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Effects of Graded Levels of Rosary Pea (*Abrus precatorius*) Leaf Meal on Growth Performance and Nutrient Utilisation of Red-Belly Tilapia (*Coptodon zillii*) Fingerlings

Tope Mathew Oladipupo[1]

[1]Department of Fisheries and Aquaculture Technology, Federal University of Technology, P. M. B 704, Akure, Nigeria

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Abstract

This study evaluated the effects of dietary inclusion of *Abrus precatorius* leaf meal on growth performance, nutrient utilisation, and physiological responses of *Coptodon zillii* fingerlings over a 70-day feeding trial. Five iso-nitrogenous diets (35% crude protein) were formulated with graded inclusion levels of 0.0, 0.5, 1.0, 1.5, and 2.0 g/100 g (T1–T5). A total of 225 fingerlings (2.33 ± 0.00 g) were randomly distributed into 15 tanks (15 fish per tank) with three replicates per treatment. Results showed significant differences ($p < 0.05$) in growth performance, with fish fed 1.0 g/100 g (T3) recording the highest weight gain, final weight, and specific growth rate. Performance declined at higher inclusion levels. Polynomial regression analysis identified 0.8 g/100 g as the optimal dietary inclusion level.. Haematological, biochemical, and carcass parameters improved at moderate inclusion levels, indicating enhanced metabolic activity, immune response, and nutrient utilisation. In conclusion, *A. precatorius* leaf meal can be safely included at 0.8–1.0 g/100 g to improve growth and physiological performance without adverse effects.

Keywords: *Coptodon zillii*; *Abrus precatorius*; Growth; Fish Health.

I. INTRODUCTION

Fisheries and aquaculture play a vital role in global food security, nutrition, income generation, and employment, particularly in developing countries. Aquaculture has remained the fastest-growing food production sector in recent years, driven by rising demand for fish protein and declining capture fisheries (FAO, 2024). In Nigeria, however, its expansion is limited by high feed costs, poor water quality management, and disease outbreaks, which collectively reduce productivity and profitability (Adewumi *et al.*, 2022; Bassey and Udo, 2023). *Coptodon zillii* is widely cultured due to its fast growth, early maturation, environmental tolerance, and efficient utilisation of low-cost feeds (FAO, 2020). Its omnivorous feeding habit and adaptability to different culture systems further support its suitability for intensive aquaculture (Lim and Webster, 2021). The growing interest in plant-based feed additives is driven by their ability to improve growth, health status, and feed efficiency in fish (Dada, 2015; Oladipupo, 2020). This has created a need to identify alternative feed resources that are nutritionally valuable, affordable, widely available, and not in competition with human or industrial uses.

Despite this, the use of *Abrus precatorius* in fish nutrition remains poorly explored, with most studies focusing on its toxicological effects in mammals rather than its dietary potential in aquaculture (Kundu *et al.*, 2019; Ismail *et al.*, 2020). This study evaluated the effects of graded dietary inclusion of *A. precatorius* leaf meal on growth performance, nutrient utilisation, haematology, biochemical profile, and carcass composition of *C. zillii* fingerlings.

II. MATERIALS AND METHODS

- *Study Area*

This study was conducted over a 70-day period at the Research Laboratory of the Department of Fisheries and

Aquaculture Technology, The Federal University of Technology, Akure, Ondo State, Nigeria.

- *Collection and Preparation of Abrus precatorius Leaves*

Fresh *A. precatorius* leaves were procured from a local plant market at Esikan Akure, Ondo State, Nigeria. They were identified and authenticated at the Department of Crop, Soil and Pest Management, The Federal University of Technology, Akure. Leaves were washed, air-dried for seven days under hygienic conditions on sterilized trays covered with mesh, ground into powder, sieved (0.5 mm), and stored at 4°C in a container until used.

- *Experimental Fish*

Apparently healthy *C. zillii* fingerlings were purchased from the Federal University of Technology fish farm, Akure, Ondo State, Nigeria. Fish were acclimatized for 14 days and fed a commercial diet (35% crude protein) twice daily to apparent satiation between 08:00–09:00 and 16:00–17:00 GMT.

