail.com

Printed ISSN 2502-9568; Electronic ISSN 2622-8734

Figure 5. *Saprolegnia* sp. on comet goldfish fry

The survival percentage of comet goldfish fry in treatments B, C, and D can be said to be good because it is above 80%. Based on SNI 8110 (BSN 2015), good survival for comet goldfish farming ranges from 80-95%. Treatment fish A (Control) had the lowest survival value because they were infected by the fungus *Saprolegnia* sp. (Figure 5). While the survival of fish in treatment B (atm pressure 5.25 atm) was lower compared to other FBs pressure treatments, this was because some of the fish in treatment B were infected with the fungus *Saprolegnia* sp. In treatment C there were also fish deaths due to fungal infections but did not cause major deaths because they could be immediately treated with treatment using fish salt and methylene blue.

Based on the analysis that has been done, it shows that the use of greater FBs pressure can increase the daily growth rate of comet fry during the study. The quality and quantity of oxygen bubbles produced by FBs are better than oxygen bubbles in the control treatment (without FBs) so that FBs technology can increase the availability of dissolved oxygen which will affect the increase in growth and physiological conditions of fish (Firman *et al.,* 2019). This is following the statement of Subhan et al. (2018) stated that high dissolved oxygen can increase growth due to the influence of nano-sized aeration bubbles. The FBs pressure given can have a positive effect on the availability of dissolved oxygen in fish-rearing media so that it can increase fish appetite (Naomi *et al.,* 2020).

In the aquaponic system, nutrient-containing waste passes through the water spinach root media which provides an attachment surface for the microbial community which plays an important role in the nitrogen cycle, where bacteria in plant roots play a role in the effective breakdown of various compounds such as the oxidation of ammonia to nitrate that plants need (Effendi *et al.,* 2016). Oxidation of ammonia by nitrifying bacteria which produces nitrate as a nutrient for plants is useful for plant productivity in aquaponic systems (Badiola *et al.,* 2012).

Conclusions

The best use of FBs pressure on comet goldfish growth is 5.75 atm. This is because the pressure of 5.75 atm produces high oxygen and comet goldfish can still survive and grow well under these conditions which results in a specific daily growth rate of 2.51%, absolute length growth of 3.33%, absolute weight growth of 1.70 grams and fish survival value of 99.3%. The use of FBs in the aquaponic system can increase its production of the aquaponic system. The treatment using FBs with a pressure of 5.75 atm in the aquaponics system showed the best results with a dissolved oxygen content of 7.83 mg/L which affected good fish growth.

References

Amara, F., F. Rahmatia, Y.L. Dwantara. 2021. Use of orchid and lettuce plants on the growth of goldfish (*Carassius auratus*) in mini aquaponics systems. Jurnal Akuatika Indonesia, 6(2): 57-61

Andinet, T., I. Kim, J. Lee. 2016. Effect of microbubble generator operating parameters on oxygen transfer efficiency in water. Desalination and Water Treatment, 57(54): 26327-26335

Badiola, M., D. Mendiola, J. Bostock. 2012. Recirculating aquaculture systems (RAS) analysis: Main issues on management and future challenges. Aquacultural Engineering, 51: 26–35

[BPS] Biro Pusat Statistik. 2020. Data on production and prices of freshwater ornamental fish in Sleman Regency. https://slemankab.bps.go.id/statictable/2017/11/15/260-type-in-sleman-regency-2017. Retrieved August 25, 2021.

Diana, F., S. Rahmita, S. Diansyah. 2017. Control of *Saprolegnia* sp fungus on tawes fish eggs (*Puntius javanicus*) using *Tagetes erecta* L. extract. Jurnal Perikanan Tropis, 4(2): 101-113

Ebina K, Shi K, Hirao M, Hashimoto J, Kawato Y, Kaneshiro S. 2013. Oxygen and air nanobubble water solution promote the growth of plants, fishes and mice. Plos One, 8(6): e65339.

Effendi H, B. Amarullah, U.B. Darmawangsa, M. Karo Karo. 2016. Phytoremediation of catfish (*Clarias* sp.) aquaculture waste with water spinach (*Ipomoea reptans*) and pakcoy (*Brassiica rapa chinensis*) in a recirculation system. Jurnal Ecolab, 9(2): 80-92

Firman, S.W., K. Nirmala, E. Supriyono, N.T. Rochman. 2019. Evaluation of the performance of a micro bubble generator on the physiological response of tilapia *Oreochromis niloticus* (Linnaeus, 1758) with different densities in the recirculation system. Jurnal Iktiologi Indonesia, 19(3): 425-436.

