



THE EFFECT OF HIGH-PROTEIN FEEDING FREQUENCY OF UFBs-RAS ON THE PRODUCTION PERFORMANCE OF GOURAMI (*Osphronemus goramy*) FRY

PENGARUH FREKUENSI PEMBERIAN PAKAN PROTEIN TINGGI PADA UFBs-RAS TERHADAP PERFORMA PRODUKSI BENIH GURAMI (*Osphronemus goramy*)

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ABSTRACT

Gourami (*Osphronemus goramy*) production in intensive systems is often suboptimal because of poor feeding management and water quality. The application of a recirculation system with ultrafine bubbles (UFBs-RAS) has the potential to improve the quality of the cultivation environment. However, feeding strategies, particularly the frequency and protein content, strongly influence their effectiveness. This study aimed to determine the optimal frequency of high-protein feeding on gourami fry production performance in the UFBs-RAS system. The study was conducted over 33 days. Feed was provided at 5% biomass/day with a protein content of $\pm 50\%$ according to the treatment frequency. The test fish had a length of 3 ± 0.00 cm and a weight of 0.8 ± 0.00 g, with a total of 720 fish. This study was designed using a completely randomized design (CRD) with feeding frequencies of 3, 4, and 5 times per day. Each treatment was repeated 4 times, resulting in 12 experimental units. Statistical analysis showed that feeding frequency significantly affected the production performance of gourami fry. Feeding five times per day resulted in the best production performance, with a 100% survival rate, length growth rate of $3.83 \pm 0.21\%$, weight growth rate of $4.16 \pm 0.16\%$, feed utilization efficiency of 127%, protein efficiency ratio of 2.56, and size variation of 9.33%. These results indicate that increasing the feeding frequency in the UFBs-RAS system can improve the nutrient utilization efficiency and optimal growth performance of gourami fry.

Keywords: feeding frequency, gourami, high protein, UFBs-RAS

ABSTRAK

Produksi gurami (*Osphronemus goramy*) dalam sistem intensif sering kali belum optimal akibat manajemen pemberian pakan dan kualitas air. Penerapan sistem resirkulasi dengan *ultrafine bubbles* (UFBs-RAS) berpotensi meningkatkan kualitas lingkungan budidaya, namun efektivitasnya masih sangat dipengaruhi oleh strategi pemberian pakan, khususnya frekuensi dan kadar protein. Penelitian ini bertujuan untuk menentukan frekuensi pemberian pakan berprotein tinggi yang optimal terhadap performa produksi benih gurami dalam sistem UFBs-RAS. Penelitian dilakukan selama 33 hari. Pakan diberikan sebanyak 5% biomassa/hari dengan kadar protein $\pm 50\%$ sesuai frekuensi perlakuan. Ikan uji yang digunakan memiliki ukuran panjang $3 \pm 0,00$ cm dan berat $0,8 \pm 0,00$ g, dengan jumlah total 720 ekor. Penelitian ini dirancang menggunakan acak lengkap (RAL) dengan perlakuan frekuensi pemberian pakan 3, 4, dan 5 kali per hari. Setiap perlakuan diulang sebanyak empat kali, sehingga terdapat 12 unit percobaan. Hasil analisis statistik menunjukkan bahwa, frekuensi pemberian pakan berpengaruh signifikan terhadap performa produksi benih gurami. Pemberian pakan sebanyak lima kali per hari menghasilkan performa produksi terbaik, yaitu tingkat kelangsungan hidup 100%, laju pertumbuhan panjang $3,83 \pm 0,21\%$, laju pertumbuhan bobot $4,16 \pm 0,16\%$, efisiensi pemanfaatan pakan 127%, efisiensi rasio protein 2,56, dan keragaman ukuran 9,33%. Hasil ini menunjukkan bahwa peningkatan frekuensi pemberian pakan pada sistem UFBs-RAS mampu meningkatkan efisiensi pemanfaatan nutrisi dan performa pertumbuhan benih gurami secara optimal.

