The effects of shallots (*Allium cepa* L. var. *aggregatum*) on growth, survival and BCR of TGGG hybrid grouper (♀ tiger grouper × ♂ giant grouper)

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Abstract. Optimizing the productivity of the TGGG hybrid grouper (♀ tiger grouper, *Epinephelus fuscoguttatus* × ♂ giant grouper, *E. lanceolatus*) cultivation business can be performed by enriching the feed using shallots (*Allium cepa* L. var. *aggregatum*). Shallots have been identified to increase fish endurance and help digestion of food. This research was performed to determine the effect of adding shallots to feed on growth, survival, feed efficiency and profits in TGGG hybrid grouper cultivation. Within this 20-day research, fish seeds with an average weight of 20.97 g (±1.57 g) were reared in tanks with a volume of 100 x 100 x 40 cm containing 28 fish per tank. This experiment included 3 treatments with 3 replications; feed soaking treatment using shallot liquid at a dose of 0% (treatment A), 2.5% (treatment B), and 5% (treatment C). The parameters measured in this research were survival rate (SR), weight growth rate (WGR), specific growth rate (SGR), feed conversion ratio (FCR), and benefit cost ratio (BCR). The results of this research showed that the addition of shallots in feed with the right dose could improve the performance of the TGGG hybrid grouper cultivation business. Treatment B appeared as the best treatment, showing an optimal dose of 2.583% for WGR, 2.584% for SGR, 2.423% for FCR and 2.428% for BCR.

Key Words: BCR, FCR, SGR, SR, WGR.

Introduction. The productivity of the TGGG hybrid grouper (♀ tiger grouper, *E. fuscoguttatus* × ♂ giant grouper, *E. lanceolatus*) cultivation business should be enhanced to strengthen the welfare of fish farmers and the food security. The TGGG hybrid grouper, also known as the 'cantang' grouper in Indonesia, is one of the major commodities for fish farming in the country, cultivated in both brackish ponds and marine cages. Its popularity stems from strong domestic and international demand, as well as its relatively high selling price, particularly when sold alive. TGGG hybrid grouper cultivation began to develop in Indonesia since 2017. Fish farmers are increasingly opting to cultivate TGGG hybrid grouper over tiger grouper (*Epinephelus fuscoguttatus*) and humpback grouper (*Cromileptes altivelis*) due to its faster growth rates and greater resilience which then accelerate the capital turnover. Efforts to control diseases aim to boost survival rates, which in turn positively affects production and profitability (Koh et al 2016; DJPB 2017; Chieng et al 2018; Hidayati et al 2021; Fadli et al 2022; Wijayanto et al 2022a, b).

The endurance and growth rate of TGGG hybrid grouper should be optimized to boost production and profits since fish health improves the growth and survival rate of the fish. Considering the prohibition of antibiotics use in increasing the fish endurance since 2017 (US-FDA 2018), fish farmers in Indonesia can use local ingredients to improve the endurance of farmed fish, one of which is using shallots (*Allium cepa* L. var. *aggregatum*). Shallots carry anti-biotic, anti-carcinogenic, anti-toxic, and anti-thrombotic properties (Liguori et al 2017; BPS Indonesia 2020; Dorrigiv et al 2021; Wijayanto et al 2022c). The aim of this research was to determine the effect of soaking shallot liquid in artificial feed on growth, survival, feed efficiency and profits in cultivating TGGG hybrid grouper.

Material and Method

Location and time of research. This experimental research was conducted for 20 days (from April to May 2023) at the Laboratory of the Faculty of Fisheries and Marine Sciences, Universitas Diponegoro, Semarang City (Indonesia).

