

CHAPTER THIRTY

Economic Assessment of Cinnamon-Enriched Diets in African Catfish Hybrid (*Clarias gariepinus* ♀ × *Heterobranchus bidorsalis* ♂) Cultivation

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Abstract

An assessment of the economic feasibility of including cinnamon in the diet of hybrid African catfish (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) was conducted throughout a 56-day feeding trial. Two hundred and ten fingerlings of hybrid African catfish were acclimatised for one week, weighed, and assigned to five feeding regimens containing 0, 0.5, 1.0, 1.5, and 2.0% cinnamon. The diets were isonitrogenous at 38% and isolipidic at 12%. Each treatment was replicated three times, with 14 fish per replication. Fish were fed 5% of their body weight in two equal portions daily. An economic analysis was conducted utilising cost incidence, profit index, profitability ratio, and cost-return analysis as analytical instruments. The study's results demonstrated the viability of utilising cinnamon, as evidenced by favourable gross margins and net returns. CTR exhibited the highest levels of BCR and ROR, whilst DT5 showed the lowest. No significant differences ($p>0.05$) were seen in the BCR of fish fed the CTR and cinnamon-treated diets, except DT5. As the concentration of cinnamon increased, the BCR and ROR decreased. This study concluded that producing African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) with diets using cinnamon powder is economically viable. Reduced levels of cinnamon powder (0.5g/100g) in dietary formulations appear to yield economic returns similar to those of the control group.

Keywords: Cost incidence; Profit index; Profitability ratio; Cost-return analysis.

Introduction

Aquaculture can serve as an economical and high-quality protein source for human consumption and enhanced health (Ansari et al., 2021). The aquaculture sector has expanded globally because of advancements in production technology and cultivation techniques (Amenyogbe et al., 2018; Boyd et al., 2020; Naylor et al., 2021). The increased use of intensive fish production techniques by farmers to meet market demands and enhance profitability induces stress, alongside an elevated risk of disease and loss (Hoseinifar et al., 2020). The adverse environmental impacts of chemical use prompted the enactment of laws restricting their use as curative or preventive measures in aquaculture (Okocha et al., 2018). Consequently, dietary modifications, including the use of medicinal herbs in fish diets to promote growth and boost health, have been suggested as a feasible solution (Alagawany et al., 2021). Medicinal herbs have become increasingly favoured for the prevention and treatment of fish illnesses due to their environmental safety, cost-effectiveness, and minimal detrimental effects compared to chemical growth promoters and health enhancers (Doan et al., 2020). Plant-derived compounds rich in bioactive secondary metabolites have been shown to enhance fish immunity (Gabriel, 2019). Phytochemicals, which are active substances derived from plants, possess immunostimulant, biocidal, anti-stress, and growth-promoting effects. Tannins, alkaloids, pigments, essential oils, steroids, terpenoids, flavonoids, and phenolics are the predominant phytochemicals (Elumalai et al., 2020). Medicinal plants possess the capacity to treat and prevent fish illnesses owing to their rich content of secondary metabolites, which exhibit activity against various bacteria and fungi (Lieke et al., 2020). Recent applications of medicinal plant products (powders, essential oils, extracts, and isolated compounds) have been used to mitigate the adverse effects of stressors on fish, including toxicants and unfavourable environmental conditions (Tadese et al., 2021). Numerous studies have demonstrated that intact herbal materials and extracts enhance fish performance and welfare (Alagawany et al., 2021; Souza et al., 2019; Zhu, 2020).

Intact plant components, including turmeric (*Curcuma longa*), coffee bean (*Coffea arabica*), green tea (*Camellia sinensis*), *Myrcia sylvatica*, rhubarb (*Rheum officinale*), Roselle (*Hibiscus sabdariffa*), and ginger (*Zingiber officinale*), have been shown to enhance growth performance and mitigate stress in fish, as evidenced by various research studies (Abdel-Tawwab et al.,

2018; El Mesallamy et al., 2016; Fagbenro et al., 2004; Kuo et al., 2020; Pérez-Escalante et al., 2012; Sodamola et al., 2016).

