The effect of ginger (*Zingiber officinale*) enrichment in artificial feed on the growth, survival, and profitability of giant gourami (*Osphronemus goramy*) cultivation

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Abstract. This research was performed to examine the effect of soaking ginger liquid in artificial feed on growth, survival, feed efficiency and profit in giant gourami (*Osphronemus goramy*) cultivation. A 40-day experiment was conducted using giant gourami seeds with an average size of 4.14 g (±0.85 g) reared in 0.4 m^3 aquariums with 16 fish each. Water recirculation was applied in water quality control. The feed used in this research was soaked in ginger liquid with different doses; 0.1% (treatment A), 0.25% (treatment B), and 5.0% (treatment C) with 3 replications. The results of this research showed that the right dose of ginger enrichment in artificial fish feed improved several parameters of the giant gourami fish cultivation, including weight growth rate (WGR), survival rate (SR), feed conversion ratio (FCR), and benefit/cost ratio (BCR). Treatment B resulted in the best performance. The modeling results show that the optimal dose of ginger treatment is 0.3%.
Key Words: FCR, ginger, giant gourami, SR, SGR, WGR.

Introduction. The giant gourami (*Osphronemus goramy*) is among the primary commodities in Indonesia's freshwater aquaculture sector, which natural habitat spreads across Southeast Asia. In Indonesia, red tilapia (*Oreochromis* sp.) and catfish (*Clarias* sp.) are leading commodities for freshwater fish farming which production reached 1.3 million tons and 1.1 million tons in 2022 respectively, while the production of giant gourami was 160 thousand tons (KKP 2022). Despite its smaller production scale, the giant gourami commands a higher market price, making it more profitable for farmers to cultivate (Azrita & Syandri 2015; Sari et al 2021; Gunawan et al 2022; KKP 2024).

Fish mortality rate is a crucial factor that influences the success of fish cultivation. Several parameters affect the fish mortality rate, including pollution, predators, pests, and disease attacks (Wijayanto et al 2022a, 2023; Grandiosa et al 2022). Maintaining good fish health supports optimal growth and survival rate of the fish. A number of researchers have added herbal nutraceutical ingredients into artificial fish feed is an alternative solution to maintain the health of the fish (Naseemashahul et al 2021; Varghese et al 2021; Wijayanto et al 2022b).

Herbal nutraceuticals have gained attention as potential substitutes for antibiotics, which have been banned in the international fish trade since 2017 (US-FDA 2019). Herbal nutraceutical ingredients are widely available in Indonesia, including ginger (*Zingiber officinale*). Ginger has long been utilized in pharmaceuticals and traditional medicine due to its antibacterial, antifungal, anti-inflammatory, and antioxidant properties (Al-Radadi et al 2022; Bitari et al 2023; Zhang et al 2023). This research was performed to determine the effect of soaking the artificial fish feed in ginger liquid on the growth, survival, feed efficiency, and profitability in giant gourami fish cultivation.

Material and Method. The experimental research was conducted at the Laboratory of the Faculty of Fisheries and Marine Sciences, Universitas Diponegoro (Indonesia) for 40 days (May to June 2024).

Experimental fish. The experiment fish used in this research were giant gourami fish seeds with an average size of 4.14±0.85 g.

Maintenance media and water quality management. Fish seeds were reared in aquariums, each with 16 fish within a water volume of 0.4 m^3. The water quality was controlled and maintained using water recirculation method. The filter media used were cloth, dacron, gravel, and commercial bioballs. To minimize bacterial and fungal contamination, water entering the experimental aquariums was passed through a channel equipped with a UV lamp. The parameters of water quality that included dissolved oxygen (DO), pH, and temperature were measured every 10 days using Horiba U-50 water quality checker.

Feed experiment. The fish feed was soaked in different doses of ginger liquid; 0.1% (treatment A), 0.25% (treatment B), and 5.0% (treatment C) with 3 replication each. The ginger liquid was produced by grating the ginger and extracted the juice (crude protein content around 40%). The test feed was then air-dried to ensure homogeneity. Fish were fed the experiment feed at a 2% of fish biomass every day during the treatments that employed a completely randomized design.

Data analysis. Every 10 days, the weight of the fish was measured to examine the fish growth and survival rate. The fish weight was also used as the baseline in determining the amount of feed given in the following day. The parameters measured in this research were weight growth rate (WGR, in %), specific growth rate (SGR, in % day^{-1}), survival rate (SR, in %), feed conversion ratio (FCR), and cost benefit ratio (BCR) using the formulas proposed by previous researchers (Gunawan et al 2022; Wijayanto et al 2023):

$$WGR = \frac{Wt - Wo}{Wo} \times 100$$

$$SGR = \frac{Ln\ Wt - Ln\ Wo}{t} \times 100$$

$$SR = \frac{Nt}{No} \times 100$$

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

$$BCR = \frac{B}{C}$$

where: Wt is the final weight of fish (in g); Wo is the initial weight of fish (in g); Ln is the natural logarithm (2.72); Nt is the final number of fish (ind); No is the initial number of fish (ind); F is the total feed (in g); B is the additional income from fish growth (in IDR); C is the cost of feed (in IDR).

