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**ORIGINAL RESEARCH**

# Growth, Feed Utilization, and Body Indices of African Catfish (*Clarias gariepinus*) Fed Diet with or without Cinnamon Inclusion

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## Abstract

This study investigated the effect of supplementing the diet with cinnamon (*Cinnamomum zeylanicum*) on the growth, feed efficiency, survival rate, and body indices of African catfish (*Clarias gariepinus*). Two diets with equal protein and lipid contents were prepared: a control (0% cinnamon) and one supplemented with 2% cinnamon powder. Each diet was fed to three groups of catfish (average initial weight 2.17 ± 0.17 g) for 28 days under controlled laboratory conditions. Growth performance metrics including specific growth rate (SGR), feed conversion ratio (FCR), feed intake, and survival as well as body condition indices (condition factor, viscero-somatic index, and hepato-somatic index) were assessed. Results showed that cinnamon supplementation did not cause significant differences ($p > 0.05$) in weight gain, FCR, SGR, or feed intake compared with the control group. Survival was 100% in both groups. Among the body indices, viscero-somatic index tended to be lower in the cinnamon-fed fish ($p = 0.059$), while hepato-somatic index and condition factor remained comparable between treatments. The inclusion of 2% cinnamon powder did not significantly affect the growth performance or feed utilization efficiency of *Clarias gariepinus*, indicating limited nutritional benefit at this inclusion level. Further research should examine varying supplementation rates and potential physiological or health-related effects to better elucidate the functional role of cinnamon in catfish diets.

**Keywords**: African catfish, cinnamon, growth performance, feed utilization, phytogenic additives

## Introduction

The utilization of phytogenic compounds, including herbs and spices as feed additives has gained increased attention in recent years, owing to their potential as eco-friendly substitutes for antibiotics and synthetic growth promoters in fish farming(Kalaiselvan et al., 2024; Yang et al., 2015). These plant-derived additives are known to improve fish growth, feed utilization and overall health due to their antimicrobial, antioxidant, and digestive-enhancing properties.

Among the phytogenic compounds, cinnamon (*Cinnamomum zeylanicum*), derived from the inner bark of Cinnamomum species (family Lauraceae), is one of the oldest known spices, originating from Sri Lanka and southern India. Historical accounts dating back over 4,000 years describe its use in ancient Egypt, China, and India for food preservation, perfumery, and medicine. Arab traders introduced cinnamon to Europe through early spice routes, concealing its true source to maintain its value, while colonial powers later established large-scale plantations in Sri Lanka, cementing its global trade importance.

Cinnamon is rich in phytocompounds such as cinnamaldehyde, eugenol, and cinnamic acid, which are responsible for its distinct aroma and numerous bioactivities, including antioxidant, antimicrobial, and anti-inflammatory effects.

In aquaculture, the search for natural feed additives to replace antibiotics has intensified due to growing concerns about resistance and environmental impact. Cinnamon and its derivatives have shown promising results in enhancing feed palatability, digestion, antioxidant capacity, and immune response in fish and crustaceans. Its long history of safe use, combined with its multifaceted bioactivity, positions cinnamon as a potential phytogenic additive for sustainable aquafeed formulation.

In Africa, *Clarias gariepinus* represents a key aquaculture species due to its fast growth, resilience, and consumer demand (Langi et al., 2024). In Nigeria, this species is extensively cultured for its affordable and high-quality protein. Additionally, local farmers and consumers highly desire African catfish. As an omnivore, the species can tolerate diverse food sources and thrive in various environmental conditions.

The rising cost of feed, driven by inflation poses a severe challenge for aquaculture operations in Nigeria, especially smallholder aquaculture. Farmers are therefore, seeking feed formulations

that maximize growth yield within shorter timeframes. Hence, the need for functional additives in modern diet formulations (Zuberi et al., 2024). Functional feed additives are currently being used in aquaculture feeds to ensure that dietary nutrients are consumed, properly digested, processed and transferred to the cells.

The utilization of phytogenic feed additives in fish feeds is gaining increased attention in aquaculture industry (Caipang, 2020). Although several phytogenic compounds have been reported to improve growth and feed utilization in farmed fish species, a review of related literature showed that many studies focus on general plant extracts or essential oils rather than processed spice powders. Despite the increasing use of plant-derived feed additives to enhance growth performance, feed efficiency, and health status in aquaculture species, research on the application of cinnamon (*Cinnamomum* spp.) in the diet of African catfish (*Clarias gariepinus*) remains limited. Existing studies have primarily focused on other fish species or emphasized the immunological and antioxidant properties of cinnamon, with relatively little attention given to its potential effects on growth, feed utilization, and body indices in *C. gariepinus*. Hence, the need for further investigation into the nutritional and physiological responses of African catfish fed diets containing cinnamon to better understand its potential as a natural feed additive in aquaculture.Therefore, the present study was conducted to evaluate the effects of dietary cinnamon inclusion on the growth, feed utilization, and body indices of African catfish (*Clarias gariepinus*).