Feed constitutes a substantial expense in the fish production cycle and is a critical determinant of the profitability and sustainability of aquaculture, representing 60 to 70 percent of the variable costs associated with fish production (Jimoh et al., 2020; Jimoh et al., 2019). Despite extensive research on the growth and health benefits of incorporating medicinal plants into fish feed, the economic ramifications of utilising medicinal plants, such as cinnamon powder, in fish feed, especially in terms of fish production economics, are yet to be investigated. This study, therefore, investigated the production economics of cinnamon supplementation in the diet of hybrid African catfish (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂).

Methods

Sources, Ingredient Processing, and Experimental Diets

Cinnamon powder, fish meal, soybean meal, and other beneficial feedstuffs were sourced from commercial suppliers in Ilorin, Nigeria, milled and screened separately to achieve a fine particle size, and duplicate samples were analysed for their proximate composition (AOAC, 2005). Cinnamon was included at concentrations of 0, 0.5, 1.0, 1.5, and 2.0g/100g in the experimental diets, designated as CTR, DT2, DT3, DT4, and DT5 (Table 1). The designed diets were isolipidic and isonitrogenous, including 12% crude lipid and 38% crude protein, respectively. To facilitate binding, the feedstuffs were pulverised and hot water was incorporated. The material was further processed through a pelleting and mixing apparatus, followed by a mincer to produce 2mm pellets, which were then immediately sundried at 30-32°C. The diets were preserved in a cold location during a three-day drying period. The nutritional composition (fatty and amino acids) of the experimental meals (Table 2) was assessed using a tool (Excel) developed by the Network of Aquaculture Centres in Asia-Pacific (NACA) in 2008.

Table 1: Gross Composition (G/100g) of Cinnamon-Supplemented Diet Fed to African Catfish Hybrid (*Clarias Gariepinus* ♀ X *Heterobranchus Bidorsalis* ♂)

Ingredients	CTR	DT2	DT3	DT4	DT5
Fishmeal@72%cp	27.80	27.80	27.80	27.80	27.80
SBM@44% cp	44.50	44.50	44.50	44.50	44.50
Yellow Maize@10%cp	4.00	4.00	4.00	4.00	4.00
Cinnamon	0.00	0.50	1.00	1.50	2.00
Fish Premix	5.00	5.00	5.00	5.00	5.00
Fish oil	2.50	2.50	2.50	2.50	2.50
Soy Oil	2.50	2.50	2.50	2.50	2.50
Starch	13.70	13.20	12.70	12.20	11.70
Total	100	100	100	100	100

Each kg of the Agri-mix fish premix contains Vitamin A 1500000 i.u, Vitamin B1 800mg; Vitamin B2 1,600mg, Vitamin B6 1,500mg, Vitamin B12 4mg, Vitamin D3 3,000,000 i.u, Vitamin E 200000mg, Vitamin C 240g, Folic Acid 300mg, Niacin 5970 mg, Biotin 40 mg, Pantothenic Acid 4000mg, Copper 800mg, Iodine 191mg, Iron 1200mg, Manganese 20,323mg, Selenium 60mg, Zinc 15996 mg, Choline 87000mg. Manufactured by Agri-Dom 20/22 Kolawole Shonibare Street, Ajao Estate, Lagos. www.agri-domintegrated.com.ng

Experimental Set-up and Feeding

The experiment was performed at the wet laboratory of the Department of Aquaculture and Fisheries at the University of Ilorin, Nigeria. The hybrid catfish fingerlings were procured from a reputed hatchery in Ilorin and transported to the project location in an aerated bag. Two hundred and ten hybrid catfish fingerlings were acclimatised to commercial catfish pelleted diet

for seven days prior to the feeding study. Each treatment consisted of five trials with three replicates, and each tank contained fourteen fingerlings. The tanks were randomly allocated to the experimental diet and were fed 5% of their body weight in two equal portions over 56 days, specifically during 9:00–10:00 am and 5:00–6:00 pm.

