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Evaluation of the Effectiveness of Turmeric (*Curcuma longa*) Extract as a Feed Additive on the Growth and Survival of Common Carp (*Cyprinus carpio*)

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Abstract: This study aimed to evaluate the effect of dietary turmeric extract supplementation on the growth performance and survival rate of common carp. The study was conducted using an experimental method with a completely randomized design (CRD) consisting of four treatments and three replicates: P1 (control), P2 (5% turmeric extract), P3 (10% turmeric extract), and P4 (15% turmeric extract). The observed parameters included weight gain, length gain, survival rate, and water quality variables, namely temperature and pH. The results showed that turmeric extract supplementation had no significant effect ($p > 0.05$) on the weight or length growth of common carp. However, descriptively, a positive growth trend was observed at the 5% supplementation level, whereas increasing the dose to 15% tended to reduce fish survival. Throughout the study, water quality parameters remained within the tolerance range for common carp and were not considered limiting factors. These findings indicate that turmeric extract was not yet effective as a primary growth promoter; however, it may have potential as a supportive feed additive when applied at low doses. Further studies are recommended to determine a more specific optimal dosage and to include physiological parameters and feed efficiency indices to obtain more comprehensive results.
Keywords: Common carp; turmeric extract; growth; feed

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INTRODUCTION

Common carp (*Cyprinus carpio*) is one of the leading freshwater aquaculture commodities in Indonesia, with high economic value and steadily increasing market demand. National aquaculture production data identify common carp as one of the major cultured freshwater commodities in Indonesia, while the species is also recognized globally as an important aquaculture fish because of its adaptability, consumer acceptance, and suitability for freshwater farming systems (KKP, 2025; FAO, 2020; FAO, n.d.). The success of common carp farming is strongly influenced by feed quality, culture management, and aquatic environmental conditions, particularly temperature, pH, and dissolved oxygen, which directly affect fish metabolism, health status, and production efficiency (Boyd, 2020; Boyd et al., 2020).

Among these factors, feed plays a dominant role because it directly supports fish growth, nutrient utilization, and survival rate. However, fish farmers in Indonesia continue to face challenges related to the high cost of commercial feed and the suboptimal efficiency of nutrient utilization. These conditions highlight the need for innovation in feed formulation through the use of natural materials as feed additives that are more economical, environmentally friendly, and compatible with sustainable aquaculture practices. One promising natural ingredient is turmeric (*Curcuma longa*), which contains the active compound curcumin and possesses antioxidant,

antibacterial, anti-inflammatory, and immunomodulatory properties (Hewlings & Kalman, 2017; Alagawany et al., 2021). Previous studies on common carp have also shown that dietary turmeric or curcumin supplementation can influence growth performance, biochemical responses, and fatty acid composition, indicating its potential relevance as a functional feed additive in carp culture (Pirani et al., 2021; Moradi et al., 2023).

Although the use of herbal ingredients in aquaculture has continued to expand, their effectiveness in improving fish growth and survival rate remains inconsistent. Several studies have reported that plant-based feed additives can enhance the immune system, antioxidant capacity, and disease resistance of fish; however, these effects are not always accompanied by significant improvements in growth performance (Dawood et al., 2020; Elumalai et al., 2021; Ahmadifar et al., 2021). In many countries, plant extracts and phytogenic compounds have been widely applied as alternatives to synthetic chemicals and antibiotics because they are biodegradable, relatively safe, and capable of supporting fish health under intensive culture conditions (Reverter et al., 2014; Elumalai et al., 2021; Dawood et al., 2022). Nevertheless, their effectiveness largely depends on fish species, dosage, form of supplementation, feeding duration, and culture environmental conditions (Abdel-Latif et al., 2020; Alagawany et al., 2021). These findings indicate that the biological response of fish to herbal ingredients is complex and not necessarily linear. Therefore, a more focused research approach is required to better understand the relationship between dosage and fish performance.

