MJSAT 6 (S1) 152-155

MJSAT

Malaysian Journal of Science and Advanced Technology

journal homepage: https://mjsat.com.my/

Effects of Plant-Based Diets on Growth Performance and Water Quality of African Catfish Cultured in a Recirculating Aquaculture System

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KEYWORDS

African catfish
Plant-based diets
Growth performance
Water quality
RAS

ARTICLE HISTORY

Received 22 November 2025
Available online 21 August 2026

ABSTRACT

This research determined the effects of plant-based dietary on the growth performance and water quality of African catfish (*Clarias gariepinus*) cultured in a Recirculating Aquaculture System (RAS). The three dietary treatments were used: commercial pellet (A1), commercial pellet with seaweed (A2) and commercial pellet with *Azolla* (A3). The growth performance indices and water quality were measured weekly such as weight gain, length gain, specific growth rate (SGR), feed conversion ratio (FCR) and water quality parameters (pH, ammonia, nitrite, and nitrate). The results showed that, the fish fed with *Azolla* diet (A3) achieved the highest weight gain (15.92 ± 2.13 g), length gain (5.12 ± 1.56 cm) and SGR (2.74 ± 0.51 % day^{-1}) whereas fish fed with seaweed diet (A2) showed lower growth performance but produced significantly improved water quality. The consistent numerical trends indicated biologically meaningful dietary effects, although growth performance differences among treatments were not statistically significant ($p > 0.05$). Thus, commercial pellet with Azolla (A3), emerged as a practical and sustainable feeding strategy that enhances growth performance while maintaining acceptable water quality in intensive systems.

1. INTRODUCTION

The African catfish (*Clarias gariepinus*) is a popular aquaculture species for its rapid growth and environmental condition for intensive culture systems. In Asia, the higher global demand, affordability and high nutritional content underscore its significance in supporting food security and aquaculture economies [4]. Recently, many studies focused on advancement improving feed efficiency and system sustainability by reducing dependence on fishmeal through natural ingredients [1,2,16]. For example, the Azolla has demonstrated potential to enhance growth and feed utilization, whereas seaweed may stimulate antioxidant and immune responses [1]. The recirculating aquaculture systems (RAS) was widely used through these intensive systems for improving water quality stability, nutrient recycling and production efficiency [17]. The intensive systems may maximize growth performance and maintain environmental quality as the catfish are commonly known for their hardiness and tolerance to suboptimal conditions and optimal diet formulation [3,12].

Despite growing interest in sustainable feed resources, research examines how alternative dietary supplements simultaneously influence fish growth and water quality within RAS environments are still limited. Many studies focus on growth performance alone, with insufficient evaluation of nitrogenous waste profiles ammonia, nitrite and nitrate which directly affect fish health and system [6,18]. The differences in digestibility and nutrient composition among unconventional feed ingredients create further uncertainty regarding their optimal inclusion levels [2]. The evidence comparing seaweed and Azolla within controlled RAS conditions remains particularly scarce, especially concerning their effects on nitrogen cycling and water stability [18]. Addressing these gaps is important for identifying feed strategies that improve biomass gain while reducing environmental impacts, supporting the development of more efficient and ecologically responsible catfish culture systems.

Therefore, the primary purposed of this research was to determine the effects of the three dietary treatments: commercial pellet (A1), pellet with seaweed (A2) and pellet with Azolla (A3) on the growth performance of African catfish in RAS systems. Second, the water quality of cultured African

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https://doi.org/10.56532/mjsat.v6iS1.786

catfish will be determined under the three different diet treatment over eight-week period.

2. Materials and Methods

2.1 Experimental Fish Preparation

The African catfish (*Clarias gariepinus*) fingerlings were obtained from Pusat Pengembangan Akuakultur Jitra. The initial range size was 2-3 cm and range weight 14-19g. The fish were stocked at 20 fingerlings per tank. The size of the rectangular glass tanks; 90 cm (length) × 45 cm (width) × 45 cm (height). The fish were acclimated for seven days before experiment began for stabilizing physiological responses [12]. The brown seaweed (*Sargassu*m spp.) was used in this study as it low-cost and sustainable feed supplement [17].

The range water temperature was 25–27 °C and pH 6.5. The nitrogenous waste (ammonia, nitrite, nitrate) and hardness levels were monitored using test kits weekly. The waste removal was performed using siphoning while 15% water exchange was applied weekly. The RAS system was used as it can enhance mineral recycling and biofiltration efficiency, supporting improved growth and environmental control in catfish systems [18].