Analysis of Production Economics

The analysis of Production Economics was conducted using the indices (equations 1–11) as documented in Jimoh et al. (2019) and Jimoh et al. (2020).

$$\text{Incidence of Cost} = \frac{\text{Cost of Feed}}{\text{Weight of Fish}} \dots\dots\dots (1)$$

$$\text{Profit Index} = \frac{\text{Value of Fish}}{\text{Cost of Feed}} \dots\dots\dots (2)$$

$$\text{Profit/kg} = \text{Value of 1kg fish} - \text{Incidence of cost} \dots\dots\dots (3)$$

$$\text{Total Cost (TC)} = \text{TVC} + \text{TFC} \dots\dots\dots (4)$$

Where TVC = Total Variable Cost (Cost of fingerlings + Cost of Feeding)

TFC = Total Fixed Cost (Cost of Aquaria Tanks)

Total Revenue(TR)=Price of Fish×Biomass Output (kg).....(5)

Gross Margin (GM) =TR-TVC..... (6)

Net Return (NR) =GM-TFC (7)

Expense Structure Ratio(ESR)=(Fixed Cost)/(Total Cost)..... (8)

Benefit-Cost Ratio (BCR)=(Total Revenue)/(Total Cost).....(9)

Gross Ratio (GR)=(Total Cost)/(Total Revenue).....(10)

Rate of Return (ROR)=(Net Return)/(Total Cost).....(11)

The straight-line method was used to assess the depreciation cost of aquaria tanks with the following properties;

Cost of Plastic Tanks (₦)	55,000
No of Years (Life span in years)	5
Savage Value (10%) (₦)	5,500

$$\text{Depreciation} = \frac{\text{Cost Price} - \text{Salvage value}}{\text{Life Span}}$$

$$\text{Depreciation} = \frac{55,500 - 5,500}{5} = \text{₦ } 9,900$$

$$\text{Depreciative Cost of 2 months plastic use} = \frac{9,900}{12} \times 2 = \text{₦ } 1,650$$

Cost of Fingerlings	=	
(14*₦28)		₦ 392

Proximate Composition (%)	CTR	DT2	DT3	DT4	DT5
Moisture	8.14	8.12	8.10	8.08	8.06
Crude Protein	37.82	38.00	38.19	38.38	38.58
Crude Lipid	12.31	12.40	12.50	12.59	12.69
Ash	7.39	7.42	7.44	7.47	7.50
Crude Fibre	5.91	5.92	5.93	5.94	5.95
NFE	28.44	28.14	27.84	27.54	27.24
Amino Acid Composition (%)					
Arginine %	3.00	3.01	3.03	3.04	3.06
Histidine	0.94	0.94	0.94	0.95	0.95
Isoleucine	1.84	1.85	1.85	1.86	1.87
Leucine	3.00	3.01	3.03	3.04	3.06
Lysine	2.82	2.83	2.85	2.86	2.88
Methionine	0.86	0.87	0.87	0.88	0.88
M+C	1.38	1.39	1.39	1.40	1.41
Phenylalanine	1.76	1.77	1.78	1.79	1.80

P+T	3.05	3.07	3.08	3.10	3.11
Threonine	1.78	1.79	1.80	1.81	1.82
Tryptophan	0.47	0.47	0.47	0.47	0.48
Valine	2.00	2.01	2.02	2.03	2.04
Fatty Acid Composition (%)					
LOA (18:2n-6)	4.89	4.92	4.94	4.97	4.99
LNA (18:3n-3)	0.69	0.70	0.70	0.71	0.71
ARA (20:4n-6)	0.07	0.07	0.07	0.07	0.07
EPA (20:5n-3)	0.35	0.35	0.36	0.36	0.36
DHA (22:6n-3)	0.82	0.82	0.83	0.83	0.84
Total n-3	1.87	1.88	1.89	1.90	1.91
Total n-6	4.96	4.99	5.01	5.04	5.07
n3:n6	0.38	0.38	0.38	0.38	0.38
Total phospholipid%	2.69	2.70	2.72	2.73	2.74

LOA: Linoleic Acid; LNA: Linolenic Acid; ARA: Arachidonic Acid; EPA: Eicosapentanoic Acid; DHA Docosahexanoic Acid

Statistical Analysis

The data were presented as the mean and standard error of the mean (SEM). A one-way Analysis of Variance (ANOVA) was conducted in IBM SPSS Statistics for Windows, version 20.0, to evaluate the importance of each profitability evaluation parameter. Where substantial variance ($p < 0.05$) was observed, Tukey's B was employed to distinguish significant differences among individual treatment means.