Kata kunci: frekuensi pemberian pakan, gurami, protein tinggi, UFBs-RAS

INTRODUCTION

Gourami (*Osphronemus goramy*) is a highly economical freshwater fish commodity in Indonesia because of its relatively high market demand and higher selling price compared to other freshwater fish species (Rambo *et al.* 2018). This high market demand makes gourami an attractive commodity for developing medium to large-scale aquaculture businesses in Indonesia (Azrita and Syandri 2018). According to a report from the Ministry of Marine Affairs and Fisheries (KKP 2025), gourami production increased by 28.83% between 2020 and 2024, from 152,668 to 196,675 tons. This increase indicates that the demand for gourami is also increasing to support the availability of raw materials for fish farming activities.

Gourami production in intensive systems is often suboptimal because of poor feeding management and water quality, which are major obstacles in hatchery operations. A widely used technology for fish fry cultivation is the Recirculating Aquaculture System (RAS) with the application of ultrafine bubbles (UFBs-RAS). UFBs-RAS technology plays a role in improving water quality and the physiological condition of fish (Tsuge 2015; Temesgen *et al.* 2017; Wang and Zhang 2017; Subhan *et al.* 2020). Several studies have shown that this technology is effective in increasing the survival and growth of aquatic organisms (Subhan *et al.* 2022; Hanif *et al.* 2021; Rachmawati *et al.* 2021). Therefore, the UFBs-RAS system is expected to create an optimal environment for gourami cultivation.

The success of fry rearing in the UFBs-RAS system is closely related to feed management, particularly feeding frequency. Appropriate feeding frequency is crucial for maintaining nutrient utilization efficiency, water quality stability, and fish growth performance. Inappropriate feeding, either too infrequently or too frequently, can lead to the accumulation of residual feed, resulting in increased ammonia and nitrite levels in the rearing medium (Hisano *et al.* 2020). Increasing the feeding frequency in systems with controlled water quality allows for more even feed distribution and increases metabolic efficiency, thus supporting optimal fish growth (Hassan *et al.* 2021).

Protein is a key nutritional component of fish feed, contributing to tissue formation, maintenance, and reproduction (Abasubong *et al.* 2018). Several studies have shown that a high protein feed intake can significantly improve the production of gourami fry (Arief *et al.* 2014; Putra *et al.* 2016). In addition to protein content, feeding frequency influences

nutrient utilization efficiency. Xing *et al.* (2023) stated that feeding frequency should be adjusted to the gastric emptying rate, which generally occurs within 12–14 h after feeding. Wibawa *et al.* (2018) reported that feeding four times per day optimally promotes growth in gourami fry. In intensive technology-based systems, such as UFBs-RAS, a higher feeding frequency has the potential to improve production performance due to stable water quality and high dissolved oxygen content. However, information on the optimal feeding frequency for gourami fry in UFBs-RAS systems using high-protein feeds is limited. Therefore, this study aims to determine the relationship between the frequency of high-protein feed (50%) and the growth performance of gourami fry maintained in the UFBs-RAS system.

METHODS

Time and location of research

This research was conducted at the University Center of Excellence (PUI-PT) Functional Nano Powder Laboratory, Padjadjaran University, Jatinangor, from November to December 2024 for 33 days (5 days of acclimatization and 28 days of the main treatment). The research stages included the preparation of materials, tools, and the construction of the UFB-RAS installation.

Research design

The research was conducted experimentally using a completely randomized design (CRD) consisting of three feeding frequency treatments: three, four, and five times per day. Each treatment was replicated four times, resulting in 12 experimental units.

