

# The effects of turmeric (*Curcuma longa* Linn.) on growth, survival and BCR of TGGG hybrid grouper (♀ tiger grouper × ♂ giant grouper) cultivation

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**Abstract.** This research was performed to determine the effect of turmeric liquid immersion in artificial feed on growth, survival, feed efficiency and profit in the cultivation of TGGG (♀ tiger grouper × ♂ giant grouper) hybrid grouper. The test fish had an average size of 46.46±3.21g given 3 different feed treatments, namely: feed immersion using turmeric liquid with a dose of 0.5% (treatment A), 1.0% (treatment B), and 1.5% (treatment C). The results of this research proved that with the right dose, turmeric can improve the performance of the TGGG hybrid grouper cultivation business by increasing the fish growth (WGR and SGR), feed efficiency (FCR), and BC ratio. Treatment C showed the most optimal performance at turmeric doses of 1.7% for FCR, 1.8% for BC ratio, 2.4% for SGR and 2.6% for WGR.

**Key Words:** benefit-cost ratio, feed conversion ratio, specific growth rate, survival rate, weight growth rate.

**Introduction.** The production of grouper fish farming in Indonesia reached 12,240 tons in 2022 (KKP 2022). TGGG hybrid grouper is one of the major brackish water commodity and sea water fish farming businesses in Indonesia. TGGG hybrid grouper is a cross between a female tiger grouper (*Epinephelus fuscoguttatus*) and a male giant grouper (*E. lanceolatus*) with faster growth and stronger resistance to diseases (DJPB 2017; KKP 2022; Long et al 2022; Fan et al 2023; Wijayanto et al 2023a, b).

Optimal fish health is essential for promoting growth and survival, which subsequently impacts the profitability of fish farming enterprises. Various engineering practices in aquaculture are implemented to enhance fish growth and survival rates, including the use of fish feed enriched with herbal nutraceuticals (Riauwaty & Windarti 2006; Shekarabi et al 2022; Wijayanto et al 2022a, b, 2023a, b).

Indonesia is abundant in herbal nutraceuticals, one of which is turmeric (*Curcuma longa*), locally called "kunyit". In Indonesia, turmeric is widely utilized both as a culinary spice and in traditional medicine. Adding immunostimulants into fish feed has been shown to enhance the immune system of fish. Herbal nutraceuticals can be added in artificial fish feed as an alternative strategy to maintain the health of farmed fish (Naseemashahul et al 2021; Varghese et al 2021). As a local biopharmaceutical product, turmeric's production volume reached 205 thousand tons in 2023 (BPS-Statistics of Indonesia 2024). This research was performed to assess the effect of turmeric liquid soaking on artificial feed enrichment on the growth, survival, feed efficiency, and profitability of TGGG hybrid grouper cultivation.

## Material and Method

**Location and time of research.** This experimental research was conducted at the Universitas Diponegoro Laboratory in Semarang City for 20 days (February 2024).

**Experimental materials.** This study utilized TGGG hybrid grouper seeds with an average weight of  $46.46 \pm 3.21$  g. The fish were maintained in a medium with a salinity of 10 ppt, housed in  $0.4 \text{ m}^3$  tanks with a stocking density of 20 fish per tank. The experimental feed treatments involved soaking commercial artificial feed in turmeric liquid, with three treatment groups: 0.5% (treatment A), 1.0% (treatment B), and 1.5% (treatment C), each repeated three times. Turmeric was grated, squeezed, and the resulting liquid was used to soak the commercial feed, which had a crude protein content of at least 46%. After soaking, the enriched feed was air-dried. The fish were fed the experimental diet daily at a rate of 3% of their biomass (frequency 3 times per day). A completely randomized design was applied for the experiment. Water quality was maintained through a recirculation system utilizing various filter media, including cloth, dacron, gravel, commercial bioballs, and mangroves. Water entering the experimental tanks was passed through a channel equipped with UV (ultraviolet) lamps to reduce bacterial and fungal contamination. Water quality parameters, including dissolved oxygen (DO), pH, salinity, and temperature, were monitored weekly using a Horiba U-50 water quality checker.