Results

Production cost of 1 kilogramme of diet

The expense (N) of generating 1kg of each diet with cinnamon powder for African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) is detailed in Table 3. The cost of producing 1 kg of the diet increased with the greater quantity of cinnamon powder used.

Table 3: Cost (₦) of production of 1kg of the experimental diets containing cinnamon

Ingredients	Cost/kg	CTR	DT2	DT3	DT4	DT5
Fishmeal@72%cp	1100.00	305.80	305.80	305.80	305.80	305.80
SBM@44% cp	270.00	120.15	120.15	120.15	120.15	120.15
Yellow Maize@10%cp	250.00	10.00	10.00	10.00	10.00	10.00
Cinnamon	6500.00	0.00	32.50	65.00	97.50	130.00
Fish Premix	600.00	30.00	30.00	30.00	30.00	30.00
Fish oil	1650.00	41.25	41.25	41.25	41.25	41.25
Soy Oil	675.00	16.88	16.88	16.88	16.88	16.88
Starch	500.00	68.50	66.00	63.50	61.00	58.50
Cost/kg Feed		592.58	622.58	652.58	682.58	712.58

Analysis of the costs associated with the production of African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) using diets supplemented with cinnamon powder

Table 4 presents the incidence of a cost analysis (IOC) for producing 1 kg of fish utilising experimental diets that include cinnamon powder, administered to African catfish hybrid fingerlings. The end weights of fish from cinnamon-based diets were numerically greater than those from the control group. However statistical similarity ($P>0.05$) was seen between them. Nonetheless, substantial changes ($p<0.05$) were observed in the cost analysis of producing 1kg of fish with the various experimental diets. The incidence of cost escalated with higher levels of cinnamon inclusion in the diet, with the DT5 group exhibiting the highest cost incidence, which was substantially higher ($p<0.05$) than that observed in other dietary treatment groups. No significant difference ($p>0.05$) was seen between the costs incurred for fish fed CTR and those fed DT2. The profit index for fish production and the profit per kilogramme of fish produced exhibited significant differences ($p<0.05$) among the various dietary treatment groups. The CTR-fed group achieved the highest results, while the DT5-fed group achieved the lowest results. No significant difference ($p>0.05$) was seen between the profit indices of fish produced by CTR and DT2.

Table 4: Incidence of a Cost Analysis of Producing African Catfish Hybrid (*Clarias Gariepinus* ♀ X *Heterobranchus Bidorsalis* ♂) with Diets Containing Cinnamon Powder

	Control	DT2	DT3	DT4	DT5
Final Weight of fish ($\times 10^{-3}$ kg)	10.60 $\pm$ 0.43 ^a	10.33 $\pm$ 1.03 ^a	11.94 $\pm$ 1.43 ^a	12.72 $\pm$ 1.69 ^a	11.25 $\pm$ 0.1
Value of Fish Produced (₦)	10.60 $\pm$ 0.43 ^a	10.33 $\pm$ 1.04 ^a	11.94 $\pm$ 1.43 ^a	12.72 $\pm$ 1.70 ^a	11.25 $\pm$ 0.1
Feed Fed ($\times 10^{-3}$ kg)	10.87 $\pm$ 0.74 ^a	10.66 $\pm$ 1.66 ^a	12.85 $\pm$ 2.23 ^a	13.01 $\pm$ 1.66 ^a	12.80 $\pm$ 0.1
Cost/kg feed	592.58	622.580	652.58	682.58	712.58

Cost of Feed Fed (₦)	6.44±0.44 ^c	6.64±1.03 ^{bc}	8.39±1.45 ^{abc}	8.88±1.14 ^a b	9.13±0.78 ^a
Incidence of Cost (₦)	607.07±29.6 3 ^d	634.833±40 .69 ^{cd}	692.71±49. 30 ^{bc}	699.39±26. 86 ^b	776.60±1 08 ^a
Profit Index	1.65±0.77 ^a	1.59±0.10 ^{ab}	1.46±0.10 ^{bc}	1.43±0.53 ^c	1.29±0.27 ^d
Profit/kg fish produced (₦/kg fish)	392.93±29.6 3 ^a	365.16±40. 70 ^{ab}	307.29±49. 30 ^{bc}	300.60±26. 86 ^c	223.39±1 08 ^d