Preparation of the research container

This study used 12 cylindrical tanks with a capacity of 20 L as gourami maintenance containers and one water container with a capacity of 80 L as a filtration container. The preparation began with cleaning the acclimatization container, a $1 \times 0.5 \times 0.4 \text{ m}^3$ fiber tub, using a brush to remove dirt. Then, sterilization was carried out with a potassium permanganate (KMnO_4) solution for 15 min, followed by drying in the sun. Next, each tank was filled with clean water that had been settled for 24 h with a uniform volume of 15 L. The maintenance system was equipped with an outflow channel from each tank to a centralized

filtration system using PVC pipes. The filtration container was filled with media in the form of a filter (japmat), filter cotton, bioballs, and zeolite to filter dirt and stabilize the water quality. Temperature stabilization was performed by installing four thermostat units, each with a power of 100 watts, in the filter system and set at 26 °C to ensure a homogeneous temperature throughout the treatment tank.

Fish acclimatization stage

The acclimatization phase was conducted to ensure that the fish could optimally adapt to their new environment. Acclimatization was carried out in two stages: before and after the fry were placed in the rearing container. In the first stage, the fry were acclimatized in a fiber tank with the addition of coarse salt (0.1 g/L) to maintain osmotic balance and Red Bluedox (1.2 mL/L) to prevent infection. The second stage was conducted after the fry were transferred to the research medium for five days to accustom the fish to the system conditions and the feed provided. Feed was provided manually by spreading evenly on the water surface at 5% of the biomass per day, which was divided according to the treatment frequency.

Preparation of fish fry

The gourami used in this study were obtained from the Singaparna Branch of the Southern Region of the Marine and Fisheries Service, Tasikmalaya Regency. A total of 800 gourami individuals with uniform sizes (3 ± 0.00 cm in length and 0.8 ± 0.00 g in weight) were used in this experiment. The length of the fry was measured using a millimeter block (measuring board) with an accuracy of 1 mm, while the weight was measured using a digital scale with an accuracy of 0.00 g, so that the length and weight data obtained were more accurate and consistent. Observations were carried out every week by sampling 25% of the population, or 15 individuals per treatment container.

Feed preparation

The feed used in the study was commercial feed PF 500, which was administered for five days during the adaptation process. Furthermore, during the treatment testing period (28 days), the feed used was commercial feed with a minimum protein content of 50%, fat 12%, ash 11%, water 9%, and carbohydrate 16%. The amount of feed provided was 5% of

the fish biomass per day, based on the results of the five-day feeding intake test. Feeding was carried out according to the treatment, namely three times a day at 06:00, 12:00, and 18:00 Western Indonesian Time (WIB), four times a day at 06:00, 10:00, 14:00, and 18:00 WIB, and five times a day at 06:00, 09:00, 12:00, 15:00, and 18:00 WIB.

Water quality control and measurement

Water quality control to meet the needs of the gourami fry was carried out by changing the water and siphoning it twice daily at 3:00 afternoon. The water quality parameters measured were DO and temperature using a HANNA HI 98193 DO meter, while pH, total ammonia (TAN), ammonia ($\text{NH}_3\text{-N}$), nitrite, and nitrate were measured using a water-testing kit (API Fresh Water Test Kit).

Test parameters

The observed growth performance parameters included feed utilization efficiency, protein efficiency ratio, specific growth rate of fish in length and weight, length variation, survival rate, and water quality.

The feed utilization efficiency was calculated according to Fransiska *et al.* (2013), using the following formula:

$$FUE = \frac{W_t - W_o}{F} \times 100$$

Description:

FUE = Feed utilization efficiency (%)

W_t = Final biomass weight (g)

W_o = Initial biomass weight (g)

F = Total feed consumed (g)

The protein efficiency ratio (PER) describes the ratio between the increase in fish biomass and the weight of the protein consumed. The PER value was calculated using the formula of Slembrouck *et al.* (2009).

$$PER = \frac{W_t - W_o}{P_i} \times 100$$

Description:

PER = Protein efficiency ratio (%)

W_t = Final biomass weight (g)

W_o = Initial biomass weight (g)

P_i = Total protein consumed (g)

The weight growth rate was calculated using the equation according to Bidlack (2000):

$$SWGR(\%/day) = \left(\frac{\ln W_t - \ln W_o}{t(day)} \right) \times 100$$

Description:

SWGR = Specific weight growth rate (%/day)

W_t = Average final weight (g)

W_o = Average initial weight (g)

t = Length of maintenance (days)

The growth rate in length was calculated using the following equation:

$$SLGR(\%/day) = \left(\frac{\ln L_t - \ln L_o}{t(day)} \right) \times 100$$

Description:

SLGR = Specific length growth rate (%/day)

L_t = Average final length (cm)

L_o = Average initial length (cm)

t = Length of rearing (days)

According to Warwick *et al.* (1995), fish size diversity was calculated using the following formula:

$$CV = \frac{SD}{X} \times 100$$

Description:

CV = Size diversity (%)

SD = Standard deviation

X = Average size

Survival rate (SR) was calculated according to the FAO (2020).

$$SR = \frac{N_t}{N_o} \times 100$$

Description:

SR = Survival rate (%)

N_t = Number of fish at the end of the study (individual)

N_o = Number of fish at the beginning of the study (individual)

Data analysis

The data analyzed in this study included the specific growth rate based on length and weight, survival rate, feed utilization efficiency, protein efficiency ratio, and length size variation. Data analysis was performed using one-way analysis of variance (ANOVA) at a 95% confidence level. If significant differences were found, further testing was performed using the Tukey test. Furthermore, water quality data, including temperature, pH, dissolved oxygen (DO), ammonia (NH₃-N), nitrite (NO₂-N), and nitrate (NO₃-N), were analyzed descriptively and quantitatively. The measurement results were compared with water quality standards for fish cultivation to evaluate the suitability of environmental conditions for the living needs and growth of the gourami fry.

RESULTS AND DISCUSSION

Feed utilization efficiency

The feed utilization efficiency (FUE) of the cultivated gourami ranged from 100.27 ± 10.14 to 127.82 ± 4.87% (Figure 1). The FUE values from lowest to highest were 100.27 ± 10.14% (Treatment A), 116.22 ± 6.13% (Treatment B), and 127.82 ± 4.87% (Treatment C). Statistical analysis showed that Treatment C had the highest EPP value compared to treatments A and B, and the EPP value of Treatment B was higher than that of Treatment A.

In line with the increase in growth rate, the feed utilization efficiency (FUE) values in this study were relatively high, ranging from 100.27 ± 10.14% to 127.82 ± 4.87%. These results are better than the FUE values reported by Azrita *et al.* (2020), Firdaus *et al.* (2024), and Nikhlani *et al.* (2025), which were 52%, 81.87%, and 97.77%, respectively. This indicates that providing a 50% protein feed five times per day in the UFBs-RAS system can increase feed efficiency in gourami fry with an initial stocking size of 3 cm. This finding is in line with Marzuqi *et al.* (2012), who reported that a 48% protein feed in grouper showed the highest growth performance (104.05 ± 5.89%). Feed efficiency is also significantly influenced by water quality, particularly low ammonia and nitrite levels (zero mg/L) and high oxygen saturation levels. Excess ammonia (>0.02 mg/L) can reduce appetite, disrupt excretion, and inhibit growth (Briggs and Fling-Smith 2002; Ijaz *et al.* 2010; Lemarie *et al.* 2004). On the other hand, high oxygen saturation (>70%) in the UFBs-RAS system maintains an optimal oxygen supply. According to Howerton (2001), supersaturation allows more energy to be used for the growth of fish. Conversely, hypoxic conditions (<65%) reduce growth because more energy is used up for respiration (Thorarensen *et al.* 2017; Buentello *et al.* 2000).

Protein efficiency ratio

The protein efficiency ratio (PER) of the cultured gourami ranged from 2.01 ± 0.20 to 2.56 ± 0.10 (Figure 2). Statistical analysis showed a significant difference ($p < 0.05$) between the treatments. Treatment C had the highest PER value (2.56 ± 0.10) compared to Treatments B (2.32 ± 0.12) and A (2.01 ± 0.20), and the PER value of Treatment B was significantly different from that of Treatment A.

