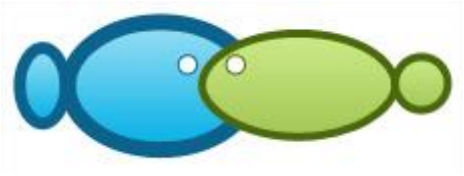

The effect of Javanese turmeric (*Curcuma xanthorrhiza*) on growth, survival and BCR of TGGG (♀ tiger grouper × ♂ giant grouper) hybrid grouper

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Abstract. The application of Javanese turmeric (*Curcuma xanthorrhiza*, locally known as *temulawak* in Indonesia) as a nutraceutical ingredient in fish feed has potential for enhancing fish health and optimizing growth. Improved growth and survival are critical for maximizing profitability in aquaculture. This research evaluated the effects of Javanese turmeric supplementation on the growth, survival, feed efficiency, and profitability of hybrid grouper (TGGG; ♀ tiger grouper × ♂ giant grouper) cultivation. The experiment utilized juvenile fish averaging 18.74±0.78 g in weight and tested three feed treatments: Javanese turmeric-soaked feed at doses of 5% (treatment A), 10% (treatment B), and 20% (treatment C). The findings indicate that an appropriate dose of Javanese turmeric enhances fish growth, survival rates, feed efficiency, and overall profitability. Among the treatments, treatment B consistently demonstrated better performance, although statistical analysis at α = 5% indicated no significant differences among treatments. Optimization modeling suggests that the optimal turmeric dosage lies within the range of 13.5 to 15.0%.
Key Words: BCR, *Curcuma xanthorrhiza,* FCR, growth, TGGG hybrid grouper.

Introduction. Indonesia is abundant with herbal nutraceuticals that are commonly used for traditional herbal medicine (‘*jamu*’), such as Javanese turmeric (*Curcuma xanthorrhiza*), turmeric (*Curcuma longa*), black pepper (*Piper nigrum*), cloves (*Syzygium aromaticum*), ginger (*Zingiber officinale*), garlic (*Allium sativum*), coriander (*Coriandrum sativum*), and shallots (*Allium cepa*). Herbal nutraceuticals offer an alternative antibiotic that have been internationally banned for aquaculture use since 2017 (US-FDA 2018; Naseemashahul et al 2021; Varghese et al 2021; Asyhar et al 2023; Wijayanto et al 2023a). Optimal fish health will support the growth and survival of fish. Javanese turmeric, ginger, turmeric, shallots, and garlic have been proven in several research to increase the growth and profits of fish farming businesses (Wijayanto et al 2022a, b, 2023a, b).

TGGG hybrid grouper is a cross between a female tiger grouper (*Epinephelus fuscoguttatus*) and a male giant grouper (*E. lanceolatus*) that grows faster and has stronger health than parental species. Faster fish growth shortens the rearing period, ultimately leading to higher profit. The use of herbal nutraceutical ingredients for disease control is expected to increase survival rates, production, and profits. Javanese turmeric contains xanthorrhizol which can act as an antimicrobial, anticancer, antitumor, anti-inflammatory, and antioxidant (Koh et al 2016; Chieng et al 2018; Nurcholis et al 2018; Rahmat et al 2021; Setiawan et al 2022; Asyhar et al 2023). This research determined the effect of soaking Javanese turmeric liquid in artificial feed on growth, survival, feed efficiency and profits in TGGG hybrid grouper cultivation.

Material and Method

Location and time of research. The research was conducted at the Universitas Diponegoro Laboratory for 40 days, namely in December 2023 to January 2024.

Experiment. The research utilized TGGG hybrid grouper fish seeds with an average weight of 18.74±0.78 g. The test fish were maintained in 0.4 m^3 tanks filled with a salinity medium of 10 ppt, stocking 27 fish per tank. Feed treatments involved soaking commercial feed (minimum crude protein content of 46%) in Javanese turmeric extract at concentrations of 5% (treatment A), 10% (treatment B), and 20% (treatment C). Each treatment was replicated three times. The turmeric extract was prepared by grating and squeezing fresh turmeric, with the resulting liquid used to soak the feed, which was then air-dried. Fish were fed daily with enriched feed at 4% of their biomass. The experiment followed a completely randomized design.

Water quality was maintained through a recirculation system, where filtered water was reused. Filtration employed layers of cloth, dacron, gravel, commercial bioballs, and mangroves. Water entering the tanks passed through channels equipped with UV lamps to minimize bacterial and fungal contamination. Water quality parameters, including dissolved oxygen (DO), pH, salinity, and temperature, were monitored every 10 days using a Horiba U-50 water quality checker.