Row means with different superscripts are significantly different (p<0.05) from each other

1 USD= N413.88

Market Price of 1kg fish = N1000

Analysis of costs and returns associated with the production of African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) with experimental diets incorporating cinnamon powder

The cost and return analysis for the production of African catfish hybrid (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) fingerlings utilising experimental diets with cinnamon powder is detailed in Table 5. No significant change (p>0.05) was seen in the biomass produced. The biomass generated with DT4 was the highest, whereas DT5 yielded the lowest. The total cost of producing fish with CTR was the lowest. However, there was no statistical difference (p > 0.05) in total costs across the dietary treatments. The gross margin and net profit diverged from total cost: fish produced by CTR achieved the highest profit margin and net return. The gross margin and net return diminished in the cinnamon-treated dietary groups compared to the control group, although exhibited statistical equivalence (p>0.05) to the control group.

Table 5: Cost And Return Analysis of Producing African Catfish Hybrid (*Clarias Gariepinus* ♀ X *Heterobranchus Bidorsalis* ♂) with Experimental Diets Containing Cinnamon Powder

	Control	DT2	DT3	DT4	DT5
Biomass produced (kg)	10.60±0.43 ^a	10.33±1.03 ^a	11.94±1.43 ^a	12.72±1.69 ^a	11.25±0.16 ^a
Total Revenue (₦) x10 ³	10.60.01±0.44 ^a	10.33±1.04 ^a	11.94±1.43 ^a	12.72±1.70 ^a	11.25±0.16 ^a
Cost of Feeding (₦) x10 ³	6.44±0.44 ^a	6.64±1.03 ^a	8.39±1.45 ^a	8.88±1.14 ^a	9.13±0.78 ^a
Total Variable Cost (₦) x10 ³	6.83±0.44 ^a	7.03±1.03 ^a	8.78±1.45 ^a	9.271±1.14 ^a	9.52±0.78 ^a
Total Fixed Cost (₦) x10 ³	1650±0.00	1650±0.00	1650±0.00	1650±0.00	1650±0.00
Total Cost (₦) x10 ³	8.48±0.44 ^a	8.68±1.03 ^a	10.43±1.45 ^a	10.92±1.14 ^a	11.17±0.08 ^a
Gross Margin (₦) x10 ³	3.77±0.33 ^a	3.30±0.70 ^a	3.16±0.37 ^a	3.45±0.70 ^a	2.24±0.23 ^a
Net Return (₦) x10 ³	2.12±0.33 ^a	1.65±0.07 ^a	1.51±0.37 ^a	1.19±0.70 ^a	0.59±0.23 ^a

Row means with different superscripts are significantly different (p<0.05) from each other.

Profitability assessment of cultivating African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) utilising experimental diets supplemented with cinnamon powder

The economic study of producing hybrid African catfish (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) using diets supplemented with cinnamon powder is detailed in Table 6. A substantial difference (p<0.05) was seen in the

Benefit-Cost Ratio (BCR) and Rate of Return (ROR) associated with the various dietary regimens for fish production. CTR exhibited the highest BCR and ROR values, whilst DT5 displayed the lowest. No substantial variations ($p>0.05$) were seen in the BCR of fish fed the control and cinnamon-treated diets, with the exception of DT5. The gross ratio (GR) exhibited a divergent trend compared to the benefit-cost ratio (BCR) and Rate of Return (ROR). No significant differences ($p>0.05$) were seen in the expense structure ratio of fish generated under different dietary regimens.

