

DIETARY EFFECTS OF WONDER BERRY (*Solanum Nigrum*) LEAF POWDER IN THE DIET OF *Clarias gariepinus* FINGERLINGS

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ABSTRACT

The dietary effect of *Solanum nigrum* leaf powder on growth performance, body composition, haematology and biochemical parameters were evaluated in *Clarias gariepinus* fingerlings. 225 *C. gariepinus* fingerlings ($6.40 \pm 0.0g$) were fed diets with five concentrations (0, 5, 10, 15, and 20g/Kg) of *S. nigrum* of leaf powder designated as Control, WB₁, WB₂, WB₃, and WB₄ for 56 days. Fish fed the WB₄ diet (20g/kg inclusion) had the highest weight gain ($25.03 \pm 2.66g$) and specific growth rate ($2.84 \pm 0.15g/day$). Proximate composition analysis revealed that WB₄ fed fish had the highest protein content ($67.81 \pm 0.02\%$) and lowest fat ($9.66 \pm 0.01\%$) and ash ($11.69 \pm 0.02\%$) levels. Dietary inclusion of *Solanum nigrum* significantly ($P < 0.05$) affected haematological and biochemical profile of experimental fish. Fish fed WB₃ had the highest haemoglobin Hb ($9.40 \pm 0.70 g/100 ml$) and red blood cells RBC ($3.08 \pm 0.23 \times 10^3/mm^3$). Fish fed diet WB₄ had highest glucose concentration of $51.50 \pm 0.50 mg/dl$. Total protein increased significantly from $3.65 \pm 0.05 g/dl$ in the Control to $5.48 \pm 0.05 g/dl$ in WB₄, suggesting improved protein metabolism. This result suggests that incorporating 20g/kg *Solanum nigrum* dry leaf powder in the diet of *C. gariepinus* fingerlings significantly boosts growth and nutrient utilization, making suitable natural supplement for sustainable aquaculture practices.

Keywords: additive, growth promoter, fish nutrition, ethnobotanicals

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1. | Introduction

Clarias gariepinus is a highly valued aquaculture species based on its fast growth rate, hardiness, and adaptability to various environmental conditions (Adewole, 2020). However, the increasing market demand for *C. gariepinus* has resulted in overuse of synthetic growth promoters and antibiotics in fish feeds, which pose risks such as antibiotic resistance, environmental pollution, and health hazards to consumers (Ogueji *et al.*, 2021).

In recent years, the use of phyto-genic feed additives—bioactive compounds derived from plants has received significant attention due to their potential to improve health and performance without the side effects associated with antibiotics and synthetic growth promoters (Eze and Akinwande, 2020). Among these, *Solanum nigrum*, commonly known as Wonder berry, stands out for its potent antioxidant, antimicrobial and hematopoietic properties (Akinwumi and Omotosho, 2015; Chen *et al.*, 2022).

Solanum nigrum is an underutilized leafy vegetable found in Southern

Africa and some parts of Nigeria. Traditionally, it is used as herbal medication to treat anaemia, infections and inflammation (Olaleye *et al.*, 2021). *S. nigrum* is rich in many bioactive compounds and phytochemicals (Geetha *et al.*, 2024; Alam *et al.*, 2022). Its abundant anthocyanin makes it a suitable antioxidative plant which arrests reactive oxygen and nitrogen species produced during acute liver toxicity (Li *et al.*, 2021). These medicinal properties have been attributed to the various secondary metabolites in the plant (Vásquez-Espinal *et al.*, 2019). The plant contains alkaloids, flavonoids, phenolics and saponins—all of which have been linked to enhanced blood profiles and immune stimulation in animals (Okonkwo *et al.*, 2018). Despite its nutritional and medicinal value, its application in aquafeed particularly as it affects the blood physiology of *C. gariepinus* remains underexplored.

This research evaluated dietary effects of dried *Solanum nigrum* leaf powder in varying inclusion quantity on growth performance, blood serum biochemistry and haematological profiles of *C. gariepinus* fingerlings. The findings from the current study could offer alternative natural approaches to sustainable aquaculture practices.

2. | Materials and Methods

2.1 | *Solanum nigrum* Leaves Collection and Preparation

Fresh leaves of *Solanum nigrum* were bought at a local market at Ara-kale Akure, Ondo State. Leaves were washed thoroughly with clean water to eliminate all contaminants as described by Sutthi *et al.* (2018). They were air-dried indoors at $28 \pm 2^\circ\text{C}$ for 5 days to preserve the phytochemical contents. After drying, the leaves were milled into fine powder with an electric blender and kept in air-tight containers at ambient temperature for further use in the feed formulation.