Based on these considerations, a clear research gap remains, namely the absence of an optimal dosage standard for turmeric extract that accounts for the trade-off between growth and survival rate, as well as the limited number of systematic studies evaluating the biological responses of common carp to different dosage levels. Most previous studies have emphasized immune enhancement, antioxidant response, or biochemical status, whereas the relationship between dosage, growth response, and survival has not been comprehensively quantified in a dose–response framework (Alagawany et al., 2021; Pirani et al., 2021; Moradi et al., 2023). Accordingly, this study focuses on a dose–response analysis to identify the effects of different turmeric extract dosages on the biological performance of common carp. An experimental approach using a Completely Randomized Design (CRD) was selected because it allows environmental variability to be controlled and provides a more accurate estimation of treatment effects. Four dosage levels were applied, representing conditions ranging from no supplementation to a high-dose treatment. In addition, water quality parameters, including temperature, pH, and dissolved oxygen (DO), were monitored to ensure that environmental conditions remained within the optimal range and did not act as major confounding variables (Boyd, 2020; Boyd et al., 2020).

This study aims to analyze the effects of dietary supplementation with turmeric (*Curcuma longa*) extract on the growth and survival rate of common carp (*Cyprinus carpio*) and to evaluate water quality conditions during the culture period. The observed parameters included weight gain, length increment, survival rate, and water quality variables, namely temperature, pH, and DO. Scientifically, this study contributes to examining the potential non-linear relationship between turmeric extract dosage and fish biological performance, particularly in identifying the optimal threshold for the use of herbal ingredients as feed additives. The findings are expected not only to enrich academic knowledge regarding the use of natural materials in aquaculture but also to provide a practical basis for fish farmers in determining effective, efficient, and safe dosage levels to sustainably improve the productivity of common carp farming.

METHOD

This study employed an experimental method with a quantitative approach to evaluate the effect of dietary turmeric (*Curcuma longa*) extract on the growth performance and survival rate of common carp (*Cyprinus carpio*). The experiment was arranged in a completely randomized design (CRD) consisting of four treatments and three replications. The treatments included P1 as the control treatment without turmeric extract supplementation, P2 with 5% turmeric extract, P3 with 10% turmeric extract, and P4 with 15% turmeric extract. The study was conducted under controlled conditions by maintaining uniformity in fish size, feed quantity, and rearing media. Each experimental unit was maintained in a separate container to prevent interaction effects among treatments. The observed variables included absolute weight gain, absolute length gain, survival rate, and water quality parameters, including temperature, pH, and dissolved oxygen (DO). This design was selected because it allows external variables to be controlled and provides a valid statistical framework for evaluating the effects of treatments on the response variables.

The experimental subjects were common carp (*Cyprinus carpio*) used as test organisms in the culture trial. The samples consisted of common carp fingerlings of relatively uniform size to minimize biological variation among individuals. Each experimental unit contained 15 fish; thus, the total number of fish used was 180, based on four treatments and three replications. Fish were selected according to health criteria, including active swimming behavior, absence of physical deformities, and no visible signs of disease. Prior to treatment application, the fish were acclimatized for 7 days to allow adaptation to the rearing environment and to reduce stress. The rearing period lasted 30 days, during which fish were fed three times daily according to the assigned treatment, with a feeding rate of approximately 3–5% of total biomass per day. The sample size followed the CRD structure with sufficient replication to support statistical analysis and improve the validity of the research findings. During the rearing period, water quality parameters, including temperature, pH, and dissolved oxygen, were maintained within optimal ranges to ensure that environmental factors did not act as confounding variables. Therefore, the observed responses were expected to more accurately reflect the effects of the treatments on fish growth and survival.

Fish growth was measured periodically throughout the study to obtain growth data and monitor environmental conditions. The research procedure included preparation of the rearing media, formulation of feed supplemented with turmeric extract according to the treatment doses, and fish maintenance during the experimental period. Fish were fed daily at a predetermined frequency based on their respective treatments. Weight and length were measured at the beginning and end of the experiment, while the number of surviving fish was recorded to calculate the survival rate. In addition, water quality parameters were measured regularly to ensure that environmental conditions remained within the optimal range for common carp growth. All data were recorded systematically for subsequent analysis. Absolute weight gain was calculated using the following formula:

$$W = W_t - W_0$$

Note:
W = absolute weight gain (g)
$\mathbf{W_t}$ = final weight (g)
$\mathbf{W_0}$ = initial weight (g)