- *Formulation of Experimental Diets*

Five experimental diets containing 35% crude protein (CP) were formulated by incorporating graded levels of *A. precatorius* leaf meal (0.0, 0.5, 1.0, 1.5, and 2.0 g/100 g). The diet containing 0.0 g/100 g *A. precatorius* leaf meal served as the control and contained no additive. Other ingredients included fish meal, soybean meal, groundnut cake, yellow maize, methionine, lysine, vitamin-mineral premix, vegetable oil, and starch (Table 1). All ingredients were thoroughly mixed and pelleted using a Hobart A-200T mixing and pelleting machine (Hobart Manufacturing Ltd., UK) fitted with a 2 mm die. The pellets were sun-dried for four days, hand-crumbled into appropriate sizes for juveniles, packed in airtight polyethylene bags, labeled by treatment, and stored at 4°C until use.

Table 1 Gross and Proximate Compositions of the Experimental Diets

Ingredients	**T1(0.0)**	**T2 (0.5)**	**T3 (1.0)**	**T4 (1.5)**	**T5 (2.0)**
Fish meal	16.8	16.8	16.8	16.8	16.8
Soybean meal	30.0	30.0	30.0	30.0	30.0
Groundnut cake	22.1	22.1	22.1	22.1	22.1
Yellow maize	18.6	18.6	18.6	18.6	18.6
Methionine	1.00	1.00	1.00	1.00	1.00
Lysine	1.00	1.00	1.00	1.00	1.00
Vegetable oil	5.00	5.00	5.00	5.00	5.00
Vitamin–mineral mix	3.50	3.50	3.50	3.50	3.50
Starch	2.00	2.00	2.00	2.00	2.00
A. precatorius leaf meal	0.0	0.5	1.0	1.5	2.0
Proximate composition (%)					
Moisture	9.54	9.62	9.38	9.33	9.21
Ash	4.96	5.11	5.27	5.19	5.09
Protein	34.55	34.84	34.75	34.82	34.60
Crude Fibre	2.98	3.23	3.66	3.94	4.10
Lipid	7.13	7.28	7.32	7.50	7.75
Nitrogen free extract	40.84	39.92	39.62	39.22	39.25

Composition of vitamin-mineral mix (Aquamix) (quantity/kg), Vitamin A, 5,500,000 IU; Vitamin D3, 1,100,000 IU; Vitamin B2, 2,000 mg; Vitamin E, 750 mg; Vitamin K, 1,000 mg; Vitamin B6, 1,000 mg; Vitamin B12, 6 mcg; Calcium; Pantothenate, 2,500 mg; Nicotinamide, 10 g; Choline Chloride, 150 g; Mn, 27,000 mg; I, 1,000 mg; Fe, 7,500 mg; Zn, 5,000 mg; Cu, 2,000 mg; Co, 450 mg. L-Lysine, 10 g; Selenium, 50 ppm.

- *Experimental Design and Management*

The experiment was arranged in a Completely Randomized Design (CRD). A total of 225 *C. zillii* fingerlings (2.33 ± 0.00 g) were weighed using a digital electronic balance (Model PB3002; ±0.01 g precision) and randomly distributed into 15 glass tanks (70 L capacity; 70 × 45 × 45 cm). Each tank contained 15 fish, representing five dietary treatments with three replicates each. Fish were fed to apparent satiation twice daily between 08:00–09:00 h and 16:00–17:00 h GMT for 70 days. Fish were batch-weighed at the start of the experiment and every two weeks thereafter. Handling time was minimized to reduce stress. Uneaten feed and feces were siphoned daily before morning feeding, followed by partial water replacement. Complete water exchange was carried out twice weekly. Water quality parameters (temperature, dissolved oxygen, and pH) were monitored twice weekly. Growth performance and nutrient utilisation indices were calculated according to Talunga *et al.* (2024). Proximate composition followed AOAC (1990) methods, while haematological analyses were conducted using standard procedures described by Svobodova *et al*. (2006).

- *Statistical Analysis*

Data were analyzed using one-way analysis of variance (ANOVA) to test differences among treatment means. Tukey's post-hoc test was used to separate significantly different means. All analyses were performed using SPSS (Version 23.0), with significance accepted at $p < 0.05$.