**Data analysis.** Fish weights were measured on the first, tenth, and twentieth days of the experiment, along with a count of the surviving fish. Weighing was used to track fish growth and calculate the amount of feed provided. The study focused on variables including weight growth rate (WGR, in %), specific growth rate (SGR, in  $\% \text{ day}^{-1}$ ), survival rate (SR, in %), feed conversion ratio (FCR), and benefit-cost ratio (BCR). The formulas for these calculations are based on Long et al (2022) and Wijayanto et al (2023a, b):

$$\text{WGR} = \frac{W_t - W_o}{W_o} 100 \quad [1]$$

$$\text{SGR} = \frac{\ln W_t - \ln W_o}{t} 100 \quad [2]$$

$$\text{SR} = \frac{N_t}{N_o} 100 \quad [3]$$

$$\text{FCR} = \frac{F}{W_t - W_o} \quad [4]$$

$$\text{BCR} = \frac{B}{C} \quad [5]$$

The variables used in this study include  $W_t$  (final weight of fish in grams),  $W_o$  (initial weight of fish in grams),  $t$  (day of the experiment),  $N_t$  (final number of fish in individuals),  $N_o$  (initial number of fish in individuals),  $\ln$  (natural logarithm, base 2.72),  $F$  (total feed given in grams),  $B$  (additional income from fish growth in Rupiah), and  $C$  (cost of feed in Rupiah). Statistical analysis was conducted using ANOVA (F-test) to determine the significance of treatment effects. If a significant effect was found, the Duncan test was applied to compare differences between treatments. Optimization modeling of the treatments was performed using the first derivative procedure set to zero. Additionally, multivariate regression analysis was carried out with the BCR as the dependent variable, and WGR and FCR as independent variables.

**Results.** Figure 1 shows the growth progress of the fish for each treatment, while Tables 1 and 2 display the results for WGR, SGR, SR, FCR, and BCR. Treatment C showed the best performance in WGR, SGR, FCR, and BCR, while treatment A had the lowest performance. Statistical analysis indicated that turmeric treatment significantly affected WGR, SGR, FCR, and BCR, but not SR (Table 2). The Duncan test further confirmed that treatment C consistently outperformed the others in WGR, SGR, FCR, and BCR.

The results of this study indicate that turmeric treatment in feed positively affects growth (WGR and SGR), feed conversion (FCR), and the BCR in TGGG hybrid grouper. However, caution is required when applying turmeric, as excessive doses can lead to a decrease in growth, feed conversion, and BCR. The optimization modeling of turmeric

treatment is shown in Table 3 and Figure 2, with the results indicating that the optimal dose for adding turmeric to TGGG hybrid grouper feed falls within the range of 1.7 to 2.6%.