Experimental material. The test fish in this research were TGGG hybrid grouper seeds with an average size of 20.97 g (±1.57 g). The salinity of the media was set at 5 ppt as suggested for locations far from the coast. The fish had been adapted to low salinity water media in tanks with a water volume of 0.4 m^3 (100 x 100 x 40 cm) filled with 28 fish per tank. Water quality management was carried out using recirculation, where water in aquaculture activities was processed and partially reused to cultivate fish (Fan et al 2023). The filter media were cotton, synthetic polyester fiber, gravel and commercial bioball. The dissolved oxygen (DO), pH, salinity and temperature were measured periodically (every week) using a water quality checker (Horiba U-50). Fish waste was collected every day (in the morning before feeding).

Feed treatment. The experiment was carried out using 3 types of treatment feed and 3 replications. Feed treatment was carried out by soaking the feed using shallot liquid at 0.0% (treatment A), 2.5% (treatment B), and 5.0% (treatment C). Shallots in certain doses (according to the type of treatment) were grated, added with water, and used to soak commercial feed. The test feed was dried in the sun. Fish were given commercial feed with a minimum crude protein content of 48%, fat (minimum) 10%, fiber (maximum) 2%, ash (maximum) 10%, and water content (max) 10%. Feeding amounted to 4% of the fish biomass per day, distributed across morning, afternoon, and evening sessions. The experiment was conducted using a completely randomized design.

Data analysis. Fish weight measurements were carried out periodically every 10 days. The variables examined in this research included survival (SR), fish growth (WGR and SGR), feed conversion ratio (FCR), and profit rate (BCR). All the formulas used are presented as follows (Long et al 2022; Wijayanto et al 2023a, b):

$$SR = (Nt/No) \times 100 \quad [1]$$

$$WGR = [(Wt - Wo)/Wo] \times 100 \quad [2]$$

$$SGR = [(Ln\ Wt - Ln\ Wo) / t] \times 100 \quad [3]$$

$$FCR = F/W \quad [4]$$

$$BCR = B / C \quad [5]$$

where: SR is the fish survival rate (in %); Nt is the final number of fish; No is the initial number of fish; WGR is the rate of increase in fish weight (in %); Wt is the weight of the fish (in g) at the end of the experiment; Wo is the initial fish weight (in g); SGR is the specific growth rate of fish (in % day^{-1}); Ln is the natural logarithm (which is 2.7183); FCR is the feed conversion ratio; F is the total feed (in g); W is the absolute growth of fish biomass (in g); BCR is the cost benefit ratio; B is additional income due to fish growth (IDR); C is the cost of feed (IDR). Statistical analysis uses the Anova test (F test) and Duncan test (if the treatment has a significant impact). Treatment optimization modeling uses a procedure where the first derivative of the variable (both WGR, SGR, FCR and BCR) is equal to zero.

Results. Detailed research results can be seen in Table 1 and Table 2. Treatment B shows the best performance, both in terms of WGR, SGR, FCR and BCR. Meanwhile, for SR, all treatments and replications had an SR of 100%. Statistically, only the WGR and SGR variables are significantly different (at $\alpha = 10\%$), while the other variables (SR, FCR and BCR) are not significantly different.

Table 1

Research result

Variables	*A1*	*A2*	*A3*	*B1*	*B2*	*B3*	*C1*	*C2*	*C3*
SR (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
W_o (g)	23.00	21.25	21.31	22.05	23.30	19.90	19.73	18.98	19.19
W_t (g)	30.63	28.37	28.62	29.71	31.36	27.41	26.38	25.32	25.84
WGR (%)	33.2	33.6	34.3	34.8	34.6	37.8	33.7	33.4	34.7
SGR (%)	1.4	1.4	1.4	1.4	1.4	1.5	1.4	1.4	1.4
FCR	4.44	4.30	4.22	4.21	4.29	3.87	4.42	4.39	4.24
BCR	1.12	1.16	1.18	1.19	1.17	1.29	1.13	1.14	1.18

Table 2

Statistical analysis

Variables	*Average*			*F value*	*Sig value*
	A	*B*	*C*		
WGR (%)	33.67^a	35.72^b	$33.92^{a,b}$	6.635	0.030
SGR (% day^{-1})	1.38^a	1.45^b	$1.39^{a,b}$	3.559	0.096
FCR	4.32^a	4.12^a	4.35^a	1.867	0.234
BCR	1.16^a	1.22^a	1.15^a	1.861	0.235

Note: 'a' and 'b' are subsets (Duncan test results with α = 10%).