2.2 Fish Feed Preparations

There were three different diets were tested: Commercial pellet (A1), pellet with seaweed (A2), pellet with Azolla (A3). The size ranged for fingerling feed from 1.0–2.0 mm. The feeding occurred twice daily at a ratio of 5% biomass [3]. The seaweed and Azolla were rinsed, drained and finely chopped for same size before fed the fish. All the feed analyses in this study were performed in triplicate. The inclusion of plant-based diet reflects toward sustainable, cost-effective feed alternatives in aquaculture [1,16].

2.3 Growth Performance of Experimental Fish

The fish were randomly sampled weekly for biometric weight (g) and length (cm). The samples were collected for growth performance analysis using the formulas recommended by [10]

$$\text{Weight gain (\%)} = (\text{Final weight} - \text{initial weight}) \times 100\%/\text{initial weight} \tag{1}$$

$$\text{Length gain (\%)} = (\text{Final length} - \text{initial length}) \times 100\%/\text{initial length} \tag{2}$$

$$\text{Specific growth rate (\%)} = (\log \text{Final weight} - \log \text{initial weight}) \times 100\%/\text{Experiment duration} \tag{3}$$

$$\text{Feed conversion rate (FCR)} = \text{Total feed consumption}/\text{Fish weight gain.} \tag{4}$$

2.4 Water Quality of Experimental Fish

The water quality was monitored before water exchange using standard colorimetric test kits for ammonia, nitrite and nitrate following the manufacturers' protocols weekly. The regular monitoring is essential as plant-based dietary components can influence nitrogen metabolism and waste production in cultured system [2,16].

2.5 Statistical Analysis

Firstly, all dataset was assessed for normality to inferential analysis. Then, Levene's test was conducted to determine homogeneity of variances. The one-way analysis of variance (ANOVA) was conducted and followed by Tukey's post hoc test for multiple comparisons using the Statistical Package (SPSS). The threshold of $\alpha = 0.05$ aligns with contemporary standards in aquaculture research [3,20]. The analytical approach is consistent with current methodologies employed in finfish nutrition and dietary evaluation studies [1,16].

3. Results and Discussion

2.6 Fish Growth Perfomance

Table 1 provide the mean value and standard deviation of the growth performance of African catfish fed different diet treatment. The result shows that positive increases in body weight and total length throughout the research. The fish fed the Pellet and Azolla diet (A3) show the highest mean final body weight (18.82 ± 1.8 g), followed by fish fed the commercial pellet (A1) (17.55 ± 4.3 g) and the lowest final weight was recorded on Pellet and Seaweed (A2) (14.84 ± 5.6 g). The similar trend was observed for total length, with fish in the (A3) was the greatest final length (12.6 ± 1.6 cm), compared to (A1) (12.06 ± 1.4 cm) and (A2) (11.16 ± 1.4 cm).

The highest weight gain (15.92 ± 2.13 g), length gain (5.12 ± 1.56 cm), and specific growth rate (2.74 ± 0.51 % day^{-1}) were observed in fish fed the Pellet and Azolla diet (A3). The feed conversion ratio (FCR) was also lowest in A3 (0.46 ± 0.32), indicating more efficient feed utilization. The fish fed commercial pellet (A1) showed intermediate performance, while the Pellet and Seaweed group (A2) exhibited the lowest growth efficiency and highest FCR (0.63 ± 0.33). The One-way ANOVA analysis indicated that differences in final body weight ($F = 2.351$, $p = 0.115$) and final length ($F = 2.461$, $p = 0.104$) among dietary treatments were not statistically significant at $p < 0.05$.

Table 1. Eight Weeks Growth Performance of African Catfish with Different Diets (Mean ± Standard Deviation).

Parameters	Pellet (A1)	Pellet + Seaweed (A2)	Pellet + *Azolla* (A3)
IW (g)	2.58 ± 0.40	2.48 ± 0.50	2.90 ± 1.10
FW (g)	17.55 ± 4.30	14.84 ± 5.60	18.82 ± 1.80
WG (g)	14.97 ± 4.40	14.97 ± 4.40	15.92 ± 2.13
LG (cm)	4.77 ± 1.38	4.77 ± 1.38	5.12 ± 1.56
SGR (% day^{-1})	2.72 ± 0.47	2.53 ± 0.66	2.74 ± 0.51
FCR	0.53 ± 0.42	0.63 ± 0.33	0.46 ± 0.32

Abbreviations: IW:Initial Weight, FW:Final Weight; WG: Weight Gain, LG:Length Gain, SGR:Specific Growth Rate, FCR: Feed Conversion Ratio.