The data of this research underwent statistical analysis using Anova (F test). If the treatments showed a significant effect, a Duncan's multiple range test was conducted to identify differences between treatment groups. Optimization modeling of the treatments was performed using the first derivative procedure, setting the derivative equal to zero .

Results. The fish growth data per treatment can be seen in Figure 1. Detailed research results regarding WGR, SGR, SR, FCR and BCR are also presented in Table 1. Treatment B generates the best performance in WGR (152.2%), SGR (2.31% per day), FCR (1.11), and BCR (3.01). FCR of 1.11 implies that 1 gram of fish growth requires 1.11 grams of feed. The BCR value of 3.01 indicates that an expenditure of IDR 1 generates an income of IDR 3.01. The SR value for all treatments and replications was 100%, making it ineligible for further statistical analysis. Statistical analysis demonstrated that the treatments had a significant effect on WGR, SGR, FCR, and BCR at a significance level of α = 10% (Table 1). The Duncan test results further confirmed that Treatment B consistently exhibited the best performance across these variables.

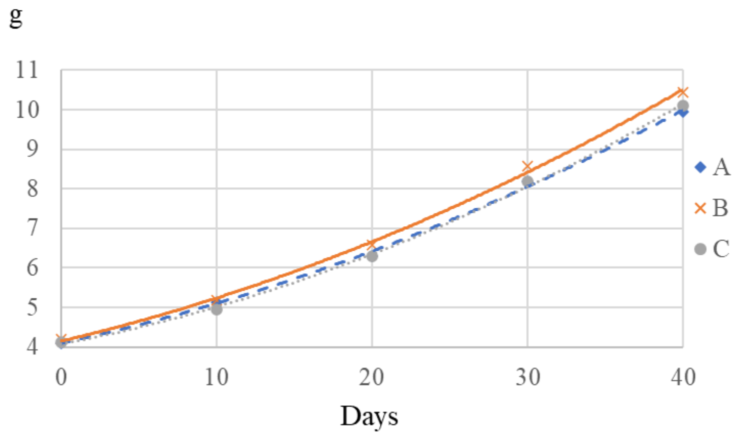

Figure 1. The progress of average weight of fish.

Table 1 presents the results of optimization modelling with a 2nd order polynomial equation. The optimal dose is estimated between 0.31 to 0.34%. It is necessary to apply correct dose of ginger liquid since excessive amounts can lead to lower performance of giant gourami cultivation (see in Figure 2).

Table 1

Research results

Code	*WGR (%)*	*SGR (%)*	*SR (%)*	*FCR*	*BCR*
A1	140	2.17	100	1.18	2.81
A2	148	2.26	100	1.15	2.97
A3	147	2.26	100	1.16	2.88
B1	153	2.31	100	1.12	3.03
B2	148	2.29	100	1.13	3.00
B3	153	2.33	100	1.09	3.00
C1	147	2.27	100	1.12	2.98
C2	147	2.26	100	1.11	2.99
C3	146	2.23	100	1.16	2.95
		Average value			
A	144.8^{a}	2.23^{a}	100.0	1.16^{b}	2.88^{a}
B	152.2^{a}	2.31^{b}	100.0	1.11^{a}	3.01^{b}
C	146.4^{b}	2.25^{a}	100.0	1.13^{a,b}	2.97^{b}
		Statistic test			
F value	3.841	4.311	Cannot be tested	4.268	5.037
Sig. value	0.084*	0.069*	Cannot be tested	0.070*	0.052*
		Optimization			
Optimal dosage	0.31%	0.31%	-	0.35%	0.34%
Estimated value	152.9%	2.32%	-	1.102	3.03

Note: * significant at α = 10%. The notations a and b indicate the same subset (Duncan's test results).

BCR function which is influenced by the FCR and WGR variables using multivariate linear regression is presented in the following equation:

$$BCR = 3.583 - 1.267\,FCR + 0.55\,WGR \quad (1)$$

$$R^2 = 70.5\%;\ F = 7.181;\ Sig = 0.26$$

Equation (1) implies that higher WGR by 1 unit can increase BCR by 0.55 units. An increase in the FCR by one unit corresponds to a decrease in the BCR by 1.267 units, indicating that feed efficiency and fish growth have a substantial impact on the profitability of giant gourami cultivation enterprises (Wijayanto et al 2022a, b, 2023).