The results of this research indicate that enriching the fish feed with shallots affects the growth of TGGG hybrid grouper fish. However, fish farmers should remain careful in adding the shallots since excessive dose might negatively affect the growth of TGGG hybrid grouper fish. The results of shallot processing optimization modelling can be seen in Table 3 and Figure 1.

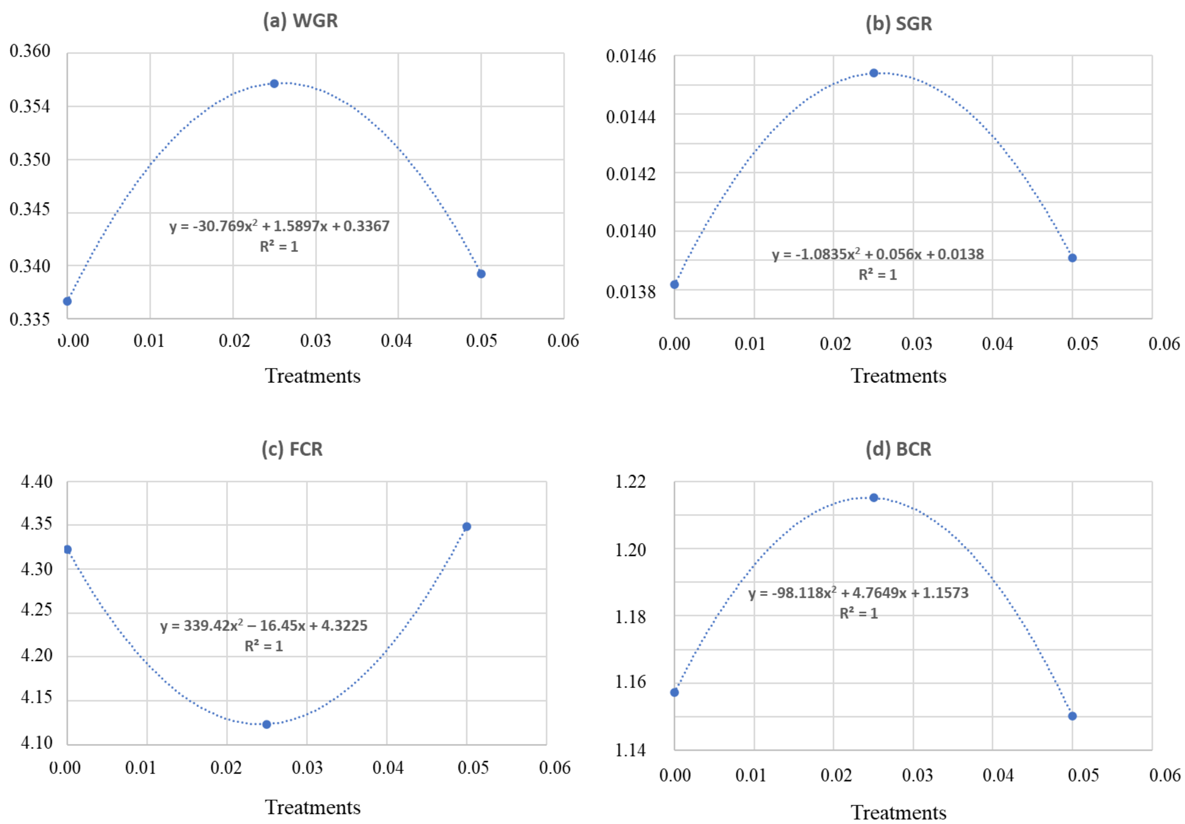

Figure 1. Relationship of treatments with WGR, SGR, FCR and BCR.