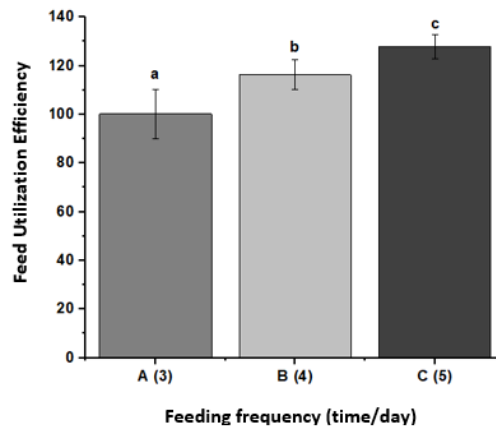


Figure 1. Feed utilization efficiency of gourami. Note: Bars followed by the same lowercase letter indicate values that are not significantly different ($P > 0.05$).

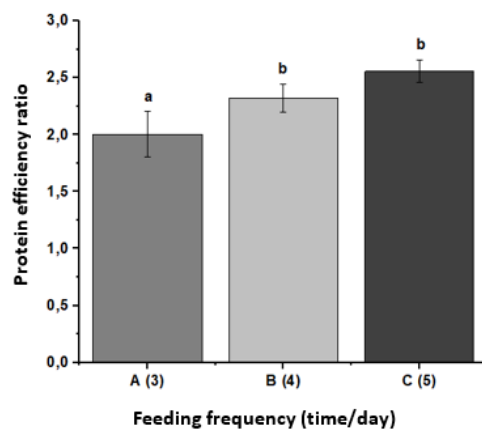


Figure 2. Protein efficiency ratio of gourami. Note: Bars followed by the same lowercase letter indicate values that are not significantly different ($P > 0.05$).

The best protein efficiency ratio (PER) value obtained was 2.56 ± 0.10 . This value is higher than the results of the study reported by Mareta *et al.* (2018), which was 1.51 ± 0.12 . This proves that feeding five times per day with a protein content of 50% meets the protein requirements of the feed consumed. According to Olusola and Nwanna (2014), the high protein efficiency ratio value is due to the ability of protein to be broken down into amino acids and their constituent components, thus making protein absorption in the fish body more efficient. Furthermore, Li *et al.* (2012) stated that this ratio value depends on the adequacy of the quality and quantity of nutrients in the feed that meet the fish's needs. In addition, the environment for raising gourami in the UFBs-RAS system is able to provide a high and stable concentration of dissolved oxygen, thereby increasing the distribution of digestive products in the small intestine (Li *et al.* 2021). This allows the protein in the feed to be optimally utilized for growth. In addition, high

protein digestibility can reduce the discharge of nitrogen metabolite waste into the cultivation medium, so that the UFBs-RAS system not only increases productivity but also reduces environmental pollution, which is in line with the development of environmentally friendly aquaculture technology (Subhan *et al.* 2022).

Growth rate

The specific growth rates measured in this study were the length growth rate (SLGR) and specific weight (SWGR). The results of the statistical analysis showed that the frequency of high-protein feed treatment had a significant effect ($P < 0.05$) on the growth rate of gourami in terms of length and weight (Figure 3). The best results were shown in Treatment C, namely $3.83 \pm 0.21\%/day$ and $4.16 \pm 0.16\%/day$, followed by Treatment B ($3.74 \pm 0.06\%/day$ and $3.46 \pm 0.20\%/day$), and Treatment A ($3.11 \pm 0.16\%/day$ and $2.46 \pm 0.39\%/day$).