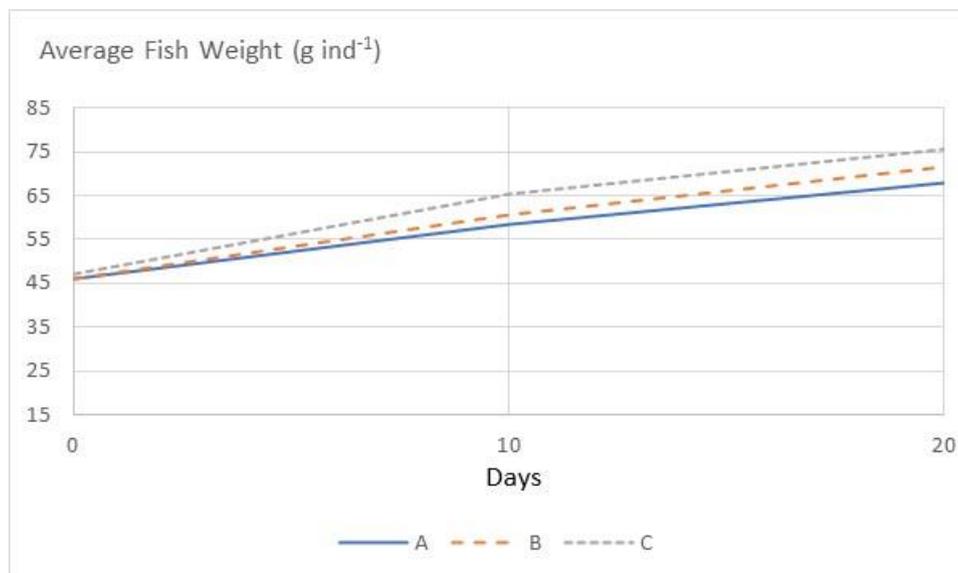


Figure 1. Average weight progress of fish

Table 1

Research results

Code	WGR (%)	SGR (% day <sup>-1</sup> )	SR (%)	FCR	BCR
A1	50.68%	1.01%	100.00%	1.29	2.97
A2	46.03%	0.91%	95.24%	1.56	2.64
A3	47.15%	0.94%	100.00%	1.46	2.72
B1	59.58%	1.16%	100.00%	1.28	3.22
B2	50.17%	0.96%	95.24%	1.34	3.02
B3	56.01%	1.08%	100.00%	1.25	3.16
C1	69.63%	1.20%	95.24%	1.12	3.69
C2	55.23%	1.14%	100.00%	1.30	3.13
C3	56.73%	1.10%	100.00%	1.26	3.14

Table 2

Statistical analysis

Variables	WGR (%)	SGR (% day <sup>-1</sup> )	SR (%)	FCR	BCR
A	48.0 <sup>a</sup>	0.954 <sup>a</sup>	98.41 <sup>a</sup>	1.43 <sup>a</sup>	2.78 <sup>a</sup>
B	55.3 <sup>a</sup>	1.067 <sup>b</sup>	98.41 <sup>a</sup>	1.29 <sup>a</sup>	3.13 <sup>b</sup>
C	60.5 <sup>b</sup>	1.147 <sup>b</sup>	98.41 <sup>a</sup>	1.23 <sup>b</sup>	3.32 <sup>b</sup>
F value	4.073	6.200	0.000	3.520	4.801
Sign	0.076*	0.035*	1.000	0.097*	0.057*

Note: \*significant at  $\alpha = 10\%$ . The notations a, and b indicate the same subset (Duncan test results).