III. RESULTS AND DISCUSSION

➢ *Proximate Analysis of Abrus precatorius Leaf*

The proximate composition of *A. precatorius* leaf showed that nitrogen-free extract (NFE) had the highest value (63.25%), while crude fibre recorded the lowest value (2.75%) (Table 2). This agrees with Okoye *et al.* (2023), who reported high NFE and digestible carbohydrate levels in tropical leaf meals. Ahmed and Bichi (2024) also highlighted the nutritional potential of unconventional plant protein sources in aquaculture. Similar proximate profiles have been reported in tropical leaf meals used in tilapia diets, where nutrient composition supports fish growth (Zuluaga-Hernández *et al.,* 2023).

Table 2 Proximate Composition of *A. precatorius* Leaves

Parameters (%)	**Values**
Moisture	10.53
Ash	8.17
Protein	9.08
Fibre	2.75
Lipid	6.22
Nitrogen free extract	63.25

➢ *Water Quality Parameters*

Water quality parameters in the culture tanks remained within acceptable ranges for freshwater aquaculture species, including *C. zillii* (Table 3). This consistency supports normal physiological functioning and growth. Similar observations were reported by Torres *et al.* (2023), who noted that stable water quality enhances metabolic efficiency and growth in tilapia culture systems.

Table 3 Water Quality Parameters for Culture of *C. zillii* Fingerlings

Treatments	**T1(0.0)**	**T2 (0.5)**	**T3 (1.0)**	**T4 (1.5)**	**T5 (2.0)**
DO (mg/L)	6.71 ± 0.08^{a}	6.82 ± 0.06^{a}	6.85 ± 0.06^{a}	6.84 ± 0.03^{a}	6.54 ± 0.13^{a}
Temperature (ºC)	27.38 ± 0.07^{a}	27.39 ± 0.12^{a}	27.40 ± 0.20^{a}	27.37 ± 0.19^{a}	27.39 ± 0.15^{a}
pH	7.59 ± 0.32^{a}	7.53 ± 0.16^{a}	7.52 ± 0.03^{a}	7.55 ± 0.18^{a}	7.56 ± 0.06^{a}

Means in the Same Row with Different Superscripts Differ Significantly ($P < 0.05$).

- Key: DO = Dissolved Oxygen, pH = Hydrogen ion concentration

➢ *Growth Performance and Nutrient Utilisation*

Table 4 shows that dietary inclusion of *Abrus precatorius* leaf meal significantly influenced growth performance and feed utilisation in *C. zillii*. Fish fed 1.0 g/100 g (T3) recorded the highest final weight, weight gain, and specific growth rate, while performance declined at higher inclusion levels, particularly in T5. This pattern indicates that moderate inclusion enhances growth, whereas excessive supplementation impairs performance. The improved growth observed at moderate inclusion levels may be attributed to enhanced nutrient digestibility and the presence of bioactive compounds that stimulate metabolic activity and feed utilisation. The superior feed intake and feed conversion ratio recorded in T3 further confirm improved diet acceptability and efficient nutrient conversion at optimal inclusion levels. In contrast, reduced feed intake and poorer feed efficiency at higher inclusion levels may be associated with increased fibre content and anti-nutritional compounds, which can limit nutrient availability and digestion. Polynomial regression analysis identified 0.8 g/100 g as the optimal inclusion level, suggesting that growth performance is maximized at low to moderate supplementation. These findings are consistent with previous reports indicating that plant-based feed additives improve growth and feed efficiency in tilapia at optimal inclusion levels, while excessive inclusion reduces performance due to dietary imbalance (Abd El-Hack *et al.,* 2022; Amare *et al.,* 2024; Zhang *et al.,* 2024).

Table 4 Growth Performance and Nutrient Utilisation of *C. zillii* Fed the Experimental Diets

