

Substrate Use On Fish Welfare Levels Goldfish (*Carassius Auratus*)

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Abstract

Goldfish (*Carassius auratus*) is a freshwater ornamental fish with high economic value and is widely kept in aquariums. Fish welfare is an important aspect in its maintenance because it affects the growth, color, behavior, and environmental conditions of the fish. This study aims to assess the effectiveness of using different substrates on the level of fish welfare of goldfish. The study was conducted for 14 days using a Completely Randomized Design (CRD) with three treatments: aquatic plant (*Hydrilla verticillata*) substrate, zeolite substrate, and no substrate, each with three replications. The parameters observed included growth in length, color changes, behavior, and water quality consisting of temperature, pH, and dissolved oxygen (DO). The results showed that the use of aquatic plants gave the best results compared to other treatments. The growth in length of fish in the aquatic plant treatment reached an average of 2.06 cm, higher than the zeolite (1.46 cm) and no substrate (1.13 cm). The highest increase in fish color was also observed in the aquatic plant treatment with an average score of 24, compared to zeolite (20) and without substrate (16). The ANOVA test results showed that the substrate treatment had a significant effect on length growth ($P = 0.0042$) and changes in fish color ($P = 0.000204$). In addition, the aquatic plant treatment resulted in more stable water quality with temperature, pH, and DO within the optimal range and showed more active and normal fish behavior. Thus, the use of aquatic plants (*Hydrilla verticillata*) as a substrate was proven to be more effective in improving fish welfare of goldfish compared to zeolite or without substrate.

Keywords

Carassius auratus, fish welfare, substrate, *Hydrilla verticillata*, zeolite, growth, fish color.



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INTRODUCTION

Goldfish (*Carassius auratus*) are a type of freshwater ornamental fish with high economic value and are highly sought after by both domestic and international communities. According to Manurung et al. (2017), goldfish are a highly sought-after ornamental fish species with high economic value, thus offering potential for aquaculture development. This potential is supported by the high value of Indonesian ornamental fish exports, which reached USD 26.07 million in the third quarter of 2022, consisting of USD 21.01 million in freshwater ornamental fish

exports and USD 5.06 million in saltwater ornamental fish exports (Suhana, 2022, cited in Arfandi, 2023). This situation indicates that goldfish cultivation offers significant potential for increasing the economic value of fish farmers.

In addition to their high economic value, goldfish also offer a diverse range of colors and body shapes compared to other ornamental fish (Adriani et al., 2018). This fish can be raised in various cultivation media, such as earthen ponds, tarpaulin ponds, hatcheries, and aquariums. Aquariums are a popular choice because they can be implemented on a household scale and with limited space. According to Sari (2019), aquariums represent the fish's natural habitat, allowing for environmental engineering to optimally support the fish's survival. However, the success of goldfish farming is determined not only by production aspects but also by the level of fish welfare. According to Santoso (2015), goldfish are sensitive to changes in environmental conditions, particularly temperature and the quality of the rearing media. Lusiastuti (2014) states that the concept of fish welfare encompasses not only the fish's physical health and disease-free condition but also its psychological state and ability to express its natural behaviors. Fish experiencing stress, fear, or environmental discomfort may appear physically normal, but are actually experiencing poor welfare.

One way to improve fish welfare in goldfish aquariums is through the use of substrates as a form of environmental engineering. Substrates such as aquatic plants and zeolite rocks are known to help improve water quality and create a more natural environment for the fish. However, the effectiveness of various substrate types on the comfort and well-being of goldfish remains unknown. Oktaviani et al. (2017) stated that of the various substrate types used in ornamental fish farming, the most effective and preferred substrate for goldfish remains unknown. Therefore, this study was conducted to compare the effectiveness of using *Hydrilla verticillata* aquatic plant substrate, zeolite rock, and no substrate on the fish welfare of goldfish kept in aquariums. This study aimed to determine which substrate best supports fish well-being..

METHODS

This study was conducted over a period of 14 days using three replications for each treatment, with the observed variables including fish behavior, color, and absolute length growth. Behavioral observations were carried out using a descriptive approach once daily throughout the 14-day experimental period to assess the welfare condition of goldfish. Fish growth was measured by calculating total body length twice during the study, namely on day 1 and day 14, in order to determine absolute

length growth. The calculation of absolute length growth followed Mulqon et al. (2017) using the formula $PM = Lt - Lo$, where PM is absolute length growth (cm), Lt is the average final length (cm), and Lo is the average initial length (cm). Color observation referred to Rosid (2019) and was conducted visually by comparing the original fish color on day 1 and day 14 using a color measurement chart with scores ranging from 1 to 30, representing a color gradient from light orange to dark red. Water quality was also monitored throughout the study by measuring temperature, dissolved oxygen (DO), and pH twice daily, in the morning and afternoon. The research was carried out at the Fisheries Wet Laboratory of Universitas Muhammadiyah Sukabumi for 14 days in January 2026. The equipment and materials used included nine aquaria as the main culture media, nine water pumps, nine aerators, *Hydrilla verticillata* and zeolite as substrate media, as well as a thermometer, pH meter, DO meter, and digital scale for sampling and water quality measurement. The tested parameters in this study were absolute length growth, color, behavior, and water quality. Data analysis was performed using a Completely Randomized Design (CRD), with observed parameters including behavior, growth, and color of goldfish. The collected data were analyzed using analysis of variance (ANOVA), and if the results indicated acceptance of H0 and rejection of H1, a t-test was then applied to verify whether significant differences existed among treatments, following Sudjiono (2010). All data analyses were conducted using Microsoft Excel 2013 and presented in the form of graphs and tables.