Table 3

Optimal treatment estimation

Variable	Estimated optimal concentration
WGR	2.6%
SGR	2.4%
FCR	1.7%
BCR	1.8%

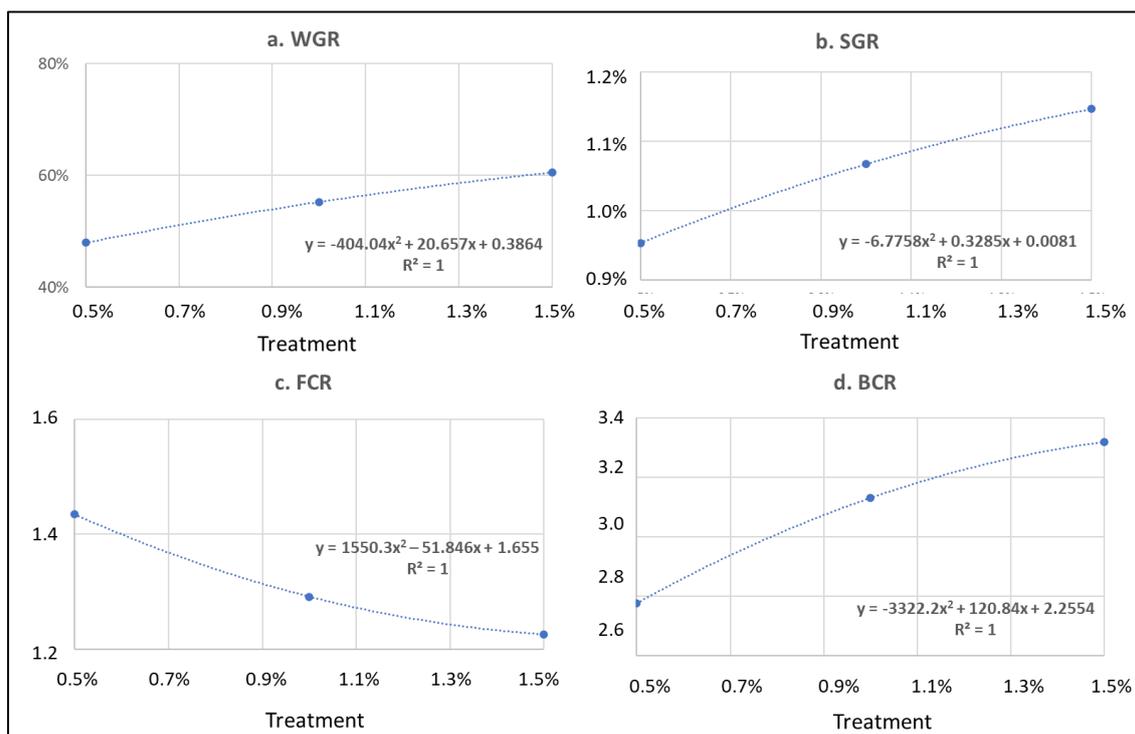


Figure 2. The relationship between treatment and WGR, SGR, FCR and BCR.

The results of the multi-variate analysis of BCR influenced by the FCR and WGR variables can be seen in the following equation:

$$\text{BCR} = 2.709 - 0.866 \text{ FCR} + 2.766 \text{ WGR}$$

$$R^2 = 98.3\%; F = 172.007; \text{Sig. value} = 0.000005$$

The first equation shows that for every 1-unit increase in WGR, the BCR increases by 2.766 units. Conversely, a 1-unit increase in FCR leads to a 0.866-unit decrease in BCR. This highlights the importance of fish growth and feed efficiency in determining the profitability of TGGG hybrid grouper farming (Wijayanto et al 2022a, b; Wijayanto 2023).

The water quality in the experiment was still acceptable for TGGG hybrid grouper (Table 4), and the test fish maintained a good appetite throughout. The experiment aimed to test whether reducing seawater salinity could allow TGGG hybrid grouper to be farmed further from the coast. If successful, this could enable fish farmers in inland areas of Indonesia to raise high-value fish, in contrast to the lower-value species such as catfish (*Clarias sp.*) and tilapia (*Oreochromis sp.*) currently being farmed (Wijayanto et al 2020, 2023b; Wijayanto 2023).

Table 4  
Water quality during research

Code	pH	DO (ppm)	Temperature (°C)
A1	7.0-7.2	5.0-5.6	27.0-27.3
A2	7.0-7.1	5.3-6.0	27.1-27.2
A3	7.0-7.1	5.5-5.7	27.1-27.3
B1	7.0-7.1	5.0-5.6	27.1-27.4
B2	7.0-7.1	5.0-5.6	27.1-27.4
B3	7.0-7.1	5.0-5.7	27.1-27.4
C1	7.0-7.1	5.2-5.7	27.1-27.5
C2	7.0-7.1	5.2-5.8	27.1-27.6
C3	7.0-7.1	5.0-5.7	27.1-27.6
Reference	7.0-8.5 <sup>a</sup>	Min 3 <sup>a</sup> , 5-8 <sup>b</sup>	27-32 <sup>b</sup>

Note: salinity of all experimental tanks was set at 10 ppt. Source: Tucker & D'Abramo (2008)<sup>a</sup>, DJPB (2017)<sup>b</sup>.

**Discussion.** Increasing productivity in fish farming is crucial for addressing global food security. With the world population expected to reach 9.8 billion by 2050, the food supply, including fish from aquaculture, must also increase (UN 2017; Bhadra et al 2024). Fish mortality rates are a critical factor in the success of fish farming. Pollution, predation, pests, and disease are among the main causes of fish mortality. Keeping fish healthy is key to supporting their growth and survival (Grandiosa et al 2022; Wijayanto et al 2024; El-Gammal et al 2025).