2.2 | Phytochemical Analysis of *S. nigrum* Powder

The *S. nigrum* dry leaf powder was analysed for bioactive compounds (alkaloids, flavonoids, tannins, and saponins) using standard phytochemical screening methods (Harborne, 2014). Quantification of key compounds was carried out with high-performance liquid chromatography (HPLC, Agilent 1260 Infinity, USA) to identify potential growth-promoting agents, as outlined by Adeyemi *et al.* (2023).

2.3 | Experimental Fish

225 fingerlings of *C. gariepinus* (average weight $6.93 \pm 0.0\text{g}$) were procured from a certified fish hatchery within Akure metropolis. The fingerlings were acclimatized for 14 days and fed with a commercial feed. Apparent healthy fish were stocked into 15 plastic tanks ($50 \times 35 \times 35 \text{ cm}^3$) with 15 fish / tank.

2.4 | Diet Formulation

Five diets (40% Crude protein) were formulated to include varying levels of *S. nigrum* powder as follows: (Control. Diet 1): 0g/kg, Diet 2 (WB₂): 5g/kg of *S. nigrum*, Diet 2 (WB₂): 10g/kg of *S. nigrum*, Diet 3 (WB₃): 15g/kg of *S. nigrum*, Diet 4 (WB₄): 20g/kg of *S. nigrum* (Table 1). *S. nigrum* powder was carefully blended with the dry ingredients, water was added to create a dough, and then fed into a mechanical pelletizer (Hobart A-2007 pelleting and mixing machine, Hobart Ltd, London, UK). The pellets were dried under the sun for 72 hours, packed into air-tight containers, and used throughout the duration of the feeding trial (Ewane *et al.*, 2025).

2.5 | Experimental Set Up

The study was carried out at the Teaching and Research Farm of the Department of Fisheries and Aquaculture Technology, the Federal University

of Technology, Akure (Dada, 2017). A completely randomized design consisting of five treatments was used for the experimental set-up. The inclusion levels of *S. nigrum* are 0.0 (control), 0.5, 1.0, 1.5 and 2.0 g/100 g feed denoted as, Control, WB₁, WB₂, WB₃, and WB₄ respectively. Each experimental diet was fed to five groups of fish in three replicates for 56 days at

5% body weight in three equal meals between 08:00h and 18:00h GMT as described by Dada, (2017). Fish in each experimental unit were batch-weighed (15 fish/tank) fortnightly using top load balance (Metler Toledo, PB 8001 LONDON) according to description by Dada (2017).

Table 1 | Gross and Proximate Compositions of the Experimental Diet

Dietary treatments					
Ingredients	C ₁ (0.0)	WB ₁ (0.5)	WB ₂ (1.0)	WB ₃ (1.5)	WB ₄ (2.0)
Fishmeal (61%)	250	250	250	250	250
Soybean meal (42%)	370	370	370	370	370
Blood meal (81%)	100	100	100	100	100
Maize meal (10%)	130	130	130	130	130
Fish Oil	60	60	60	60	60
Veg. Oil	40	40	40	40	40
Vit/Min Premix*	30	30	30	30	30
Starch	20	20	20	20	20
<i>S. nigrum</i>	0	5	10	15	20
Proximate composition (%)					
Moisture	7.33	8.46	8.50	8.02	9.65
Lipid	20.86	21.22	21.18	20.29	19.30
Fibre	2.06	2.57	3.02	3.80	3.60
CP	40.19	40.20	40.25	40.27	40.29
Ash	6.51	5.38	5.55	6.55	6.72
Carbohydrate	23.05	22.17	21.50	21.07	20.44
GE (Kcal/g) **	5.18	5.18	5.15	5.05	4.93

CP = Crude protein, GE = Gross energy

2.6 | Water Quality Monitoring

Water quality parameters including temperature (Knick portable meter, Model 912), pH (Knick portable meter, Model 912, and dissolved oxygen (Hanna 40SE meter) were monitored twice a week using standard procedures.