Parameters	**T1(0.0)**	**T2 (0.5)**	**T3 (1.0)**	**T4 (1.5)**	**T5 (2.0)**
IW(g)	2.33 ± 0.01^{a}	2.34 ± 0.01^{a}	2.33 ± 0.10^{a}	2.33 ± 0.00^{a}	2.34 ± 0.01^{a}
FW (g)	11.29 ± 0.10^{ab}	11.67 ± 0.02^{b}	12.45 ± 0.12^{c}	9.82 ± 0.06^{ab}	8.75 ± 0.13^{a}
WG (g)	8.96 ± 0.10^{ab}	9.33 ± 0.02^{b}	10.12 ± 0.11^{c}	7.49 ± 0.05^{ab}	6.41 ± 0.14^{a}
SGR(%/day)	2.25 ± 0.01^{b}	2.30 ± 0.00^{b}	2.39 ± 0.05^{b}	2.06 ± 0.01^{ab}	1.88 ± 0.02^{a}
FI (g)	15.54 ± 0.96^{b}	15.93 ± 0.24^{b}	17.05 ± 0.30^{c}	13.67 ± 0.38^{ab}	12.03 ± 0.29^{a}
FCR (g)	1.73 ± 0.15^{ab}	1.71 ± 0.05^{ab}	1.68 ± 0.04^{a}	1.83 ± 0.03^{b}	1.88 ± 0.01^{b}
FER (g)	0.58 ± 0.06^{a}	0.59 ± 0.02^{a}	0.59 ± 0.01^{a}	0.55 ± 0.02^{a}	0.53 ± 0.00^{a}
Survival (%)	97.78 ± 2.22^{a}	95.55 ± 4.44^{a}	100 ± 0.00^{a}	93.33 ± 6.67^{a}	100.00 ± 0.00^{a}

Mean in the Same Row with Different Superscripts are Significantly Different at $P<0.05$

- Key: IW=Initial weight, FW=Final weight, WG=Weight gain, SGR=Specific growth rate (%/day), FI=Feed intake, FCR=Feed conversion ratio, FER=Feed efficiency ratio.

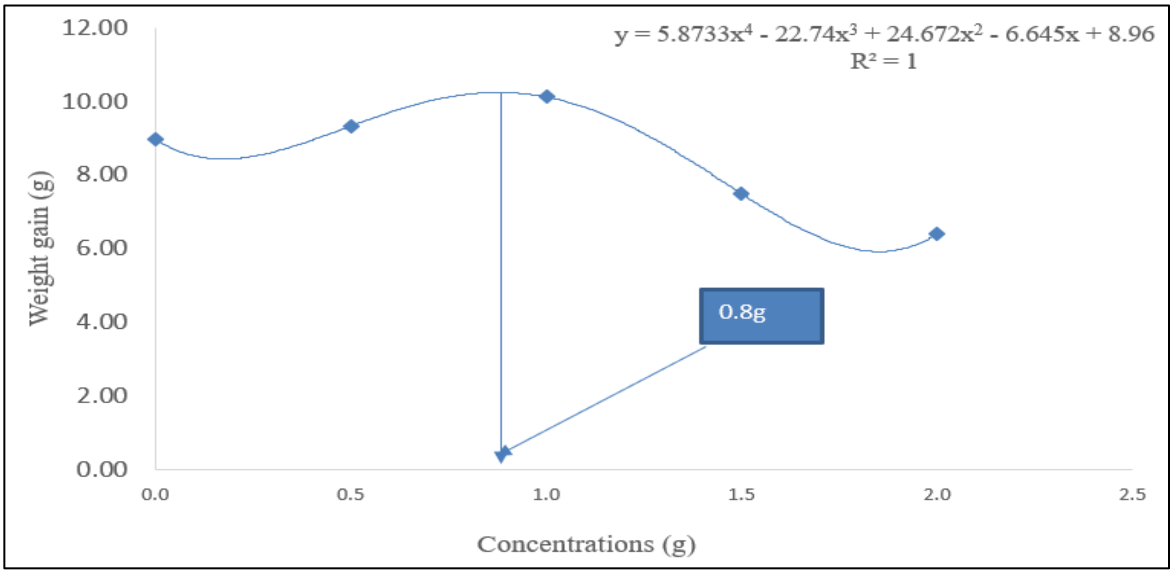

Fig 1 Fourth Degree Polynomial Regression Relationship Between Dietary Inclusion of *A. precatorius* Meal and Weight Gain of *C. zillii* Fed with Experimental Diets