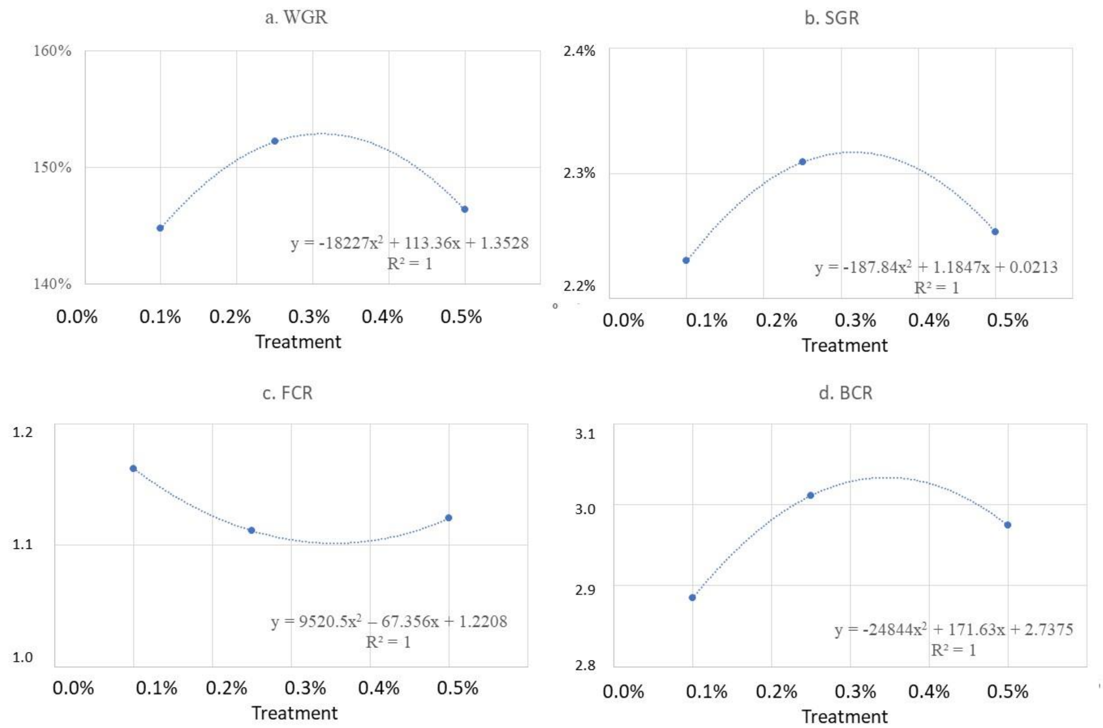

Figure 2. The curve of treatment relationship with WGR, SGR, FCR and BCR.

The water quality in the fish rearing media was within the tolerable range for giant gourami (Table 2). Adequate water quality that meets the physiological needs of fish is essential for supporting their survival and growth. A significant challenge in maintaining an effective recirculation system lies in managing organic matter from uneaten feed and fish waste. Recirculation systems help mitigate the risk of external environmental pollution, which can compromise fish health and weaken their immunity (Ghazala et al 2014; Hamed et al 2021; Wijayanto et al 2022a, b).

Table 2

Water quality parameters

Code	*pH*	*DO (ppm)*	*Temperature (°C)*
A1	8.1-8.4	4.3-6.2	24.0-26.1
A2	8.0-8.3	4.4-6.3	24.1-25.2
A3	8.0-8.4	4.3-5.7	24.2-25.5
B1	8.1-8.5	4.4-5.5	25.0-26.1
B2	8.0-8.4	4.3-5.7	24.2-25.4
B3	8.0-8.2	4.2-6.2	24.2-25.5
C1	8.1-8.5	4.8-5.4	24.0-26.1
C2	8.0-8.4	4.1-5.4	24.3-25.2
C3	8.0-8.5	4.2-6.3	24.2-25.4
References	6.5-8.5[a,b]	Min 3 ppm[a,b]	25-30[a]

Sources: BSN (2000)[a]; Tucker & D'Abramo (2008)[b].

Discussion. Giant gourami are freshwater herbivorous fish that are cultivated for consumption and ornamental fish which have a better ability to adapt to high-carbohydrate feeding compared to carnivorous fish. Giant gourami fish live in clear water, move slowly and are rather calm. Its high economic value offers high profit for fish farmers in Indonesia, regardless of its slower growth compared to either tilapia or catfish (Azrita & Syandri 2015; Sari et al 2021; Gunawan et al 2022; Pribawastuti and Samara 2022).