2.7 | Assessment of Growth and Feed Utilization

Weighing of fish was done fortnightly (every two weeks) to measure weight. After 8 weeks, all fish were weighed. Growth performance and feed utilization were assessed using the following parameters, as described by Dada (2017):

Weight gain = Final weight – Initial weight

Specific Growth Rate (SGR)(%/day) =
$$\frac{\log \text{ final weight(g)} - \log \text{ initial weight (g)}}{\text{No. of days}} \times 100$$

Feed Conversion Ratio (FCR) =
$$\frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

(Olafusi *et al.*, 2025)

Feed Efficiency Ratio (FER) =
$$\frac{\text{Weight gain (g)}}{\text{Feed intake (g)}}$$

(Olafusi *et al.*, 2025)

Survival (%) =
$$\frac{\text{No of fish at the end of the experiment}}{\text{Total no of fish at the onset of the experiment}}$$

2.8 | Proximate Composition of Experimental Feed and Fish

Proximate analysis of the formulated feed and experimental fish was conducted following AOAC (2016) methods.

2.9 | Haematological Analysis

After 56 days of feeding, three fish were selected randomly from individual tank for blood removal using heparinized syringe from the caudal vein of fish as described by Nandi *et al.* (2026). The collected

blood was analysed for haematological parameters using standard laboratory techniques as described by Svobodova *et al.*, (1991). Serum concentrations of globulin, cholesterol, total protein, glucose, and albumin were determined following the procedures described by Radeka *et al.* (2022).

2.10 | Analysis of Data

Data obtained were analysed with one-way analysis of variance (ANOVA) using Statistical Package for Social Science software (version 23.0). Differences between means were separated using Duncan’s Multiple Range Test (DMRT) at a 5% level of significance (p < 0.05). All results were expressed as mean ± standard error (SE).

3. | Results

The results of water quality parameters during the experimental period are presented in Table 2. There was no significant difference in all the treatments.

The growth performance of *C. gariepinus* fed diets supplemented with different quantity of *S. nigrum* dry leaf for 56 days is presented in Table 3. The results revealed significant differences (P<0.05) across the treatments.

Table 2 | Water Quality Parameters Measured During the Experimental Diet

Parameters	Dietary treatments g/100g <i>Solanum nigrum</i>				
	C ₁ (0.0)	WB ₁ (5)	WB ₂ (10)	WB ₃ (15)	WB ₄ (20)
Temperature (°C)	26.57 ±0.03	26.57±0.03	26.57±0.03	26.73±0.03	26.61±0.05
pH	7.58± 0.02	7.63±0.03	7.64±0.02	7.67±0.01	7.70±0.09
DO ₂ (ml/g)	4.96± 0.12	4.93±0.09	4.97±0.20	4.97±0.18	5.68±0.17

Table 3 | Growth Performance of African Catfish Fed Diets Supplemented with *Solanum nigrum* Dry Leaf

Parameters	C ₁ (0)	WB ₁ (5)	WB ₂ (10)	WB ₃ (15)	WB ₄ (20)
IW (g)	6.40±0.00 ^a	6.40±0.00 ^a	6.40±0.00 ^a	6.40±0.00 ^a	6.40±0.00 ^a
FW (g)	24.08±2.28 ^b	28.20±3.97 ^{cd}	19.81±3.11 ^a	26.71±3.46 ^c	31.43±2.66 ^d
WG (g)	17.68±2.28 ^b	21.80±3.97 ^{cd}	13.41±3.11 ^a	20.31±3.46 ^c	25.03±2.66 ^d
SGR(%/day)	2.37±0.18 ^b	2.65±0.24 ^{bc}	2.02±0.29 ^a	2.55±0.23 ^{bc}	2.84±0.15 ^c
FI (g/fish)	34.29±3.49 ^b	40.72±5.09 ^{cd}	26.50±4.64 ^a	38.94±2.50 ^c	42.45±2.10 ^d
FCR	1.94±0.23 ^c	1.87±0.33 ^{ab}	1.98±0.50 ^d	1.92±0.27 ^c	1.70±0.31 ^a
FER	0.52±0.05 ^a	0.54±0.09 ^{ab}	0.51±0.04 ^a	0.54±0.06 ^{ab}	0.59±0.06 ^b
Survival (%)	53.33±3.85 ^a	46.67±16.78 ^a	33.34±6.67 ^a	35.56±5.88 ^a	24.45±2.22 ^a

Mean in the same row with different letters are significantly different (P<0.05)

The inclusion of powdered *S. nigrum* dry leaf to the diet of *C. gariepinus* fingerlings influenced several haematological indices, as presented in Table 4. Significant difference (P<0.05) was recorded in some of the haematological parameters among

treatments. The highest Hb value was recorded in WB₃ (9.40 ± 0.70 g/100 ml) and the lowest in WB₂ (7.65 ± 0.05 g/100 ml). PCV value recorded the highest value in WB₄ (28.00±2.00%) and the lowest in WB₂ (23.00±0.00%).