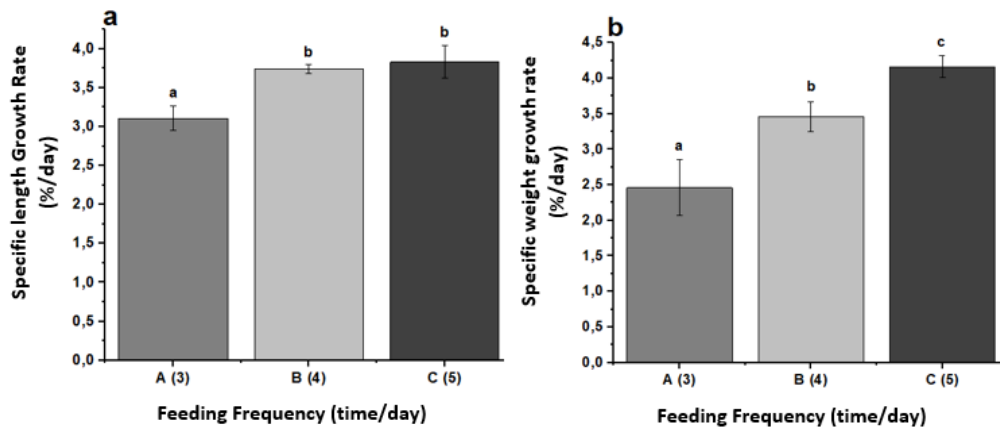


Figure 3. Specific growth rate (a) length and (b) weight of gourami. Note: bars followed by the same lowercase letter indicate values that are not significantly different ($P > 0.05$).

The specific growth rate for length and weight in Treatment A was lower than in Treatments B and C. This was due to the same amount of feed being fed in each treatment but at a lower frequency, resulting in decreased digestive efficiency, particularly because the high-protein feed (50%) required a longer digestion time. In contrast, Treatments B and C showed better results because the feed was fed more frequently and in amounts that matched the capacity and rate of gastric emptying. These results differ from those of Azrita *et al.* (2020), who reported that feeding three times was more effective than feeding four times, possibly due to differences in protein content and feed quantity, as well as the use of the UFBs-RAS system, which increases oxygen saturation and aids high-protein metabolism. Protein is crucial in the early stages of growth for tissue formation and repair (Herawati and Agus 2014; Agustono *et al.* 2009), and small fish require more frequent feeding to facilitate digestibility (Fujaya 2008; Wibowo *et al.* 2018).

Size variation

Size is a key parameter in aquaculture. In fish hatchery operations, this parameter is used as a selection indicator to determine the quality of the harvested fry. The lower the percentage of diversity, the better the quality of the harvested fish. The size diversity values in this study ranged from 9.33 ± 1.42 to $10.26 \pm 3.66\%$ (Figure 4). The statistical analysis results showed no significant differences ($P > 0.05$) between the treatments.

In this study, size variation was not affected by feeding frequency. This is in line with the findings of Firdaus *et al.* (2024), who stated that a feeding frequency of 1-3 times per day, with a feeding rate of 6% and a protein

content of 31%, did not affect the length variation of gourami fry ($7.70 \pm 1.34 - 14.55 \pm 8.86\%$). However, the range of values was greater than that of the results of this study ($9.33 \pm 1.42 - 10.26 \pm 3.66\%$). Firdaus *et al.* (2024) also reported an increase in size diversity with increasing feeding frequency, while in this study, there was a decrease. This difference was influenced by the maintenance system. This study used UFBs-RAS with high oxygen saturation ($>70\%$ or $6-7.2$ mg/L) and zero mg/L nitrite, while Firdaus *et al.* (2024) used a system without aeration and recirculation, which resulted in low oxygen concentrations of only $0.30-3.36$ mg/L and contained nitrite ranging from $0.002-0.027$ mg/L. This is supported by the statements of Zakes *et al.* (2006) and Dwyer *et al.* (2002) that the rearing system plays a significant role in size diversity. With an optimal environment and minimal stress, fish have equal opportunities to access food and grow proportionally, thereby reducing size variation between individuals.

Survival rate

The survival rate of gourami fry during the maintenance period in the UFBs-RAS system ranged from 98.50 ± 1.73 to $100.00 \pm 0.00\%$. Statistical analysis showed that feeding frequency significantly affected survival rate ($P < 0.05$) among the treatments (Figure 5). The highest survival rate was shown in Treatments B and C (100%), followed by Treatment A (feeding three times a day) at 98%.