Hu, L., Z. Xia. 2018. Application of ozone micro-nano bubbles to groundwater remediation. Journal of Hazardous Materials, 342: 446-453.

Irawan, D., S.P. Sari, E. Prasetiyono, A.F. Syarif. 2019. Growth performance and survival of seluang fish (*Rasbora einthovenii*) at different ph treatments. Journal of Aquatropica Asia, 4(2):15–21.

Meegoda, J.N., S.A. Hewage, J.H. Batagoda. 2018. Stability of nanobubbles. Environmental Engineering Science, 35(11): 1216 – 1227

Mubarak, A.S., D.A. Satyari, R. Kusdarwati. 2010. Correlation between Dissolved Oxygen Concentration at Different Densities and Color Scoring of *Daphnia* sp. Jurnal Ilmiah Perikanan dan Kelautan, 2(1), 45–50.

Muchlisin, Z.A., A.A. Arisa, A.A. Muhammadar, N. Fadli, I.I. Arisa, M.N. Siti Azizah. 2016. Growth performance and feed utilization of keureling (*Tor tambra*) fingerlings fed a formulated diet with different doses of vitamin E (alpha-tocopherol). Archives of Polish Fisheries, 24: 47-52

Naomi, M., Z. Hasan, Sumadi, H. Hamdani, Y. Andriani, U. Subhan. 2020. Growth of striped catfish fingerlings (*Pangasianodon hypophthalmus*) in aquaponic system with fine bubbles (FBs) application. Asian Journal of Fisheries and Aquatic Research, 7(2): 1–9.

Nurlaili, N., K. Eriani, I. Salma, S. Maulida, S. R Rahayu, L. S. Handayani, F. K. Kocabas, M. N. Siti-Azizah, M. Wilkes, Z. A. Muchlisin. 2023. Effect of cryoprotectant and pre-freezing on the sperm motility, viability and fertility of goldfish carassius auratus (Pisces: Cyprinidae) post short-term cryopreservation. CryoLetters, 44(3): 169-177.

Ogunji, J., R.S. Toor, C. Schulz, W. Kloas. 2008. Growth performance, nutrient utilization, of nile tilapia *Orheochormis niloticus* fed housefly maggots meal diets. Turkish Journal of Fisheries and Aquatic Science, 8:141 – 147.

Padli, K., Rusliadi, Mulyadi. 2017. Growth and survival of comet goldfish in an aquaponic system with different densities of watercress. Student Online Journal (JOM) in the Field of Fisheries and Marine Sciences, 34(2): 233-248.

Patty, S.I. 2018. Dissolved Oxygen and apparent oxygen utilization in the lembeh strait waters, North Sulawesi. Platax Scientific Journal, 6(1): 54–60.

Scabra, A.R., M. Marzuki, B.D.H. Setyono, N. Diniarti, L.F. Mulyani. 2021. Application of microbubble technology to tilapia farmers in Bayan Village. Indonesian Journal of Fisheries Community Empowerment, 1(1): 36–43.

Serizawa, A. 2017. Fundamentals and applications of micro/nano bubbles. Proceeding. International Symposium on Application of High Voltage, Plasmas, and Micro/Nano Bubbles to Agriculture and Aquaculture, 5-7 January. Rajamangala University of Technology Lanna Chiang Mai. Thailand.

Silaban, T.F., L. Santoso, Suparmono. 2012. In improving the performance of water filters to reduce ammonia concentration in maintenance of carp (*Cyprinus carpio*). E-Journal of Aquaculture Engineering and Technology, 1(1): 47-56

[BSN] Badan Standardisasi Nasional. 2015. SNI 8110:2015 Production of red rainbow ornamental fish. Badan Standardisasi Nasional Jakarta.

Subhan, U., V. Muthukannan, S.Y. Azhary, M.F. Mulhadi, E. Rochima, C. Panatarani, I.M. Joni. 2018. Development and performance evaluation of water fine bubbles on water quality of Thai catfish rearing. AIP Conference Proceedings, 1927:1-5.

Yi, Y., C.K. Lin. 2001. Effects of biomass of caged Nile tilapia (*Oreochromis niloticus*) and aeration on the growth and yields in an integrated cage-cum-pond system. Elsevier Science, 195(3–4): 253–267

Zidni, I., Iskandar., A. Rizal., Y. Andriani, R. Ramadan. 2019. The effectiveness of aquaponic systems with different types of plants on the water quality of fish culture media. Journal of Fisheries and Maritime Affairs, 9(1): 81–94.