Table 4 | Haematological Parameters of *C. gariepinus* Fed Experimental Diets

Parameters	C1 (0.00)	WB1 (05)	WB2 (10)	WB3 (15)	WB4 (20)
Hb (g/100ml)	8.50±0.80 ^{ab}	8.20±0.20 ^{ab}	7.65±0.05 ^a	9.40±0.70 ^c	8.85±0.85 ^b
PCV (%)	25.50±2.50 ^{ab}	24.50±0.50 ^{ab}	23.00±0.00 ^a	28.00±2.00 ^b	28.50±2.50 ^b
WBC (x10 ³ /mm ³)	6.65±1.50 ^{ab}	7.75±0.95 ^b	5.65±0.55 ^a	7.81±0.10 ^b	6.60±1.80 ^{ab}
RBC (x10 ³ /mm ³)	2.80±0.30 ^b	2.68±0.08 ^{ab}	2.50±0.00 ^a	3.08±0.23 ^c	2.90±0.30 ^b
MCV (fl)	91.07±0.84 ^a	91.42±0.70 ^a	92.00±0.00 ^a	90.91±0.16 ^a	98.28±0.84 ^b
MCH (pg)	30.36±0.40 ^a	30.60±0.11 ^a	30.60±0.20 ^a	30.52±0.04 ^a	30.52±0.23 ^a
MCHC (%)	33.33±0.14 ^a	33.47±0.14 ^a	33.26±0.22 ^a	33.57±0.11 ^a	31.05±0.60 ^a

Means in same row with different superscript are significantly different (P<0.05)

The serum biochemistry profile is presented in Table 5. Fish fed diet WB₄ had the highest total protein levels (4.61 ± 0.15 g/dL) and Control had the lowest value (3.22 ± 0.20 g/dL). Albumin levels ranged from 2.30 ± 0.20 g/dL (WB₄) to 1.65 ± 0.05 g/dL (C1). Globulin levels were between 2.26 ± 0.05 g/

dL (WB₄) and 1.35 ± 0.25 g/dL (control). Glucose concentration was highest in WB₄ (51.50 ± 0.50 mg/dL) and lowest in C1 (39.00±1.00 mg/dL). The highest cholesterol level of 64.5 ± 1.50 mg/dL was observed in fish fed diet WB₄ and the least was in WB₂ (42.50±4.50 mg/dL).

Table 5 | Biochemical Profile of *C. gariepinus* Fed on the Experimental Diets for 56 Days

Parameters	Diets				
	C1 (0)	WB ₁ (5)	WB ₂ (10)	WB ₃ (15)	WB ₄ (20)
Glucose (mg/dl)	41.50±3.50 ^b	39.00±1.00 ^a	42.50±7.50 ^b	46.00±5.00 ^{bc}	51.50±0.50 ^c
Total protein (g/dl)	3.65±0.05 ^a	4.00±0.50 ^b	3.75±0.65 ^a	5.35±0.05 ^c	5.48±0.05 ^c
Albumin (g/dl)	2.32±0.05 ^b	2.36±0.75 ^b	1.70±0.50 ^a	2.43±0.05 ^b	3.15±0.05 ^c
Globulin (g/dl)	1.30±0.00 ^a	2.15±0.25 ^b	2.09±0.15 ^b	2.40±0.10 ^c	2.40±0.00 ^c
Cholesterol (mg/dl)	53.50±6.50 ^c	48.00±2.00 ^b	42.50±4.50 ^a	52.00±8.00 ^c	47.00±1.00 ^b

Mean in the same row with different letters are significantly different (P<0.05)

4. | Discussion

Fish fed diet WB₄ treatment (20g/kg inclusion) showed significant growth improvements, suggesting that *S. nigrum* supplementation, particularly at higher levels, enhances growth. The enhanced growth was attributed to higher feed intake and better feed conversion ratio resulting in superior feed efficiency. This result aligns with research on phytogenic additives, where bioactive compounds like alkaloids, flavonoids, and phenolics in *S. nigrum* are known to improve metabolic processes and nutrient absorption (Akubugwo *et al.*, 2007). These improvements result from *S. nigrum*’s bioactive compounds stimulating digestive enzyme activity and improving gut health, thereby enhancing feed digestibility (Citarasu, 2010). This is comparable to findings where phytogenic additives reduce feed transit time and improve nutrient uptake (Gatlin, 2002).