- ***Haematological Parameters***

Dietary inclusion of *A. precatorius* leaf meal significantly affected the haematological profile of *C. zillii*, reflecting changes in physiological status and immune function (Table 5). The progressive increase in white blood cell (WBC) count, particularly in fish fed higher inclusion levels, suggests a stimulatory effect on the immune system. This response is likely associated with bioactive phytochemicals such as flavonoids, saponins, and phenolics, which are known to enhance immune activity (Kumar *et al.,* 2023). The elevated WBC values therefore indicate improved immune readiness rather than pathological stress. In contrast, red blood cell (RBC), haemoglobin (Hb), and packed cell volume (PCV) were highest in fish fed 1.0 g/100 g, indicating improved oxygen-carrying capacity, erythropoietic activity, and overall physiological condition. These parameters are key indicators of metabolic efficiency and health status in fish, and their enhancement suggests that moderate inclusion improves oxygen transport and supports growth performance (Andriani and Aisyah, 2024; Amjad *et al.*, 2024).

Erythrocyte indices (MCHC, MCH, and MCV) remained within normal physiological ranges across treatments, confirming that dietary supplementation did not induce anaemia or disrupt red blood cell integrity. The observed improvements in erythrocyte characteristics at moderate inclusion levels further indicate enhanced physiological efficiency, while slight reductions at higher inclusion levels suggest mild physiological stress likely associated with increased fibre and anti-nutritional factors. These findings align with Souza *et al.* (2023), who reported improved haematological health in fish fed moderate levels of plant-based additives.

Table 5 Hematological Indices of *C. zill*ii Fed the Experimental Diets

Parameters	**T1(0.0)**	**T2 (0.5)**	**T3 (1.0)**	**T4 (1.5)**	**T5 (2.0)**
WBC ($x10^3/mm^3$)	3.04±0.01^a	4.72±0.06^c	3.65±0.09^b	4.63±0.01^c	5.29±0.08^d
RBC ($x10^3/mm^3$)	2.21±0.06^a	2.51±001^b	2.96±0.01^c	2.87±0.00^c	2.54±0.01^b
Hb (g/100ml)	5.88±0.01^a	6.98±0.58^{ab}	8.07±0.25^d	7.89±0.01^c	7.10±0.07^b
PCV (%)	22.75±0.00^a	23.61±0.42^a	24.98±0.58^c	23.54±0.34^b	24.65±0.53^c
MCHC (%)	25.85±1.21^a	29.56±2.01^b	32.31±0.93^c	33.49±0.64^c	28.80±0.03^b
MCH (pg)	26.61±0.89^a	27.81±2.19^a	27.26±0.31^a	27.49±0.39^c	27.95±0.12^b
MCV (fl)	102.94±2.53^d	94.06±1.15^b	83.83±1.70^a	82.02±1.79^a	97.05±0.32^c

Means in the Same Row with Different Superscripts are Significantly Different at (P<0.05)

- Key: WBC- White Blood Cell, RBC- Red Blood Cell, Hb- Haemoglobin, PCV - Packed Cell Volume, MCHC-Mean Cell Haemoglobin Concentration, MCH-Mean Cell Haemoglobin, MCV- Mean Corpuscular Volume.

- ***Biochemical Profile of C. zillii Fed Experimental Diets***

Table 6 presented the biochemical profile of *C. zillii* and revealed significant alterations in metabolic and immune-related parameters following dietary inclusion of *A. precatorius* leaf meal. Serum glucose and cholesterol levels were highest at moderate inclusion (T3), indicating enhanced carbohydrate and lipid metabolism. These increases suggest improved energy mobilization and metabolic activity, which are essential for growth and physiological performance (Akpan *et al.*, 2023). Total protein levels varied across treatments, with higher values observed at moderate to high inclusion levels. This reflects improved protein synthesis and nutrient assimilation. However, the most balanced metabolic response was observed at moderate inclusion, where growth performance was also optimal. Globulin levels increased at higher inclusion levels, indicating an enhanced immune response likely triggered by bioactive compounds such as flavonoids and saponins (Zuluaga-Hernández *et al.*, 2023). This immunostimulatory effect, however, did not correspond with improved growth, suggesting a trade-off between immune activation and growth efficiency at higher inclusion levels. Albumin levels remained stable across treatments, indicating that liver function and protein homeostasis were not adversely affected by dietary supplementation. Moderate inclusion of *A. precatorius* leaf meal enhanced metabolic efficiency and maintained physiological balance, whereas higher inclusion levels appeared to shift metabolism toward immune stimulation rather than growth promotion. These findings agree with Fawole *et al.* (2023), who reported improved biochemical status in fish fed optimal levels of plant-based feed additives.