Herbal nutraceuticals like turmeric offer a potential alternative to antibiotics, which have been banned internationally since 2017 (US-FDA 2019; Naseemashahul et al 2021; Varghese et al 2021; Asyhar et al 2023). Turmeric contains curcumin, a compound that can boost fish growth, improve resistance, and enhance feed efficiency. As a native Indonesian plant, turmeric contains curcuminoids - curcumin, desmethoxycurcumin, and bisdesmethoxycurcumin - that have antioxidant, anticancer, anti-inflammatory, antilipidemic, liver-protective, antibacterial, and antifungal effects. Curcumin is a polyphenolic extract from turmeric that acts as an antioxidant, and has antibacterial, immune-boosting, and anti-inflammatory properties, benefiting both humans and animals, including fish (Batubara et al 2015; Darmawan & Pramono 2016; Atun et al 2020; Rahmat et al 2021; Ashry et al 2021; Setiawan et al 2022; Asyhar et al 2023; Bhadra et al 2024; Ren et al 2024; El-Gammal et al 2025).

Prior research have shown that adding turmeric to fish feed can improve fish farming results. For example, Pirani et al (2021) found that adding 5% turmeric to the feed boosted the growth of *Cyprinus carpio* and reduced the fat content in the fish. Riauwaty & Windarti (2006) showed that turmeric helped reduce gill damage in *Clarias batrachus* infected with *Aeromonas hydrophila*, indicating its antibacterial effects. Syawal et al (2022) found that turmeric improved the hematologic and physiological profiles of *Pangasionodon hypophthalmus*. Anene et al (2022) determined that the optimal amount of turmeric flour for *C. gariepinus* is 1%. In the study of Wijayanto et al (2023c), the best level of turmeric for Asian seabass was found to be between 0.93 and 1.29%. Ashry et al (2021) reported that the optimal curcumin level in feed for *Sparus aurata* was 2-3%. Curcumin at specific doses has also shown positive results in the farming of snakehead fish (*Channa argus*), rainbow trout (*Oncorhynchus mykiss*), and largemouth bass (*Micropterus salmoides*). The response to turmeric in feed varies depending on the fish species, with optimal levels differing across studies (Li et al 2022; Aqmasjed et al 2023; Wang et al 2023; Ren et al 2024).

This study shows that adding turmeric to fish feed can improve fish growth, feed conversion efficiency (FCR), and profitability (BCR). However, using turmeric at excessively high levels can harm the fish. Herbal nutraceuticals help strengthen fish immunity, making them less prone to stress from environmental changes (Chowdhury et al 2021; Paray et al 2021; Shekarabi et al 2022). Healthy fish with strong immunity are more likely to grow, metabolize, and survive better, which leads to higher production, and profits in fish farming (Cheong 1989; Hidayati et al 2021; Wijayanto et al 2022a, b). Feed conversion and profit are closely linked since feed costs make up a large share of expenses in intensive fish farming, such as 40% in Asian seabass farming (Cheong 1989; Wijayanto et al 2022b). Efficient use of feed is key to increasing productivity and profitability (Wijayanto et al 2022a, b).

**Conclusions.** This study confirms that using the right dose of turmeric in artificial fish feed improves TGGG hybrid grouper farming performance. It enhances growth (WGR and SGR), feed efficiency (FCR), and the benefit-cost ratio (BCR). The study showed that there was no significant difference in SR due to differences in treatment. This study has also proven that FCR and WGR have a significant impact on BCR. Treatment C showed the best results overall. The optimal turmeric doses, based on the modeling results, are 1.7% for FCR, 1.8% for BCR, 2.4% for SGR, and 2.6% for WGR. Research on the application of other herbal nutraceuticals ingredients has the potential to be conducted to optimize the growth, SR, and profitability of the TGGG hybrid grouper cultivation.

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

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