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Growth, Haematogical and Economic Response of *Clarias gariepinus* (Burchell, 1822) Juveniles to Lemon Grass (*Cymbopogon citratus*) as Feed Additive

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Abstract

Concerns over the excessive use of antibiotic growth promoters in animal feeds have prompted the search for substitute medicinal plants which are available, safe, cheap, and optimize growth of food fish. This study investigated the growth performance of *Clarias gariepinus* juveniles (n = 225, 21.25 ± 0.23 g) fed graded levels of lemon grass (*Cymbopogon citratus*) leaf powder as a feed additive. The experiment was conducted in a completely randomized design with 5 treatments, each replicated thrice, using 50 L capacity plastic tanks. The treatment diets included graded levels of lemon grass leaf powder of in the following concentrations: The control diet (T1 = 0.0 g/kg); T2 = 2.0 g/kg; T3 = 4.0 g/kg; T4 = 6.0 g/kg; and T5 = 8.0 g/kg. The stocking density was fifteen fish per tank and they were fed at 5% body weight, twice daily for 60 days. At the end of the feeding trial, blood samples were collected from three fish randomly selected from each replicate for analysis. The water quality parameters were within the expected range for culture of *Clarias gariepinus*. Supplementation of the diets with lemon grass leaf powder significantly ($P < 0.05$) enhanced weight gain and specific growth rate, with the best performance recorded with T5. Survival rate varied from 88.89% ± 3.85% to 95.56% ± 3.85% but was not significantly ($P > 0.05$) different among treatments. Red blood cell count (RBC), white blood cell count (WBC), lymphocytes count, hemoglobin, mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC), were within haematological values recommended for cultured African catfish and were not different (P > 0.05) within treatment except WBC that was significantly lower (P < 0.05) in test ingredient groups compared to the control. Results of economic analysis showed that the Benefit cost ratio (BCR) ranged from 0.41 ± 0.06 in T1 to 1.27 ± 0.06 in T5. Lemon grass leaf powder can be included as feed additives to improve growth performance for *Clarias gariepinus* juveniles. Safe level for inclusion is 2 - 8 g/kg for *Clarias gariepinus* juveniles.

Keywords

Clarias gariepinus, *Cymbopogon citratus*, Feed Additive, Haematological Values, Growth Performance

1. Introduction

Aquaculture is the fastest growing animal production activity in the world. Global aquaculture production reached 122.6 million tones in live weight in 2020 despite the COVID-19 Pandemic [1]. However, this production depends on feeds which constitute about 70% of production cost. Furthermore, there are increasing concerns on the use of antibiotic growth promoters which enhance the effectiveness of fish feed. This is because their use and misuse cause antimicrobial resistance which further raises public health budgets. Consequently, there is a strong interest to search for plant-based growth promoters, which are available, safe, cheap, and optimize growth of food fish. This interest for suitable phytogenic feed additives from medicinal plants has necessitated a trial with lemon grass (*Cymbopogon citratus*).

Several authors have confirmed that lemon grass when incorporated in feeds can confer a wide range of beneficial effects ranging from enhancing growth, nutrient utilization and blood parameters [2]. Supplementing lemon grass (*Cymbopogon citratus*) in the diet of *Clarais gariepinus* has proven to increase growth and blood parameters [2]. However, optimum inclusion level of lemon grass in feed of juvenile of *Clarias gariepinus* is still to be determined. Adebayo *et al.* [2] reported that high inclusion levels (15 g LGM/kg) of lemon grass leaf powder in the diet of *Clarias gariepinus* decreased growth performance and suggested that anti-nutritional factors in the lemon grass leaf may have inhibited nutrient uptake by the fish. They recommended 5 g LGM/Kg for optimum results. However, Adebayo *et al.* [2] had compared inclusion levels with a wide range (0.0 g LGM/Kg, 5 g LGM/Kg, 10 g LGM/Kg, 15 g LGM/Kg and 20 g LGM/Kg). The actual optimum level could therefore be below 5 g LGM/Kg or above 5 g LGM/Kg. The above observations necessitate a feeding trial of lemongrass powder for *Clarias gariepinus* at levels of inclusion below 10 g LGM/Kg to verify how close the optimal level of inclusion is to 5 g LGM/Kg.

Cymbopogon citratus commonly known as Lemon grass is a perennial grass belonging to the grass family Poaceae (true grasses) [3]. It is a fast-growing, lemon-scented grass reaching a height of 1 m with bluish-green leaves [4]. *Cymbopogon citratus* has been used in the treatment of flu diseases in human due to its antimicrobial properties. It has been used in poultry and livestock to improve their performance [5]-[7].