Data analysis. Every 10 days, fish biomass was weighed, and the number of surviving fish was recorded. This procedure facilitated monitoring fish weight development and adjusting feed quantities accordingly. The research variables included weight growth rate (WGR, %), specific growth rate (SGR, % day^{-1}), survival rate (SR, %), feed conversion ratio (FCR), and benefit-cost ratio (BCR). The formulas used for these calculations were derived from Ashry et al (2021), Long et al (2022), and Wijayanto et al (2023a, b):

$$WGR = \frac{Wt - Wo}{Wo} \times 100 \quad [1]$$

$$SGR = \frac{\text{Ln } Wt - \text{Ln } Wo}{t} x\ 100 \quad [2]$$

$$SR = \frac{Nt}{No} \times 100 \quad [3]$$

$$FCR = \frac{F}{W} \quad [4]$$

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

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

Statistical analysis was conducted using ANOVA (F-test) to evaluate the significance of treatment effects. If significant differences were observed, Duncan's multiple range test was applied for further analysis. Optimization of treatment effects was modeled by solving the first derivative equation set to zero.

Results. The fish growth progress for each treatment is illustrated in Figure 1, while the analysis results for WGR, SGR, SR, FCR, and BCR are presented in Tables 1 and 2. Treatment B demonstrated the best performance across most variables, including WGR, SGR, FCR, and BCR, and showed comparable SR to treatment C. In contrast, treatment A

exhibited the lowest performance. However, statistical analysis (Table 2) indicated no significant differences among treatments; therefore, further testing using Duncan's multiple range test was not conducted.

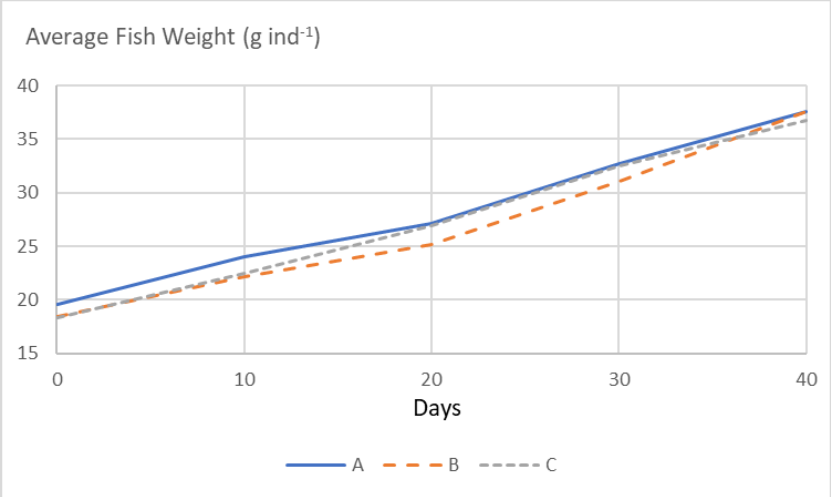

Figure 1. The average fish growth progress.

Table 1

WGR, SGR, SR, FCR and BCR

Code	*WGR (%)*	*SGR (% day^{-1})*	*SR (%)*	*FCR*	*BCR*
A1	83.2	1.59	100	2.36	1.68
A2	84.2	1.61	91	2.39	1.66
A3	102.9	1.86	96	2.00	1.98
B1	113.3	1.99	100	1.80	2.20
B2	100.5	1.83	96	1.96	2.02
B3	99.4	1.82	96	2.01	1.97
C1	96.3	1.76	96	1.82	1.82
C2	100.0	1.75	100	1.82	1.82
C3	96.4	2.00	96	2.13	2.13

Table 2

Statistical analysis

Variables	*WGR (%)*	*SGR (% day^{-1})*	*SR (%)*	*FCR*	*BCR*
A	90.1	1.69	95.78	2.25	1.77
B	104.4	1.88	97.57	1.92	1.92
C	101.5	1.84	97.57	2.07	2.07
F value	0.213	0.263	0.325	0.567	0.371
Sig value	0.814	0.777	0.735	0.595	0.705

The research demonstrates that incorporating Javanese turmeric into feed can influence the growth, FCR, and BC ratio of TGGG hybrid grouper. However, caution is advised, as excessive doses may negatively affect these parameters. The optimization modeling results for Javanese turmeric treatment are presented in Table 3 and Figure 2, indicating that the optimal turmeric dosage for feed enrichment lies between 13.5 and 15.0%.