FINDINGS AND DISCUSSION

1. Growth

Based on the research results, the highest growth of goldfish was found in the aquarium treatment with aquatic plants, with an average growth of 2.06 cm. The treatment with zeolite stones showed moderate growth (1.46 cm), while the lowest growth occurred in the aquarium without any media (water only), with an average of 1.13 cm (Table 3).

Table 2. Results of Fish Length Measurement

Treatment	Replication	Day 1	Day 14	Growth (cm)	Average
Aquatic Plants	1	7.0	9.2	2.2	
	2	7.1	9.2	2.1	2.06
	3	6.9	8.8	1.9	
Zeolite	1	7.0	8.5	1.5	
	2	7.2	8.9	1.7	1.46
	3	7.1	8.3	1.2	

Without Substrate	1	7.0	8.3	1.3	
	2	7.1	8.0	0.9	1.13
	3	7.0	6.2	1.2	

The results of the ANOVA test showed that the substrate treatment had a significant effect on fish length growth ($P = 0.0042$; $P < 0.05$). Further testing showed significant differences between the aquatic plant treatment and zeolite ($P < 0.019$), as well as between aquatic plants and without substrate ($P < 0.0016$), while the zeolite and without-substrate treatments were not significantly different ($P > 0.063$). The highest length growth was obtained in the aquatic plant treatment. This was presumably because aquatic plants functioned as biofilters that were able to improve water quality, provide additional oxygen, and create a more natural environment for the fish. According to Ningtyas (2020), aquatic plants can improve environmental quality and support fish growth, while zeolite acts as a physical and chemical filtration medium in aquariums (Suandi, 2019).

2. Color

Based on the research results with three replications, the treatment with aquatic plants showed the highest color improvement with an average final score of 24, meaning that the fish color approached dark red. The treatment with zeolite stones showed moderate improvement with an average score of 20. The treatment without media showed the lowest improvement with an average score of 16 (Table 2).

Table 3. Results of Fish Color Measurement

Treatment	Replication	Initial Score	Final Score	Average	STDEV
Aquatic Plants	1	12	24		
	2	12	25	24	1.00
	3	12	23		
Zeolite Stones	1	12	20		
	2	12	21	20	1.00
	3	12	19		
Without Treatment	1	12	16		
	2	12	17	16	1.00
	3	12	15		

The results of the ANOVA test showed that the substrate treatment had a significant effect on changes in fish color ($P = 0.000204$; $P < 0.05$). Further testing showed significant differences in all treatment comparisons, namely between aquatic plants and zeolite ($P < 0.0040$), aquatic plants and without substrate ($P < 0.00030$), as well as zeolite and without substrate ($P < 0.00040$). The aquatic plant treatment produced the

highest color improvement compared to the other treatments. This was presumably because aquatic plants were able to create a healthier and more comfortable environment, thereby optimally supporting the fish pigmentation process. According to Nur (2020), a healthy environment plays an important role in supporting the formation and enhancement of color in ornamental fish.

3. Behavior

Treatment 1 (Aquatic Plants) showed stable swimming activity, appetite, and physical condition from day 1 to day 14. Treatment 2 (Zeolite Stones) showed swimming activity, appetite, and physical condition that improved each day, which means that the fish experienced mild stress, most likely because the fish needed time to adapt to their environment. Meanwhile, Treatment 3 (Without Substrate) showed less active movement and decreased appetite, indicating stress in the fish. This decline occurred quite fluctuatively and was less stable, although the fish were able to survive until day 14.

4. Water Quality Parameters

Table 3. Observation of Water Quality

Parameter	Unit	Standard Quality	Aquatic Plants	Zeolite Stones	Without Substrate
Temperature	°C	20–25	22.7–24.5	24.2–24.6	24.1–24.5
pH	-	6–8	7.1–7.5	7.2–7.7	7.5–8.7
DO	mg/L	6–8	6.4–7.5	5.9–7.2	5.4–6.8

The results of water quality observations showed that the aquatic plant treatment produced the most stable environmental conditions compared to the zeolite and without-substrate treatments. The temperature in the aquatic plant treatment ranged from 22.7–24.5°C, while in the zeolite treatment it ranged from 22.3–25.3°C, and in the without-substrate treatment it ranged from 22.1–25.6°C. These temperature ranges were still within the optimal range for goldfish rearing, namely 20–25°C (Wahyuningsih, 2012). The temperature stability in the aquatic plant treatment was presumably caused by the utilization of light energy for the photosynthesis process, thereby reducing the direct increase in water temperature (Raharjo, 2018).

The pH value in the aquatic plant treatment ranged from 7.1–7.5, in zeolite from 7.2–7.7, and in without substrate from 7.5–8.7. The aquatic plant and zeolite treatments showed more stable pH values compared to the without-substrate treatment and were still within the suitable range for goldfish maintenance (Subandiyah, 2010; Kuncoro, 2011). The pH stability in the aquatic plant treatment was presumably influenced by photosynthesis and respiration processes that

regulate CO₂ concentration in the water, while zeolite acted as a medium that helped maintain pH stability (Ramadhani, 2023; Suandi, 2018).

The dissolved oxygen (DO) content in the aquatic plant treatment ranged from 6.4–7.5 mg/L, which was higher than in the zeolite treatment (5.9–7.2 mg/L) and without substrate (5.4–6.8 mg/L). These values indicate that the aquatic plant treatment was able to provide more optimal oxygen conditions for the fish. The high DO value in the aquatic plant treatment was presumably derived from additional oxygen produced through photosynthesis, so that water quality became better and supported the fish welfare level of goldfish (Kadarini, 2012; Telaumbanua, 2025).

CONCLUSION

Based on the research results, it can be concluded that the use of different substrates significantly impacts fish welfare. The substrate that significantly improves growth, color, behavior, and water quality is aquatic plants, or hydrilla..

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