The strong performance of (A3) agrees with earlier studies showing that Azolla can enhance growth in catfish and tilapia because it contains high-quality protein, essential amino acids, and beneficial bioactive compounds that support nutrient uptake [2,20]. These nutritional attributes likely supported more rapid metabolic turnover, contributing to the improved SGR and FCR observed in the (A3).

In contrast, fish fed the (A2) diet showed slower growth even though water quality improved. This supports previous findings that polysaccharides in seaweed can reduce digestibility and protein absorption, which may limit growth despite their potential immune benefits [7,13]. The moderate performance of the (A1) diet (commercial pellet) is consistent with earlier studies reporting that standard pellet feeds support acceptable, but not exceptional, growth in African catfish [9,11].

Although the differences were not statistically significant, the clear positive trend seen in the Azolla-fed group suggests meaningful biological effects. According [19], the trends should not be disregarded simply because statistical power is low, especially when sample sizes are small and variation within groups is high. The high standard deviation in (A2) indicates variation in feeding behaviour and nutrient intake among the fish, a pattern also reported in studies on individual growth differences in cultured species [8]. Overall, these findings show that incorporating Azolla into RAS-based African catfish culture is a promising approach, as it can improve growth efficiency while still maintaining suitable water quality conditions.

2.7 Water Quality

Table 2 provides the mean values and standard deviation of water quality under different dietary treatments of African catfish. There was a significant difference among dietary treatments for all water quality variables. The pellet with seaweed (A2) was the most favourable water quality conditions, with a slightly alkaline pH (7.20 ± 0.1) and the lowest concentrations of ammonia (0.65 ± 0.2 mg L^{-1}), nitrite (0.07 ± 0.1 mg L^{-1}), and nitrate (14.0 ± 5.2 mg L^{-1}). However, the commercial pellet diet (A1) was highest concentrations of nitrogenous wastes, including ammonia (1.0 ± 0.0 mg L^{-1}), nitrite (0.38 ± 0.3 mg L^{-1}), and nitrate (20.0 ± 0.0 mg L^{-1}). There were significant differences in the value of pH ($F = 93.25$, $p < 0.001$), ammonia ($F = 7.63$, $p = 0.002$), nitrite ($F = 7.98$, $p = 0.002$), and nitrate ($F = 5.25$, $p = 0.012$). Based on Tukey HSD test, the seaweed-diet (A2) was highlighted as the superior water quality.

Table 2. Water Quality of African Catfish (Mean ± Standard Deviation.

Parameters	Pellet (A1)	Pellet + Seaweed (A2)	Pellet + *Azolla* (A3)
pH	6.64 ± 0.20^c	7.20 ± 0.10^a	6.40 ± 0.13^b
Ammonia (mg L^{-1})	1.00 ± 0.00^a	0.65 ± 0.20^c	0.75 ± 0.30^b
Nitrite (mg L^{-1})	0.38 ± 0.30^a	0.07 ± 0.10^c	0.10 ± 0.10^b
Nitrate (mg L^{-1})	20.00 ± 0.00^a	14.00 ± 5.20^c	16.00 ± 5.20^b

The dietary composition had a pronounced effect on water quality parameters in the recirculating aquaculture system. The seaweed-supplemented diet (A2) resulted in significantly lower ammonia, nitrite and nitrate concentrations which indicating reduced nitrogenous waste accumulation. The seaweed may enhance microbial activity and nutrient assimilation within the system, thereby promoting nitrification and improving overall water stability [5,14].

Although the Azolla-supplemented diet (A3) supported superior growth, it produced moderate levels of nitrogenous waste which likely due to increased feed intake and metabolic activity associated with enhanced growth. Nevertheless, these levels remained within acceptable limits for African catfish culture and did not compromise fish health. The commercial pellet diet (A1) resulted in the poorest water quality, characterized by elevated ammonia and nitrate concentrations. This finding highlights the environmental benefits of incorporating plant-based supplements into aquafeeds to improve nutrient utilization and reduce waste output.

Based on the combined evaluation of growth performance and water quality, the Pellet with Azolla (A3) emerged as the most effective and balanced feeding strategy for African catfish under the conditions of this study whereas pellet with seaweed (A2) provided superior water quality, it did not support optimal growth. In contrast, the Azolla enhanced growth and feed efficiency while maintaining acceptable environmental conditions. These findings suggest that Azolla is a promising, sustainable dietary supplement for African catfish culture and may contribute to improved productivity and reduced reliance on conventional feed ingredients.

4. CONCLUSION

In conclusion, this research showed that a clear trade-off between rising growth performance and optimizing water quality of African catfish cultured in a RAS. The *Azolla* (A3) diet may improve growth efficiency while seaweed (A2) enhanced water quality. Although the growth performances differences were not statistically significant, the consistent biological trends support the potential of *Azolla* (A3) as a sustainable diet. Future studies should optimize inclusion levels and conduct in long-term period.