## Materials and Methods

### Experimental design and diet preparation

Fingerlings of African catfish with an initial mean weight of 2.17 ± 0.17 g were randomly assigned two diet treatments, each in triplicate. To prepare the experimental diets, a commercial

feed (40% crude protein, 8% crude lipid) was coated with commercially processed cinnamon powder at 0% (control) or 2% inclusion levels.

Prior to coating the feeds, 2% cinnamon powder was added to 10 mL distilled water and homogenized. The mixture was added onto a kilo of feed and manually mixed. After coating, the feeds were air-dried at room temperature and stored in plastic containers with lids until use. The 2% inclusion was chosen based on recommendations in earlier studies (Hamid et al., 2022).

**Fish Sourcing, Acclimation and Husbandry**

African catfish were obtained from a reputable fish farm in Zango, Lokoja and were acclimated in the laboratory at the Department of Zoology, Federal University Lokoja for 14 days, during which they were fed a commercial diet (40% crude protein, 8% crude lipid).

After acclimation and prior to the commencement of the experiment, the fingerlings were graded to ensure homogenous sizes and weighed. Following that, each tank was randomly stocked with 10 fish. The volume of water in each tank was 10 L. Continuous aeration was provided to all tanks positioned under a shade canopy structure, and water quality was maintained within optimal conditions for fish rearing."

The fish were hand-fed to apparent satiation twice daily (09:00 and 16:00 h) for 28 days. During the experiment, fish were bulk-weighed to monitor growth on day 14. To maintain good water quality, water in each tank was changed twice in a week. Temperature and pH were recorded regularly to maintain optimal physiological conditions and minimize stress-induced variability.

**Sampling**

At the end of the feeding trial, fish were food-deprived for 12 hours to standardize gut contents and minimize stress prior to final sampling. Each fish was counted and individually weighed to assess survival and final body weight, respectively.

**Growth metrics and survival calculations**

Growth and survival indices were computed using standard formulas:

a. Weight gain (g) $=$ final weight $-$ initial weight

b. Specific growth rate (%day$^{-1}$) $= \left[\frac{\ln Weight_{\text{final}} - \ln Weight_{\text{initial}}}{duration\ in\ days}\right] \times 100$

c. Feed conversion ratio $= \frac{Total\ feed\ intake}{weight\ gain}$

d. Survival rate (%) $= \left(\frac{number\ of\ surviving\ fish}{initial\ number\ of\ fish}\right) \times 100$

**Tissue Collection for Body Indices Determination**

Two fish were chosen at random. Each fish was sedated on ice, measured for total length (cm) and whole weight (g), and dissected. The whole visceral was removed and weighed. After that, each liver was carefully removed and weighed. The body indices were then calculated:

a. Condition factor (CF) $= (body\ weight/length3)$x 100

b. Hepato-somatic index (HSI, %) $= (liver\ weight/body\ weight)$ x 100

c. Viscero-somatic index (VSI, %) $= viscera\ weight/bodyweight)$ x 100

**Statistical Analysis**

All data (growth, survival, body indices, water quality) were analyzed using a statistical software (SPSS version 25). Means from the two treatments were compared using independent samples t-test, with significance defined at $p < 0.05$. Results are presented as mean ± standard error (SE).

**Results**

**Growth, feed utilization efficiency, and survival**

At the beginning of the trial, the average body weight of *Clarias gariepinus* fingerlings did not differ between the two dietary groups (2.17 ± 0.17 g; $p = 0.321$). After 28 days of feeding, no statistically significant differences ($p > 0.05$) were observed in final body weight, feed intake, weight gain, feed conversion ratio, and specific growth rate between the control and cinnamon-fed fish (Table 1). Survival was 100% in both treatments.

**Table 1: Growth, Feed Utilization, and Survival of African Catfish after 28 Days of Experiment**

| Parameter | Control | Cinnamon | P-value |
|---|---|---|---|
| Initial weight (g) | 2.17 ± 0.17 | 2.15 ± 0.21 | 0.321 |
| Final weight (g) | 5.30 ± 0.51 | 4.39 ± 0.42 | 0.803 |
| Feed Intake (g) | 4.58 ± 0.08 | 4.48 ± 0.03 | 0.142 |
| Weight gain (g) | 3.13 ± 0.58 | 2.22 ± 0.22 | 0.322 |
| Feed conversion ratio | 1.58 + 0.33 | 2.06 ± 0.20 | 0.433 |
| Specific growth rate | 3.05 ± 0.42 | 2.42 ± 0.19 | 0.323 |
| Survival rate (%) | 100.00 ± 0.00 | 100.00 ± 0.00 | - |

**Body Indices**

No significant differences were observed for condition factor or hepatosomatic index (HSI) between the groups (Table 2). However, the viscero-somatic index showed a tendency to decrease in the cinnamon-fed fish, but it was not statistically significant ($p = 0.059$).