Table 6: Profitability Analysis of Producing African Catfish Hybrid (*Clarias Gariepinus* ♀ X *Heterobranchus Bidorsalis* ♂) with Experimental Diets Containing Cinnamon Powder

	Control	DT2	DT3	DT4	DT5
Benefit Cost Ratio	1.25±0.43 _a	1.19±0.20 ^a _b	1.15±0.42 ^a _b	1.15±0.50 ^a _b	1.05±0.02 ^b
Gross Ratio	0.80±0.03 _b	0.83±0.02 ^a _b	0.86±0.32 ^a _b	0.87±0.04 ^a _b	0.95±0.02 ^a
Expense Structure Ratio	0.19±0.01 _a	0.19±0.02 ^a	0.16±0.02 ^a	0.15±0.01 ^a	0.14±0.001 _a
Rate of Return	0.25±0.04 _a	0.19±0.02 ^a _b	0.15±0.07 ^a _b	0.16±0.05 ^a _b	0.05±0.02 ^b

Row means with different superscripts are significantly different ($p<0.05$) from each other

Discussion

The research employed biomass production, economic viability, and profitability as metrics to assess the economic feasibility of integrating cinnamon into the practical diets of African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂). The principal nutritional categories of fish demonstrated a significant response to feeding. The increased biomass seen in the cinnamon-based dietary groups compared to the control group may be attributed to the bioactive constituents in the feed, which could stimulate the gustatory and olfactory nerves of fish consuming cinnamon-enriched diets, as suggested by Pallaya-Baletta et al. (2021). Our results mirrored those reported by Habiba et al. (2021), who fed European sea bass (*Dicentrarchus labrax*) a cinnamon-based diet. Abdel-Tawwab et al. (2018) documented a beneficial

growth-enhancing effect of dietary cinnamon nanoparticles on Nile tilapia (*Oreochromis niloticus*), consistent with the findings of this investigation. The inclusion of cinnamon in the diet elevated the cost per kilogramme of the experimental diets, resulting in diminished profit margins for the groups that received cinnamon. This contrasts with our previous findings about the economic analysis of substituting basic feed ingredients for protein sources (Jimoh et al., 2015; Jimoh et al., 2020; Jimoh et al., 2019). Cinnamon serves a fundamental role as an additive in diets; its dose-dependent increase will significantly affect the cost per kilogramme of feed produced and the cost of producing one kilogramme of fish, as the variable production costs rise with higher levels of cinnamon inclusion in the diet. Nevertheless, all dietary treatments resulted in a profit index over 1, indicating the profitability of feeding African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) with cinnamon-based diets. Nonetheless, the profit index and profit per kilogramme of fish produced diminish with the increasing incorporation of cinnamon. The mean total variable cost and the overall cost of producing African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) with diets featuring different inclusion levels of cinnamon were offset by the total revenue generated from the sale of these hybrids, leading to a favourable gross margin and net returns across all dietary treatment groups. A positive gross margin and net returns indicate profitability in feeding (Jimoh et al., 2015). The diminished gross margin and net return in the experimental dietary treatments relative to the control were attributable to the supplementary expense of cinnamon incorporation in the diet of African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂), rather than inferior growth performance. This suggests that, despite substantial evidence supporting cinnamon's growth-promoting properties, the economic implications of its dietary inclusion may not justify its use. As the concentration of cinnamon increased, the BCR and ROR diminished. A larger Benefit-Cost Ratio (BCR) indicates greater profitability; the further it deviates from 1, the more profitable it becomes. All dietary interventions produced fish with a BCR exceeding 1. The incorporation of 20g/kg of cinnamon resulted in reduced growth. The diminished palatability of the feed at a greater cinnamon inclusion level (20%) may account for the observed reduction in growth. This aligns with the findings of Habiba et al. (2021).

Conclusion

This study's findings indicated that including cinnamon into the diets of African catfish hybrids (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂) is economically feasible. In addition to its growth-promoting properties, the cinnamon powder was an economical supplement. The incorporation of cinnamon presented several disadvantages, including its high cost. Consequently, incorporating a higher level is not economically feasible. Future experiments may explore additional techniques to lower the cost of cinnamon for incorporation into the diets of the African catfish hybrid (*Clarias gariepinus* ♀ x *Heterobranchus bidorsalis* ♂). Reduced concentrations of cinnamon powder (0.5g/100g) in dietary formulations appear to yield economic yields similar to those of the control group.

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