Table 3

Estimated optimal treatment

Variables	*Optimal estimation*
WGR	2.583%
SGR	2.584%
FCR	2.423%
BCR	2.428%

The data of the water quality during the experiment are shown in Table 4. The water quality in the experimental media still supports the growth and survival of the TGGG hybrid grouper. The optimal grouper cultivation medium is pH 6.5 to 8.5, and DO more than 5 ppm (Herry et al 2019; Yanuhar et al 2020). Das et al (2021) suggest that the optimal temperature for optimal rearing of grouper fish is 26.32±0.62^{o}C. The temperature during the experiment was set around 24^{o}C, where the experiment was carried out in an indoor laboratory.

Table 4

Water quality

Variables	*A*			*B*			*C*		
	A_1	A_2	A_3	B_1	B_2	B_3	C_1	C_2	C_3
pH	7.6±0.35	7.5±0.40	7.4±0.35	7.4±0.29	7.4±0.26	7.4±0.26	7.5±0.26	7.5±0.23	7.5±0.26
DO (ppm)	5.4±0.38	5.2±0.12	5.3±0.46	5.7±0.12	5.9±0.10	5.7±0.26	5.8±0.12	5.4±0.31	5.7±0.21
Temperature (^{o}C)	24.0±0.67	24.1±0.61	24.3±0.66	24.4±0.70	24.5±0.70	24.7±0.71	24.7±0.71	24.7±0.70	24.8±0.75
Salinity (ppt)	5±0	5±0	5±0	5±0	5±0	5±0	5±0	5±0	5±0

During the experiment, the test fish's appetite remained relatively high. When given food, the fish took turns reaching for food on the surface, then swam back to the bottom. The feed used sinks slowly to the bottom. The salinity of the experimental media of 5 ppt was proven not to reduce the fish's appetite, even though grouper fish naturally live in sea water. Meanwhile, Wijayanto et al (2023b) found that the optimal salinity for cultivating TGGG hybrid grouper is 7 to 8 ppt for 13 g of fish cultivate for 40 days.

The water source affects the quality of the water in the cultivation media which in turn influences the survival and growth of grouper fish. Water pollution has been a concerning issue in fish farming. Water pollution from pollutants (including fertilizers, pesticides, food waste and fish waste) can decrease the blood health of the fish, eventually lowering the immunity (Ghazala et al 2014; Hamed et al 2021). Water re-circulation system is an eco-friendly system that is expected to reduce the risk of fish death from water pollution.

Discussion. The TGGG hybrid grouper is the result of a cross between the giant grouper (*E. lanceolatus*) and the tiger grouper (*E. fuscoguttatus*). The giant grouper is the largest species from the Serranidae family that lives in tropical and subtropical waters, including Indonesia (Myoung et al 2013). The practice of hybridizing tiger grouper and giant grouper has started since 2006 (DJPB 2017; Shapawi et al 2019; Tan 2021; Long et al 2022). TGGG hybrid grouper tends to grow faster than tiger grouper, encouraging fish farmers to cultivate TGGG hybrid grouper instead (Wijayanto et al 2023a, b).

In fish farming, fish growth factors, survival (SR), feed efficiency (FCR) and profit are key success factors. Fish growth and SR affect the amount of production. Meanwhile, the amount of production and selling price affect income and profits. FCR affects costs, where feed costs have the largest proportion of cost variables in intensive fish farming businesses (Wijayanto et al 2022b, 2023a, b). According to Shekarabi et al (2022), final weight, body weight gain and SGR can be significantly increased by using the supplementation of shallots in the feed in case of rainbow trout (*Oncorhynchus mykiss*) cultivation.