Table 6 Biochemical Profile of *C. zillii* Fed Supplemented Diets

Parameters (%)	**T1(0.0)**	**T2 (0.5)**	**T3 (1.0)**	**T4 (1.5)**	**T5 (2.0)**
Glucose (mg/dl)	29.80±1.15[a]	37.28±0.01[ab]	39.47±0.88[c]	32.52±0.10[b]	36.00±0.07[ab]
Cholesterol (mg/dl)	42.00±0.58[b]	40.64±0.32[ab]	44.33±0.15[c]	38.74±1.76[a]	44.09±1.15[c]
Protein (g/dl)	6.59±0.12[a]	7.06±0.07[b]	6.85±0.12[ab]	6.49±0.09[a]	7.60±0.18[c]
Globulin (g/dl)	4.09±0.06[ab]	4.52±0.20[b]	3.76±0.09[a]	4.37±0.18[c]	4.53±0.12[c]
Albumin (g/dl)	3.03±0.09[a]	3.13±0.06[a]	3.06±0.12[a]	3.17±0.11[a]	3.21±0.15[a]

Means in the Same Row with Different Letters are Significantly Different (P<0.05)

➢ *Carcass Composition*

Carcass composition analysis showed that dietary inclusion of *A. precatorius* leaf meal significantly influenced nutrient deposition in *C. zillii* (Table 7) Moisture content remained relatively stable across treatments, indicating that dietary inclusion did not disrupt physiological water balance. Ash content increased with inclusion level, particularly at moderate and high levels, suggesting improved mineral deposition and nutrient availability. Crude protein was highest in fish fed 1.0 g/100 g, indicating enhanced muscle development and protein deposition at moderate inclusion levels. This supports the view that optimal supplementation improves carcass quality and growth efficiency in tilapia, consistent with (Talunga *et al.*, 2024; Adeyemi *et al.*, 2023). Crude lipid content remained within acceptable limits across treatments, indicating efficient energy utilization without excessive fat accumulation. However, nitrogen-free extract decreased with increasing inclusion levels, particularly at moderate supplementation, suggesting a shift from carbohydrate storage toward protein synthesis and tissue growth. At higher inclusion levels, improvements in carcass composition were less consistent, likely due to increased dietary fibre and anti-nutritional compounds that may impair nutrient digestibility and feed efficiency (Patel *et al.*, 2022).

Table 7 Carcass Composition of *C. zillii* Fingerlings fed Experimental Diets.

Parameters (%)	**T1(0.0)**	**T2 (0.5)**	**T3 (1.0)**	**T4 (1.5)**	**T5 (2.0)**
Moisture	7.35±0.08[a]	8.34±0.31[c]	8.23±0.02[c]	7.95±0.09[b]	8.28±0.02[c]
Ash	10.72±0.10[a]	11.93±0.04[b]	12.45±0.04[c]	11.60±0.02[b]	12.64±0.23[c]
Crude protein	55.16±0.07[a]	55.97±0.08[b]	59.62±0.08[c]	57.34±0.26[c]	57.98±0.06[c]
Crude lipid	8.62±0.03[a]	10.03±0.10[d]	8.96±0.06[b]	9.64±0.05[c]	9.53±0.12[c]
NFE	18.15±0.24[d]	13.73±0.28[c]	10.74±0.20[a]	13.47±0.02[c]	11.57±0.11[b]

Mean in the Same Row with Different Superscripts Differ Significantly (P<0.05)

IV. CONCLUSION

This study concludes that *Abrus precatorius* leaf meal can be included at 0.8–1.0 g/100 g in the diet of *C. zillii* to enhance growth performance, nutrient utilisation, and physiological status without adverse effects on health. Its local availability and year-round accessibility make it a cost-effective feed additive for aquaculture. Fish farmers are therefore encouraged to incorporate *A. precatorius* leaf meal into diets at optimal inclusion levels of 0.8–1.0 g/100 g. Future research should focus on evaluating its application across different fish species and refining feeding strategies for improved aquaculture productivity.

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