REFERENCES

[1] Abdelhamid, A. M., Abdel-Tawwab, M., & Reda, R. M. (2021). Use of plant-based feed ingredients in aquaculture nutrition. Aquaculture Nutrition, 27(3), 1001–1015.

[2] Abdel-Tawwab, M., El-Sayed, G. O., & Shady, S. H. (2021). Effects of Azolla inclusion on growth performance, feed utilization, and health status of cultured fish. Aquaculture Reports, 20, 100737.

[3] Ali, M. E., Rahman, M. M., & Hasan, M. R. (2024). Feeding strategies and growth optimization of African catfish in intensive culture systems. Aquaculture Research, 55(2), 845–858.

[4] Chandra Segaran, T., Zainol, Z. E., Idris, N. S., & Ramli, R. (2023). Sustainable aquaculture practices for African catfish production. Aquaculture International, 31(4), 1765–1782.

[5] Crab, R., Avnimelech, Y., Defoirdt, T., Bossier, P., & Verstraete, W. (2007). Nitrogen removal techniques in aquaculture for sustainable production. Aquaculture, 270(1–4), 1–14. doi: https://doi.org/10.1016/j.aquaculture.2007.05.006

[6] Effiong, B. N., & Sanni, A. (2009). Nitrogenous waste dynamics in intensive aquaculture systems. African Journal of Environmental Science and Technology, 3(12), 468–475.

[7] El-Sayed, A. F. M. (2020). Tilapia culture (2nd ed.). Academic Press. doi: https://doi.org/10.1016/c2017-0-04085-5

[8] Gardeur, J. N., Lemarié, G., & Coves, D. (2001). Individual growth variability in cultured fish. Aquaculture, 194(3–4), 271–282.

[9] Giri, S. S., Sahoo, S. K., Sahu, A. K., & Meher, P. K. (2003). Effect of dietary protein level on growth and feed utilization of African catfish. Aquaculture Nutrition, 9(1), 17–24.

[10] Kari, Z., Kabir, M. A., & Kamarudin, M. S. (2022). Growth indices and feed utilization efficiency in warmwater fish. Journal of Applied Aquaculture, 34(3), 395–408.

[11] Kumar, V., Lee, S., & Romano, N. (2020). Plant protein sources in aquafeeds: Constraints and opportunities. Reviews in Aquaculture, 12(2), 1140–1160.

[12] Langi, S., Hasan, M. R., & Ali, M. (2024). Acclimation and stocking density effects on African catfish performance. Aquaculture Research, 55(1), 112–124.

[13] Makkar, H. P. S., Tran, G., Heuzé, V., & Giger-Reverdin, S. (2016). Seaweeds for livestock diets: A review. Animal Feed Science and Technology, 212, 1–17. doi: https://doi.org/10.1016/j.anifeedsci.2015.09.018

[14] Ngugi, C. C., Bowman, J. R., & Omolo, B. O. (2007). A new guide to fish farming in Kenya. Aquaculture Collaborative Research Support Program.

[15] Rahim, A., Hossain, M. A., & Islam, M. S. (2023). Nutritional value and market demand of African catfish. Journal of Fisheries Science, 17(2), 89–98.

[16] Reda, R. M., Ibrahim, R. E., & Abdel-Tawwab, M. (2021). Effects of alternative plant protein sources on growth and water quality in aquaculture. Aquaculture Nutrition, 27(2), 650–662.

[17] Strauch, S. M., Wenzel, L. C., Bischoff, A., & Stelz, H. (2018). Commercial recirculating aquaculture systems: Design, management, and productivity. Aquacultural Engineering, 83, 13–24. https://doi.org/10.1016/j.aquaeng.2018.07.001

[18] Sun, J., Li, Y., Wang, Y., & Zhang, X. (2023). Nitrogen cycling and water quality control in RAS. Aquaculture Engineering, 101, 102308. https://doi.org/10.1016/j.aquaeng.2023.102308

[19] Thorarensen, H., Kubiriza, G. K., & Imsland, A. K. (2015). Experimental design and statistical power in aquaculture studies. Aquaculture Research, 46(1), 1–14.

[20] Yadav, R. K., & Jha, D. K. (2021). Statistical considerations in aquaculture nutrition studies. Journal of Aquatic Research, 29(3), 215–223.

[21] Yadav, R. K., Jha, D. K., & Kumar, N. (2021). Azolla as a sustainable feed ingredient in aquaculture. Aquaculture Reports, 19, 100563. https://doi.org/10.1016/j.aqrep.2021.100563*J.*