Absolute length gain was calculated using the following formula:

$$Lm=Lt-L0$$

Note:
$\mathbf{L_m}$ = absolute length gain (cm)
$\mathbf{L_t}$ = final length (cm)
$\mathbf{L_0}$ = initial length (cm)

Survival rate (SR) was calculated using the following formula:

$$SR\ (\%) = (Nt / N0) \times 100$$

Note:
SR = survival rate (%)
$\mathbf{N_t}$ = number of fish at the end of the rearing period
$\mathbf{N_0}$ = number of fish at the beginning of the rearing period

Feed conversion ratio (FCR) was calculated using the following formula:

$$FCR = \frac{Total\ feed\ given}{Increase\ in\ fish\ biomass}$$

Note:
Total feed given (g) = total amount of feed provided during the rearing period
Increase in fish biomass (g) = total final weight − total initial weight
A lower FCR indicates greater feed efficiency, whereas a higher FCR indicates lower feed utilization efficiency.

The data obtained in this study were analyzed quantitatively using statistical procedures to evaluate the effects of the treatments on the observed variables. Prior to the main analysis, the data were tested for statistical assumptions using the Shapiro–Wilk test for normality and Levene's test for homogeneity of variance to confirm the suitability of parametric analysis. The data were then analyzed using one-way analysis of variance (ANOVA) to determine whether significant differences existed among treatments. When ANOVA indicated a significant difference ($p < 0.05$), a post hoc test was performed to identify specific differences between treatments. All data were presented as mean ± standard deviation (mean ± SD) to provide a representative description of data variation. Water quality parameters were analyzed descriptively to confirm that environmental conditions remained within the tolerance range for common carp. When no significant differences were detected, interpretation was not based solely on *p*-values but also considered response trends and biological relevance in relation to relevant literature. Thus, the interpretation of the results incorporated both statistical and biological perspectives to provide a more comprehensive and scientifically grounded evaluation of fish responses to the treatments.

RESULTS AND DISCUSSION

This study aimed to evaluate the effect of dietary turmeric extract supplementation on the growth performance, feed utilization, survival rate, and water quality response of common carp (*Cyprinus carpio*). The treatments consisted of P1 as the control treatment without turmeric extract, P2 with 5% turmeric extract, P3 with 10% turmeric extract, and P4 with 15% turmeric extract. Data were analyzed using one-way analysis of variance (ANOVA) after the assumption of homogeneity of variance was satisfied ($p > 0.05$).

Growth Performance of Common Carp

Growth performance was evaluated based on body weight and total length, which were measured at two sampling periods. The mean values of weight gain and length gain are presented in Table 1.

Table 1. Mean weight and length growth of common carp during the study

Treatment	Weight at Sampling 1 (g)	Weight at Sampling 2 (g)	Weight Gain (g)	Length at Sampling 1 (cm)	Length at Sampling 2 (cm)	Length Gain (cm)
P1 (Control)	7.93	8.37	0.44	7.96	8.12	0.16
P2 (5%)	7.78	8.46	0.68	8.18	8.32	0.14
P3 (10%)	7.88	8.40	0.52	8.18	8.38	0.20
P4 (15%)	8.06	8.55	0.49	6.58	8.40	1.82
Mean	**7.91**	**8.45**	**0.53**	**7.73**	**8.31**	**0.58**

The results of one-way ANOVA showed that dietary supplementation with turmeric extract did not significantly affect weight gain or length gain in common carp ($p > 0.05$). This indicates that, statistically, the differences among treatments were not strong enough to demonstrate a significant growth-promoting effect. Nevertheless, descriptive differences were observed among treatments, particularly in weight gain. The highest mean weight gain was recorded in P2, with 0.68 g, whereas the lowest value was observed in P1, with 0.44 g. This pattern suggests that the 5% turmeric extract treatment may have provided a more favorable biological response than the control and higher-dose treatments, although the effect was not statistically significant.