The supplementation of shallots in fish feed can lower the FCR. The average FCR in B treatment was 4.12, implying that 1 gram weight gain requires 4.12 grams of artificial feed. Meanwhile, the average BCR value in treatment B was 1.22, showing that every IDR 1 spent generate income of IDR 1.22. Feed selection and feed management are very crucial in determining the profits of a grouper cultivation business. The proportion of feed costs to the variable costs of grouper cultivation reaches around 85.5% (Dennis 2021). Efficient use of feed to encourage fish growth will be able to increase production and income at more efficient cost, eventually leading to optimal profits (Wijayanto et al 2022a, b).

In cage grouper cultivation, business operators need to effectively, and efficiently manage the feeding. Leftover feed can lead to water pollution and cost inefficiencies. According to Fan et al (2023), in fish farming using a recirculation system, feed is the main source of pollution. Leftover feed can increase the ammonia and nitrite content. In addition, polluted water cultivation media can cause an increase in disease attacks in fish. Ammonia poisoning is a very serious threat to aquatic organisms which inhibits the fish growth and decreases the fish health (Yousefi et al 2020).

Enriching the fish feed using the members of the Alliaceae family, such as shallots, offers several health benefits. These include antibacterial, anticancer, antifungal, anti-inflammatory, and antioxidant properties, as well as anti-parasitic effects and support for the digestive system (Talpur & Ikhwanuddin 2012; Asimi et al 2013; Liguori et al 2017; Shang et al 2019; Yousefi et al 2020; Xu et al 2020; Chowdhury et al 2021; Dorrigiv et al 2021; Matrella et al 2022; Lipșa et al 2024). The species within the Alliaceae family contain allicin or diallyl thiosulfinate which has strong anti-bacterial and anti-pathogenic properties. Shallots in fish feed improve the activity of amylase, lipase, and protease in the fish intestine (Shekarabi et al 2022). Therefore, *Allium* sp. treatment can help the process of digestion. *Allium* sp. (including shallots) contain high levels of phenolic compounds, flavonoids, polyphenols, terpenoids, lectins, alkaloids, quinine polypeptides and quinine. *Allium* sp. also contain sulfur, trace minerals, vitamins, and fatty acids (Gabriel 2019; Shekarabi et al 2022). Inulin in shallots has also been proven to have a significant influence on the SGR and FCR of sea bass (Ali et al 2016; Aisara et al 2021). Furthermore, allicin in shallots acts as a herbal bioactive substance that binds free radicals and increase the activity of endogenous antioxidant enzymes (Alam et al 2018). Allicin is also an effective antioxidant in the cultivation of tilapia, rainbow trout and sea bass (Hamed et al 2021; Shekarabi et al 2022; Wijayanto et al 2022b). The research results showed that the optimal dose of shallots in feed ranges from 2.42 to 2.58%.

The use of feed made from herbal nutraceuticals, including shallots, is increasingly being explored in the fish farming industry. Herbal nutraceutical ingredients improve the digestion and body immunity, as well as strengthening the fish resistance to stressors from biotic and abiotic environmental disturbances (Chowdhury et al 2021; Paray et al 2021; Shekarabi et al 2022). Herbal extracts in fish farming can be administered orally, through injection and soaking. Oral administrated appears as the most efficient method that reduces stressor (Gabriel 2019). While shallots can enhance the performance of TGGG hybrid grouper cultivation, it is important to avoid excessive use. Overfeeding shallots can lead to negative effects, primarily due to their sulfur content, which can be toxic at high concentrations (Kim et al 2015; Park et al 2021; Wijayanto et al 2022c).

Conclusions. Research findings indicate that adding shallots into fish feed at the correct dosage can significantly enhance the performance of TGGG hybrid grouper cultivation, particularly in terms of WGR and SGR. Treatment B yielded the best results across multiple variables, including WGR, SGR, FCR, and BCR. The optimization modelling further suggests that the optimal dosage of shallots is 2.583% for WGR, 2.584% for SGR, 2.423% for FCR, and 2.428% for BCR.

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

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