The water quality parameters in the experimental media were within tolerable ranges for TGGG hybrid grouper (Table 4).

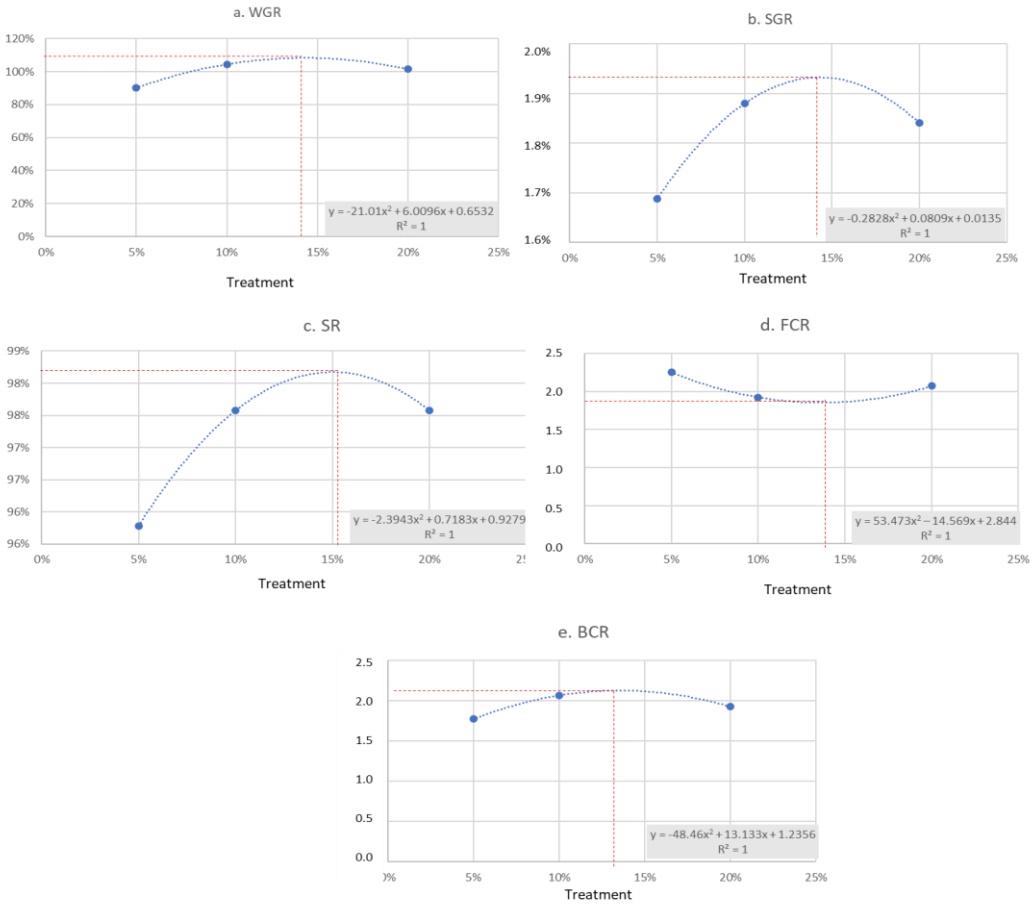

Figure 2. The relationship of treatment with WGR, SGR, SR, FCR and BCR.

Table 3

Optimal treatment estimation

Variables	*Estimated optimal concentration*
WGR	14.3%
SGR	14.3%
SR	15.0%
FCR	13.6%
BCR	13.5%

Table 4

Water quality during research

Code	*pH*	*DO (ppm)*	*Temperature (°C)*
A1	7.4±0.18	4.5±0.08	24.9±0.60
A2	7.6±0.15	4.6±0.14	24.7±0.47
A3	7.5±0.10	4.7±0.29	24.9±0.25
B1	7.4±0.10	4.6±0.14	24.9±0.15
B2	7.6±0.17	4.6±0.14	24.7±0.47
B3	7.5±0.13	4.8±0.54	24.6±0.51
C1	7.4±0.08	4.8±0.49	24.7±0.47
C2	7.4±0.10	4.8±0.44	24.7±0.47
C3	7.3±0.10	4.7±0.24	24.9±0.30
References	7.0-8.5[a,b]	Min 3 ppm[a], Min 3.5 ppm[b]	16-26 (optimum 25)[c]

Note: the salinity of all experimental tanks was set at 10 ppt. Sources: Tucker & D'Abramo (2008)[a], BSN (2024)[b] Das et al (2021)[c].