The absence of a significant effect may be related to the bioavailability and physiological utilization of curcumin, the main bioactive compound in turmeric (*Curcuma longa*). Curcumin has been widely reported to have antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory properties, which may support fish health and performance (Alagawany et al., 2021). However, its effectiveness in fish nutrition may be limited by poor water solubility, rapid metabolism, and relatively low bioavailability, which can restrict its absorption and utilization in the digestive system (Alagawany et al., 2021). Therefore, although turmeric extract contains biologically active compounds, these compounds may not have been sufficiently available to produce a statistically significant improvement in growth under the conditions of this study.

The descriptive superiority of P2 suggests that turmeric extract may be more effective at lower inclusion levels. Similar dose-dependent responses have been reported in previous studies. Jiang et al. (2016) found that dietary curcumin supplementation improved growth performance, digestive enzyme activity, and antioxidant capacity in crucian carp (*Carassius auratus*) when administered at an appropriate level. Yang et al. (2022) also reported that curcumin supplementation improved digestive physiology and growth-related responses in *Seriola dumerili*, but the response varied depending on the inclusion level. These findings support the interpretation that the effectiveness of curcumin or turmeric-based feed additives is strongly influenced by dose, species, physiological condition, and feed formulation.

In contrast, the higher turmeric extract levels in P3 and P4 did not result in greater weight gain. This may indicate a non-linear dose-response relationship, in which low supplementation levels may provide stimulatory effects, whereas higher levels may reduce feed acceptability or impose physiological stress. Excessive inclusion of plant-derived bioactive compounds can alter feed palatability, affect nutrient intake, or

disrupt metabolic balance, thereby limiting their growth-promoting potential (Alagawany et al., 2021; Yang et al., 2022). Thus, the lower weight gain observed in P3 and P4 compared with P2 suggests that increasing the extract dose does not necessarily enhance fish growth.

For length gain, the highest value was recorded in P4, at 1.82 cm, which was substantially higher than the values observed in the other treatments. This result should be interpreted cautiously because the initial length of fish in P4 was considerably lower than those in the other treatments. Consequently, the greater length increment may partly reflect a compensatory growth response rather than a direct effect of turmeric extract supplementation. Individual variation in growth potential, initial fish size, and adaptation to culture conditions may also contribute to unequal length increments among treatments. Because no formal statistical outlier test, such as Grubbs' test, was conducted, the P4 length-gain value was retained in the analysis but should be interpreted as an extreme observation that may not represent the general growth pattern.

Overall, the growth results suggest that turmeric extract did not act as a primary growth promoter in common carp during this study. However, the descriptive trend observed in P2 indicates that low-dose supplementation may have potential as a supportive feed additive. This interpretation is consistent with previous findings showing that herbal feed additives, including turmeric-derived compounds, may improve physiological condition, immunity, and antioxidant status, but do not always produce consistent or significant growth enhancement across fish species and culture conditions (Giri et al., 2019; Khieokhajonkhet et al., 2023).

Feed Conversion Ratio

Feed conversion ratio (FCR) is an important indicator of feed utilization efficiency and is calculated as the ratio between the amount of feed provided and the increase in fish biomass. Lower FCR values indicate more efficient conversion of feed into body mass. The FCR values of common carp in each treatment are presented in Table 2.

Table 2. Feed conversion ratio of common carp

Treatment	Total Overall Weight (g)	Total Feed Administered During Rearing (g)	FCR
P1 (Control)	169.50	237.17	1.40
P2 (5% extract)	169.64	237.72	1.40
P3 (10% extract)	171.40	239.96	1.40
P4 (15% extract)	176.61	242.52	1.37

The FCR values across treatments ranged from 1.37 to 1.40, indicating relatively efficient feed utilization. The lowest FCR was observed in P4, with a value of 1.37, suggesting slightly better feed conversion than the other treatments. However, the differences among treatments were small, and the overall FCR pattern was relatively uniform. This indicates that dietary turmeric extract supplementation did not produce a clear improvement in feed conversion efficiency.

The relatively low FCR values observed in all treatments suggest that the feed was efficiently utilized by the fish. However, the similarity among treatments indicates that the addition of turmeric extract did not substantially enhance the conversion of feed into biomass. This finding is consistent with the growth results, which also showed no significant differences among treatments ($p > 0.05$). Therefore, under the conditions

of this study, turmeric extract appeared to have limited influence on feed utilization efficiency.