The survival rate in this study was considered excellent compared to the general standard for fish fry survival, which is usually in the range of 73.5–86.0% (Andriyan *et al.* 2018), and for gourami fry, a minimum of 80% (BSN 2000). This result is also higher than the

findings of Azrita *et al.* (2020), who reported a survival rate of $82.22 \pm 3.85\%$ for gourami fry fed three times per day, with a protein content of 39.21% maintained in a recirculation system. The high survival rate in this study was due to the feeding frequency of 3–5 times per day with a protein content of 50%, which is still in accordance with the digestive capacity of the gourami. In addition, the UFBs-RAS maintenance system plays a crucial role in maintaining water quality, particularly the optimal dissolved oxygen concentration for fry. Stable and supportive environmental conditions, as well as adequate feed availability, are key factors in preventing stress and increasing gourami fry survival. Furthermore, Subardi *et al.* (2016) reported that fry survival is largely determined by feed quality and an optimal maintenance environment.

Water quality

Water quality measurements, including temperature, pH, dissolved oxygen (DO), ammonia, nitrite, and nitrate, were conducted daily throughout the study period (Table 1).

Maintaining good water quality creates a comfortable habitat for gourami, increasing appetite, accelerating growth, and helping maintain the fish's physiological functions to avoid environmental stress.

Temperature is a crucial factor influencing metabolic activity and gas solubility in water (Zonneveld *et al.* 1991). Based on water quality measurements, the temperature in the aquarium was within the range of 25–26 °C. This range is within the temperature quality standards set by the National Standardization Agency (BSN) (2000), which are 25–30 °C. Therefore, the temperature range in this study fell within the range that supports optimal survival and growth. At low temperatures, feed consumption tends to decrease compared to optimal temperatures, but this consumption also decreases if the temperature exceeds the optimal limit (Gunawan *et al.* 2019).

DO measurements showed a range of 6.6–7.0 mg/L, suitable for supporting gourami, which have a DO range of 5.8–7.3 mg/L (Dirmansyah *et al.* 2022). Gourami are inherently able to survive low oxygen levels due to their labyrinth organ (BSN 2000).

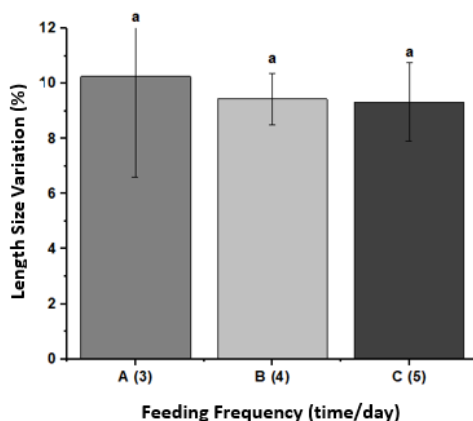


Figure 4. Length variation of the gourami. Note: Bars followed by the same lowercase letter indicate values that are not significantly different ($P > 0.05$).

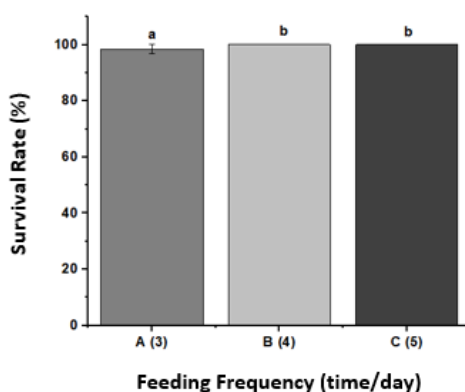


Figure 5. Survival of gourami. Note: bars followed by the same lowercase letter indicate values that are not significantly different ($P > 0.05$).

Table 1. Water quality measurements for gourami fry rearing in UFBs-RAS under different feeding frequencies.