**Table 2: Body Indices of African Catfish after the 28-Day Feeding Experiment**

| Parameter | Control | Cinnamon | P-value |
|---|---|---|---|
| Condition factor | 0.71 ± 0.04 | 0.67 ± 0.03 | 0.908 |
| Viscero-somatic index | 6.74 ± 0.78 | 5.45 ± 0.40 | 0.059 |
| Hepato-somatic index | 1.02 ± 0.25 | 0.63 ± 0.13 | 0.346 |

**Water Quality Parameters**

Throughout the experiment, water temperature and pH remained stable and comparable between treatments ($p > 0.05$) and were within the optimal range for rearing African catfish (Table 3).

**Table 3: Water Quality Characteristics of Experimental Tanks During the Feeding Period**

| Parameter | Control | Cinnamon | P-value |
|---|---|---|---|
| Temperature (°C) | 28.87 ± 0.07 | 28.93 ± 0.09 | 0.653 |
| pH | 8.58 ± 0.10 | 8.64 ± 0.14 | 0.515 |

**Discussion**

The aquaculture industry should adopt innovative approaches that enhance production, sustainability, resilience, efficiency, and profitability to meet the global demand for aquatic

animal protein (Gruber et al., 2025). One such approach involves the use of phytogenic additives such as cinnamon. Cinnamon and its derivatives are increasingly recognized as valuable natural feed additives in aquaculture for their potential to enhance fish growth and health(Abd-Elhakim et al., 2025). Additionally, the use of plants as part of fish feed additives offers a sustainable, cost-effective, and nutrient-rich alternative to synthetic feed additives that improves fish health while reducing environmental impact.

In this study, 2% dietary cinnamon had no significant effect on growth or feed utilization of *C. gariepinus* over 28 days. These findings suggest that cinnamon at this dietary level may not be effective as a growth promoter under the tested conditions. Although cinnamon has been reported to improve digestion and metabolism in terrestrial animals including poultry (Ali et al., 2021), its efficacy in fish appears inconsistent. For instance, Habiba et al. (2021) reported that supplementation of cinnamon at 1% significantly enhanced growth performance and feed utilization efficiency in European Sea Bass (*Dicentrarchus labrax*) after a 90-day feeding experiment. Similarly, Hamed et al. (2022) reported a significantly improved growth in Nile tilapia (*Oreochromis niloticus*) fed diet added with 1% cinnamon for 60 days. However, Mohammad (2021) documented that the addition of cinnamon at up to 1.5% in common carp (*Cyprinus carpio*) diet for 56 days had no significant impact on the final weight and feed consumption. The lack of improvements in feed conversion ratio and specific growth rate in this study may indicate that the 2% inclusion level is either suboptimal or excessive, possibly affecting the feed palatability or nutrient absorption. Additionally, the short experimental duration may have been insufficient to observe measurable effects. Variability in reported outcomes among studies (Habiba et al., 2021; Hamed et al., 2022; Mohammed, 2021) could be attributed to differences in species, diet formulation, or feeding duration.

Body indices are indicators of fish health and energy reserves. In this study, CF, VSI, and HSI were unaffected by cinnamon inclusion in the diet. The CF values were similar between treatments ($p$ = 0.908), indicating no effect on body condition. Although not statistically significant, the lower VSI ($p$ = 0.059) and HSI ($p$ = 0.346) in the cinnamon-fed group could suggest a possible reduction in visceral fat and liver size. This trend may reflect the lipid-modulating and hepatoprotective properties of bioactive compounds in cinnamon (Fateh & Amin, 2024). These bioactive responses may become more pronounced with prolonged feeding or optimized inclusion levels (Kuebutornye et al., 2024). Overall, while the differences were not significant, the observed tendencies point to potential metabolic benefits of cinnamon that warrants further investigation with larger sample sizes and extended feeding durations.

Water quality parameters were stable throughout the experiment. These findings indicate that supplementation with cinnamon had no measurable effect on the ambient temperature or pH of the rearing water. Maintaining stable temperature and pH conditions is crucial for ensuring the well-being of cultured aquatic organisms, as fluctuations can induce physiological stress and alter metabolic performance. The present results demonstrate that cinnamon inclusion did not compromise these key parameters, suggesting that its application at the level of inclusion is environmentally safe and does not interfere with the physicochemical stability of the culture system. The observed temperature and pH ranges fall within the optimal limits for most tropical aquaculture species, supporting normal growth and physiological function. Similar findings were reported in other phytogenic additives (Hamid et al., 2022; Somdare et al., 2025). Thus, any biological responses observed in the cinnamon-fed group can be associated with bioactive properties of cinnamon rather than the water quality parameters monitored.

## Conclusion

Inclusion of 2% cinnamon powder in the diet of African catfish did not significantly improve growth or feed efficiency, implying that supplementation at this level was safe for *C. gariepinus* but ineffective as a growth enhancer. A trend towards reduced VSI suggests potential metabolic effects. Further research is recommended to explore different inclusion levels, longer feeding durations, and health parameters.

## Conflict of interest

The authors declare that they have no competing interests.

## Author contribution

Somdare, P.O: Conceptualization, methodology, data curation, analysis, original draft preparation, review and editing., Muhammed, H. O: Data curation, Abbah, B. G: Data curation, Abdulsalam, O. A: Data curation, Uchendu, C. N: Data curation, final review and editing.

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