From a physiological perspective, turmeric extract has the potential to support feed utilization through the activity of curcumin. Curcumin has been reported to stimulate digestive processes by enhancing the activity of enzymes such as protease, amylase, and lipase, thereby improving nutrient breakdown and absorption in the intestinal tract (Jiang et al., 2016; Yang et al., 2022). Improved digestive enzyme activity may contribute to better nutrient assimilation and feed efficiency. In common carp, Giri et al. (2019) reported that turmeric-derived bioactive compounds improved growth, skin mucosal immunity, antioxidant responses, and resistance to *Aeromonas hydrophila* challenge. However, the response to turmeric or curcumin supplementation depends strongly on dosage, feeding duration, fish species, and physiological status.

The lack of a clear FCR improvement in the present study may therefore be explained by two possible factors. First, the bioactive compounds in turmeric extract may not have been sufficiently bioavailable to produce measurable changes in feed efficiency. Second, higher inclusion levels may have reduced the potential benefits of turmeric extract by affecting palatability or physiological balance. This supports the view that turmeric extract is more appropriately considered a functional feed additive with potential health-supporting effects rather than a consistently effective enhancer of feed conversion efficiency.

Survival Rate

Survival rate is an important biological indicator reflecting the ability of fish to withstand rearing conditions, dietary treatments, and physiological stress. The survival rate of common carp varied among treatments and tended to decrease as the dose of turmeric extract increased. The survival rate data are presented in Table 3.

Table 3. Survival rate of common carp in each treatment

Treatment	Initial Number of Fish	Number of Dead Fish	Final Number of Fish	Survival Rate (%)
P1 (Control)	45	11	34	75
P2 (5% extract)	45	16	29	64
P3 (10% extract)	45	18	27	60
P4 (15% extract)	45	21	24	53

The highest survival rate was observed in P1, with 75%, whereas the lowest survival rate was recorded in P4, with 53%. Although statistical analysis indicated that the differences among treatments were not significant ($p > 0.05$), the descriptive trend shows a gradual decline in survival as the concentration of turmeric extract increased. This pattern suggests that higher inclusion levels of turmeric extract may have imposed physiological stress on the fish.

The decline in survival rate at higher doses may be associated with excessive exposure to bioactive compounds present in turmeric extract. Although curcumin is generally recognized for its beneficial biological properties, including antioxidant and immunomodulatory effects, its effectiveness depends on the appropriate dose and physiological tolerance of the fish (Alagawany et al., 2021). At excessive levels, phytogenic additives may negatively affect feed palatability, reduce feed intake, or disturb metabolic balance. Reduced palatability may also increase uneaten feed in the culture system, which can indirectly affect water quality and fish health.

In addition, fish exposed to physiological stress may become more susceptible to disease and environmental fluctuations. Stress can reduce immune competence and weaken the ability of fish to maintain homeostasis, which may contribute to increased mortality. Although turmeric-based compounds have been reported to enhance immune responses in fish, including common carp and goldfish, these benefits are usually observed when supplementation is provided at suitable levels (Giri et al., 2019; Khieokhajonkhet et al., 2023). Therefore, the decreasing survival trend observed in this study reinforces the importance of determining an optimal inclusion level before turmeric extract is applied in common carp feed.

The survival results also indicate that the potential benefits of turmeric extract should not be evaluated solely based on growth or FCR. A treatment may show a slight improvement in feed efficiency or length gain but still reduce survival when the dose exceeds the physiological tolerance of the fish. Thus, survival rate should be considered a critical parameter in evaluating the practical suitability of herbal feed additives in aquaculture.

Water Quality During the Study

Water quality was monitored based on temperature and pH, as these parameters directly influence metabolism, feed utilization, physiological balance, and survival in fish. The observed water quality values are presented in Table 4.

Table 4. Water quality parameters during the study

Treatment	Temperature (°C)	pH
P1 (Control)	27.9	6.40
P2 (5% extract)	28.1	6.19
P3 (10% extract)	28.3	6.08
P4 (15% extract)	29.1	5.91
Mean	**28.35**	**6.15**

During the study, water temperature ranged from 27.3 to 29.4°C, while pH ranged from 5.58 to 6.63. The temperature range was generally suitable for common carp culture and supported metabolic activity. Common carp are known to grow well within warm-water culture conditions, and optimal growth has been reported within a temperature range of approximately 23–30°C (FAO, n.d.). Therefore, temperature was unlikely to be a major limiting factor affecting growth, feed utilization, or survival in this study.