No	Parameters	Range Values	Quality Standards
1	Temperature (°C)	25–26	25–30 °C (BSN 2000)
2	pH	7–7.6	6.5–8.5 (BSN 2000)
3	DO (mg/L)	6.6–7	2.38–7.67 (Nirmala dan Rasmawan 2010)
4	NH ₃ -N (mg/L)	0	< 0.02 mg/L (Masser <i>et al.</i> 1999)
5	NO ₂ -N (mg/L)	0	≤ 0.06 mg/L (Khasani <i>et al.</i> 2024)
6	NO ₃ -N (mg/L)	0	3 mg/L (Sucipto dan Prihartono 2007)

The pH range was 7.0–7.6, which is within the standard range of 6.5–8.5 (BSN 2000), making it suitable for gourami cultivation. Furthermore, Abdella *et al.* (2024) stated that pH values within this range are optimal for freshwater fish cultivation because a pH of 6.5–8.5 generally supports the physiological comfort of the fish, while pH values outside this range can trigger stress.

The results of measurements of the concentration of non-ionized ammonia (NH₃-N) during the study were 0 mg/L. This condition is thought to be influenced by several factors, including the role of ultrafine bubbles that can reduce ammonia (Subhan *et al.* 2021), the use of zeolite in the filtration system, which has a high ability to adsorb ammonia through ion exchange and surface adsorption mechanisms, and siphoning activities carried out twice daily. Nikhlani *et al.* (2025) reported that NH₃-N levels of 0.013–0.07 mg/L are still suitable for gourami cultivation. This is in line with the statement of Ijaz *et al.* (2010) that the absence of NH₃-N in the maintenance media significantly supports the growth of grass carp, compared to media containing NH₃-N. Yildiz *et al.* (2017) added that high NH₃-N concentrations can reduce survival, inhibit growth, cause various physiological dysfunctions, and trigger stress. According to Masser *et al.* (1999), the NH₃-N concentration range of 0.02–0.07 mg/L can slow growth and damage tissue in several tropical fish species; concentrations of more than 0.6 mg/L can cause fish death (Durborow *et al.* 1997).

In line with NH₃-N, the nitrite (NO₂-N) concentration in the rearing medium was zero. Firdaus *et al.* (2024) reported that a nitrite concentration of 0.002–0.0048 mg/L was relatively safe for maintaining the survival of gourami fry, as indicated by high survival rates. A similar finding was reported by Muin *et al.* (2020), who stated that a nitrite concentration of 0.05–0.28 mg/L produced the best growth and survival rates (14.73 ± 0.44% and 86.46 ± 1.04%, respectively). Khasani *et al.* (2024) stated

that the optimal safe nitrite concentration for fish is ≤ 0.06 mg/L. Nitrite concentrations > 0.3 mg/L during 60 days of rearing can reduce the immune system of Chinese perch and impact their growth (Zhang *et al.* 2021).

Nitrate (NO₃-N) concentrations during the study were low, at zero mg/L. Nitrate is the final product of the nitrification process and is less toxic than ammonia and nitrite. The low nitrate values in this study indicate that the biological filtration system in the UFBs-RAS worked optimally to manage nitrogen waste and maintain stable water quality. Furthermore, low nitrate accumulation is influenced by the efficient utilization of nutrients by fish during cultivation (Abdella *et al.* 2024; Li *et al.* 2021).

CONCLUSION

Feeding management by increasing the frequency to 5 times per day, feed amount to 5%, and protein content to 50% in the UFBs-RAS maintenance system can improve the production performance of gourami fry, namely survival (100%), specific growth rate (length (3.83 ± 0.209%/day) and weight (4.16 ± 0.156%/day), feed utilization efficiency (127.82%), protein efficiency ratio (2.56), and length variation (9.33 ± 1.423%). This increase occurs because an appropriate feeding strategy can improve nutrient utilization and physiological responses in fish, thereby supporting growth, feed utilization efficiency, and maintaining water quality stability during maintenance, which ultimately produces gourami fry with better productivity and quality.

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