Proximate composition analysis further supports the nutritional benefits of *S. nigrum*. Fish fed WB₄ exhibited the highest protein content (67.81 ± 0.02%) and lowest fat (9.66 ± 0.01%) and ash (11.69±0.02%) levels, indicating enhanced nutrient assimilation. These investigations are consistent with reports of improved body composition in fish fed phytogenic diets, where bioactive compounds like flavonoids enhance protein synthesis or reduce catabolism

(Akubugwo *et al.*, 2007). The reduced fat content in WB₄ suggests efficient energy utilization, a valuable trait for cost-effective aquaculture (Gatlin, 2002).

The overall performance indicates that *S. nigrum* leaf powder at 20g/kg inclusion optimally enhances growth of and feed utilization in African catfish fingerlings.

The elevated Hb values in WB₃ and WB₄ indicate that dietary supplementation with *Solanum nigrum* at 15g/kg and 20g/kg may help to reduce oxidative stress in the fish. According to Ekunwe *et al.* (2020), high Hb levels in fish suggest a boost in respiratory efficiency and resistance to stress.

The PCV values recorded for fish fed diets WB₃ and WB₄ shows oxygen transportation and production of red blood cell was optimal as supported by Ogueji *et al.*, (2021). This aligns with the findings of Gbadamosi and Ugwumba (2013) who reported that dietary plant extracts could stimulate haematopoiesis in fish. The RBC count, an important marker of erythrocyte production, also increased with increasing inclusion of *Solanum nigrum*. The increase in RBC may result from the antioxidant activity of bioactive compounds like flavonoids and saponins present in wonder berry (Akinwumi *et al.*, 2016). The WBC count increased significantly across treatment groups, especially WB1 and WB4,

which supports the idea that *Solanum nigrum* has immune-boosting potential. This corresponds with the results by Tiamiyu *et al.*, (2020) who reported that natural herbal additives increase leukocyte production in fish, thus enhancing immunity and resistance to infections.

The biochemical profiles provide insight into the nutritional, metabolic and health status of fish (Adewolu *et al.*, 2008). Fish fed diets containing WB₄ recorded significantly higher levels of total protein and globulin, which are strong indicators of enhanced immune response and protein metabolism (Eyo *et al.*, 2019).

The increased levels of both albumin and globulin in WB₃ and WB₄ indicate improved liver function, immune response and nutrient assimilation as albumin aids nutrient transport. The protein levels in WB₃ and WB₄ suggest improved protein utilization and synthesis, likely a result of bioactive compounds present in the plant additive that support efficient nutrient metabolism. These results indicate enhanced immune function and better health status in the groups fed *Solanum nigrum*. Adewolu and Adoti (2010) similarly reported that plant-based additives reduce stress indicators in *Clarias gariepinus*. A significant decrease in serum cholesterol in the treated groups indicates the hypocholesterolaemia

effect of *Solanum nigrum*, similar to the findings of Ayoola (2010), who observed that *Moringa oleifera* leaves reduced lipid build up in fish fed herbal-enhanced diets.

Conclusion

S. nigrum dry leaf powder at 20g/kg inclusion level significantly enhances growth and feed utilisation in African catfish fingerlings. The reduced survival rates suggest potential toxicity or stress induced by compounds in wonderberry leaf which might limit its use. The use of wonderberry leaf as a natural growth promoter shows promise but requires optimization to balance growth benefits with fish health.

It can be concluded that dietary inclusion of Wonder Berry (*Solanum nigrum*) dry leaf powder positively influences the haematological and biochemical indices of African catfish fingerlings with marked improvements. Concurrently, stress and liver markers such as glucose, cholesterol, were significantly reduced. These outcomes indicate that *Solanum nigrum* dry leaf powder possesses erythropoietic, immunostimulatory, anti-stress and hepatoprotective properties, making it a viable alternative to synthetic additives in aquafeed.

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