The pH values, however, tended to be slightly acidic, particularly in the higher-dose treatments. Although the pH values were lower than the general optimum range for common carp, they were still within a tolerable range. Prakoso & Radona (2018) reported that different pH treatments did not significantly affect growth or survival of Rajadanu strain common carp, although the best growth response was observed at pH 6–7. This suggests that the slightly acidic pH in the present study may not have been severe enough to independently suppress fish performance. Nevertheless, acidic pH can influence enzyme activity, ion regulation, and physiological balance, especially when combined with dietary stressors.

The gradual decrease in pH from P1 to P4 may also be relevant to the interpretation of survival rate. Although water quality was not considered the main limiting factor, the combination of higher turmeric extract doses and slightly more acidic water conditions may have contributed to physiological stress. This interaction may

partly explain why survival decreased as turmeric extract concentration increased. Therefore, the biological response of fish in this study should be interpreted as the result of interactions among dietary treatment, physiological tolerance, and environmental conditions. Overall, water quality remained within a range that could support common carp culture. The relatively stable temperature helped maintain metabolic function, while the slightly acidic pH may have influenced physiological responses but was unlikely to be the sole cause of the observed differences among treatments.

The results of this study demonstrate that turmeric extract supplementation did not significantly improve growth performance, feed conversion ratio, or survival rate in common carp. However, descriptive trends indicate that the 5% turmeric extract treatment produced the highest weight gain, suggesting that low-dose supplementation may provide a more favorable biological response than higher doses. In contrast, increasing the dose to 10% and 15% did not improve weight gain and was associated with a declining trend in survival rate.

These findings support the concept of a non-linear dose-response relationship in the use of turmeric extract as a feed additive. At an appropriate dose, turmeric-derived bioactive compounds may support digestion, antioxidant capacity, immune response, and general physiological condition. However, excessive inclusion may reduce palatability, alter metabolic balance, or induce stress responses that reduce survival. Similar dose-dependent effects have been reported in studies involving curcumin supplementation in fish, where beneficial effects on growth, digestive enzyme activity, antioxidant capacity, and immunity were observed only at suitable inclusion levels (Jiang et al., 2016; Giri et al., 2019; Yang et al., 2022).

The findings also suggest that turmeric extract should not be positioned primarily as a growth promoter in common carp, especially when used in crude extract form or at high inclusion levels. Instead, it may be more appropriate to regard turmeric extract as a functional feed additive with potential immunostimulatory and physiological-supporting properties. This interpretation is consistent with previous reports showing that herbal feed additives often produce variable effects depending on species, dosage, culture environment, extract form, and feeding duration (Alagawany et al., 2021; Khieokhajonkhet et al., 2023).

CONCLUSION

The inclusion of turmeric (*Curcuma longa*) extract in feed at 5–15% was not effective as a growth promoter for common carp (*Cyprinus carpio*), as it did not significantly improve weight or length growth ($p > 0.05$). Although the 5% dose showed a slight tendency to enhance growth, FCR values remained relatively similar across treatments, indicating no clear improvement in feed efficiency. Higher doses were associated with reduced survival, suggesting potential adverse physiological effects. Since water quality remained within the optimal range, these responses were likely driven mainly by the dietary treatments. Overall, turmeric extract may serve as a supportive feed additive at low doses, but its use should carefully balance growth benefits and fish survival.

RECOMMENDATION

Future studies should examine lower and more specific doses of turmeric (*Curcuma longa*) extract over longer rearing periods to identify an optimal level that improves growth without reducing the survival of common carp (*Cyprinus carpio*). Additional parameters, including accurate FCR, feed efficiency, hematological profiles,

and immune responses, should be included to provide a more comprehensive evaluation. Improved extraction and feed formulation methods are also needed to enhance the bioavailability of turmeric bioactive compounds. Stricter control of initial biomass data, fish biological variation, and water quality is recommended to improve the reliability of future findings.

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