The productivity of giant gourami cultivation should be enhanced to support the food security and the welfare of fish farmers. Besides Indonesia, giant gourami is also widely cultivated in Thailand, the Philippines and Malaysia (Pribawastuti & Samara 2022). Several researchers highlight the effect of herbal nutraceutical ingredients in improving the fish farming performance. For instance, the use of shallots and garlic has been demonstrated to enhance the performance of Asian seabass (*Lates calcarifer*) and the TGGG (♀ tiger grouper, *Epinephelus fuscoguttatus* × ♂ giant grouper, *E. lanceolatus*) hybrid grouper in aquaculture. The optimal dose of shallots in the feed ranges between 2.4 and 2.5% for TGGG hybrid grouper, and between 3.6 and 4.2% for Asian seabass. Whereas, the optimal dose of garlic is 0.3-0.6% in feed for TGGG hybrid grouper, and 0.5 to 0.9% in feed for Asian seabass. The phenolics, flavonoids, polyphenols, terpenoids, lectins, sulfur, trace minerals, vitamins, and inulin in those herbal nutraceutical ingredients have anti-oxidant, anti-inflammatory, anti-bacterial, anti-fungal, anti-parasitic and anti-cancer properties, while also improving the fish digestive system (Wijayanto et al 2022a, b, 2023, 2024). The results of this research reveal the potentials of ginger to be used as an enrichment ingredient to the feed of giant gourami.

Ginger contains anti-bacterial, anti-fungal, anti-Alzheimer, anti-oxidant, and anti-inflammatory properties. In addition, ginger has been widely used in the treatments of digestive disorders, headaches, rheumatism, colds, and coughs for humans. However, the optimal dose of ginger used in human differs from the one used for fish, even different fish species requires different doses of ginger (Syafitri et al 2018; Al-Radadi et al 2022; Bitari et al 2023; Zhang et al 2023). The enrichment of ginger in the feed can increase the SR of *Cyprinus corpio* (Syafirah et al 2021). This research revealed the optimal dose of ginger liquid is at 0.3%.

Ginger is a tropical plant that grows in China, India, Bangladesh, Jamaica, Nigeria, the US, and Indonesia. India is the largest producer of ginger (Syafitri et al 2018). In 2018, ginger production in Indonesia reached 207.41 thousand tons, with the highest production coming from East Java (37%), followed by Central Java (19%) and West Java (13%) (BPS-Statistics Indonesia 2018). Ginger production has continued to rise, reaching 307.24 thousand tons in 2021 (BPS-Statistics Indonesia 2022). Ginger contains bioactive compounds, including phenolics and terpenes, and has been utilized in traditional Chinese medicine for centuries (Mao et al 2019; Mukjerjee & Karati 2022). The bioactive compounds in ginger are known to enhance the immune system of fish and act as natural antimicrobial agents (Vaz et al 2022). Furthermore, ginger extract has been shown to suppress coccidiosis, a protozoan parasitic disease that affects the digestive tract of both animals and humans (Mubaraki et al 2022). Ginger can also improve fish resistance during disease outbreaks or environmental stressors (Park et al 2021; Varghese et al 2021).

Optimizing fish growth, feed efficiency and disease control are the key challenges in fish farming production. Slow fish growth leads to higher production costs (Hajirezaee et al 2015; Satriawan et al 2020; Hidayati et al 2021; Wijayanto et al 2024). Adequate disease control can increase the fish survival rates, production and profits (Hidayati et al 2021; Wijayanto et al 2022a, b). In this research, the water quality was controlled using water recirculation method, where dirty water was filtered and reused (Fan et al 2023). The use of superior seeds also affects the growth rate and resistance of gourami fish. Additionally, the growth of giant gourami is influenced by water current speed, as these fish prefer calm waters. Spectral lighting manipulation has also been shown to affect both the coloration and growth of gourami fish (Azrita & Syandri 2015; Satriawan et al 2020; Gunawan et al 2022).

The ban on antibiotic use has encouraged the development of herbal nutraceutical applications in fish feed to increase the resistance of farmed fish. Continuous use of chemicals and antibiotics at inappropriate concentrations can increase parasite resistance to the synthetic compounds used (Grandiosa et al 2022). Herbal extracts can be administered in fish farming through oral, injectable, or soaking methods, with oral administration being the most efficient, as it minimizes stress in fish (Gabriel 2019). While ginger can improve the performance of giant gourami cultivation, it should be served in the right dose. Excessive dose can decrease the performance of giant gourami fish farming business.

Conclusions. The results of this research confirm that the right dose of ginger treatment in artificial fish feed can improve the performance of giant gourami fish farming business as seen from parameters WGR, SR, FCR and BCR. In this research, treatment B yielded in the most optimal performance at a dose of 0.3% (as the result of modeling).

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Conflict of interest. The author declares that there is no conflict of interest.

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