This experiment specifically aimed to assess the feasibility of maintaining TGGG grouper in reduced salinity conditions, simulating environments with salinity levels lower than natural seawater. The goal was to explore the potential for farming TGGG grouper in inland areas far from coastal or marine regions. If successful, this approach could enable fish farmers in inland Indonesia to cultivate high-value species like TGGG grouper, addressing the limitations of their current focus on lower-value species such as catfish and tilapia (Wijayanto et al 2023b). Throughout the experiment, the test fish exhibited consistently high appetite levels.

Discussion. The development of TGGG hybrid grouper cultivation technology holds significant strategic value both nationally and internationally. This advancement addresses critical issues such as food security, employment generation, and the welfare of aquaculture stakeholders, particularly in Indonesia, a developing country. The cultivation of TGGG hybrid grouper seeds in Indonesia began in 2017, and the species has since gained popularity among fish farmers. It has increasingly replaced traditional species like tiger grouper and humpback grouper (*Cromileptes altivelis*) due to its economic and practical advantages (DJPB 2017; Shapawi et al 2019; Long et al 2022).

This research highlights the potential of Javanese turmeric as a nutraceutical herbal ingredient to enhance the productivity of TGGG hybrid grouper cultivation. The findings suggest that the optimal dosage for Javanese turmeric treatment ranges from 13.5 to 15.0%. In comparison, the research by Wijayanto (2023) determined that a 9.6% dose of Javanese turmeric was optimal for improving the benefit-cost ratio (BCR) in Asian seabass (*Lates calcarifer*) cultivation. These results underscore that different fish species exhibit varying responses to Javanese turmeric as a nutraceutical additive.

Javanese turmeric is a medicinal plant native to Indonesia that contains curcuminoid and xanthorrhizole compounds with health-promoting properties. It has been traditionally used to treat kidney stones, hepatitis, microbial infections, and high cholesterol. Its bioactive compounds possess antioxidant, anticancer, anti-inflammatory, antilipidemic, antibacterial, and antifungal properties. In aquaculture, curcumin can enhance fish growth, resilience, and feed efficiency, while essential oils from Javanese turmeric can lower LDL-C levels and inhibit weight gain. However, excessive doses may adversely affect fish growth, emphasizing the importance of dose optimization (Batubara et al 2015; Darmawan & Pramono 2016; Nurcholis et al 2018; Atun et al 2020; Rahmat et al 2021; Ashry et al 2021; Setiawan et al 2022; Asyhar et al 2023).

Water quality in cultivation media is a critical determinant of fish health, influencing SR, FCR, and growth. High-quality water supports optimal growth and survival of fish (WWF Indonesia 2015; Venkatachalam et al 2018; Wijayanto et al 2020, 2022a, b). This research employed a water recirculation system to enhance resource efficiency and promote environmental sustainability. The primary challenge in such systems is managing organic matter, including uneaten feed and fish waste. However, recirculation systems offer advantages, such as minimizing the risk of external environmental pollution. Prolonged exposure to pollutants can compromise fish blood health and immunity (Ghazala et al 2014; Hamed et al 2021; Fan et al 2023).

In this research, daily removal of uneaten feed and feces, along with the use of bioballs to support decomposing bacteria and mangroves for organic matter absorption, helped maintain water quality. Feed efficiency and disease management remain significant challenges in aquaculture (Hajirezaee et al 2015; Hidayati et al 2021). The ban on antibiotics in aquaculture has driven interest in herbal nutraceuticals, such as Javanese turmeric, as immunostimulants in fish feed.

This research confirms the potential of Javanese turmeric as a herbal immunostimulant for TGGG hybrid grouper, improving fish health and immunity. The oral administration of herbal nutraceuticals via feed is the most effective approach. Enhanced immunity contributes to better growth, metabolism, and survival, ultimately increasing production and profitability in fish farming (Gabriel 2019; Hidayati et al 2021; Paray et al 2021; Wijayanto et al 2022a, b).

Conclusions. This research demonstrates that incorporating Javanese turmeric into artificial fish feed at appropriate doses can significantly enhance the performance of TGGG hybrid grouper cultivation. Improvements were observed in growth metrics (WGR and SGR), feed conversion ratio (FCR), survival rate (SR), and benefit-cost (BC) ratio. Among the treatments, treatment B consistently yielded the best results. Optimization modeling identified the optimal doses of Javanese turmeric as 13.5% for BCR, 13.6% for FCR, 14.3% for WGR and SGR, and 15% for SR.

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

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