Increasing interest in farming *Clarias gariepinus* is linked to improvements in its artificial reproduction techniques, and its acceptability by both consumers and fish farmers. These advantages are additive to the basic beneficial characteristics of *C. gariepinus,* which include fast growth and high market demand [8]. However, one of the challenges faced by *C. gariepinus* farming is access to quality feeds for fry and juveniles [9]. Despite the challenges, catfish farming offers strong potential to meet local fish demand among the cultivable fish species. This is because it contributes to reducing importation, provides employment, alleviates poverty and helps to meet the millennium development goals [10].

2. Methodology

2.1. Collection and Processing of *Cymbopogon citratus*

Cymbopogon citratus leaves were obtained from plots around the faculty of Agriculture and Veterinary Medicine Teaching and Research Farm (FAVM-TRF) in the University of Buea, Cameroon. The fresh leaves were air dried at room temperature in a green house and milled to a fine powder using electric blender (BL-500). The powdered leaves were packaged in air tight glass jar then stored at room temperature prior to use.

2.2. Experimental Ingredients and Formulation of Diets

Graded amounts of the lemongrass powder were incorporated into five iso-calorific and iso nitrogenous diets used for the experiment (**Table 1**). The amounts mixed in 1000 g of a basal diet to constitute and treatment diets were: T1 (control) = 0 g, T2 = 2.0 g, T3 = 4.0, T4 = 6.0 g, mT5 = 0.8. The basal diet was (40% crude protein), comprising maize, soybeans cake, fishmeal, groundnut cake, fish oil, corn starch, DCP, methionine, lysine and vitamin premix formulated according to Fagbenro and Adebayo [11]. The ingredients were thoroughly mixed in with a wooden pestle to obtain a homogenous mass and corn starch added as a binder. The resulting mash was then passed through a pelleting machine with 4 mm die. The pellets were air-dried and packed in air tight containers. The diets were analyzed for proximate composition, including crude protein, crude lipid, crude fiber, ash and moisture as described by AOAC [12].

2.3. Experimental Procedure

Fifteen plastic tanks of 50-litre capacity, each three quarter filled with water, were aerated continuously using an air compressor. Two hundred and twenty five farm-raised *C. gariepinus* juveniles (21.25 ± 0.23 g) were acclimated to laboratory conditions for 14 days at the Fisheries Laboratory in Faculty of Agriculture and Veterinary Medicine Teaching and Research Farm (FAVM-TRF), University of Buea, before being distributed randomly into the 15 tanks which served as experimental units in a completely randomized design experiment. There were five treatments and each was replicated thrice at a stocking density of 15 fish per tank. The five treatments included a control and four test diets which had graded levels of Lemon grass meal powder. The treatments were labeled T1 (control = 0 g) T2 = 2.0 g, T3 = 4.0 g, T4 = 6.0 g and T5 = 8.0 g. Fish were fed at 5% of their body weight (bw) per day in two equal meals. A four stage procedure was used for randomization of the fingerlings to the various experimental units. First the 15 experimental units were placed properly on the tables with functional aerators and aerator stones. Then hand written labels indicating the treatment and the replicate number (which had been folded) were randomly drawn from a hat and assigned to each of the 15 units. The acclimatized fingerlings were pooled into one aerated tank, from which 5 fingerlings were scooped, weighed individually and placed in each experimental units. The scooping of 5 fingerlings was done 3 times to reduce scooping bias and eventually place 15 fingerlings per experimental unit. All fish were weighed and counted fortnightly and feeding rates were adjusted accordingly. The daily ration was divided into five equal parts and fed at specific periods during the day (9.00 am, 11.30 am, 2.00 pm, 4.30 pm and 7.00 pm). However, when an electrical failure lasting more than one hour just before feeding, that portion of the daily ration was carried over to the next feeding period and the amounts for the remaining feed period of the day readjusted accordingly. The experiment lasted for 60 days.

2.4. Water Quality Assessment

Sixty percent of all the water in the aquaria was siphoned daily every morning from 6.00 am to 8.30 am and replaced with fresh water previously stored for 24 hrs at room temperature in drums within the laboratory. Every Sunday all the water in the experimental tanks was removed, the tanks washed thoroughly and disinfested with virunet. The water source was the spring water meant to serve the university community for agricultural, domestic and research purposes. It was usually not chlorinated. However, the main catchment tank was washed once every Monday. Preliminary measurements of water quality before start of the experiment showed that nitrite was not detectable. The water quality parameters such as dissolved oxygen, temperature and pH were observed before the first feeding ration of the day. Dissolved oxygen and temperature was measured using DO meter (DO9100) in mg/l and ˚C units respectively while pH was measured using a pen type pH meter (pH-009 111).

2.5. Growth Parameters Measured

The following growth and feed utilization indices were calculated: weight gain (WG), specific growth rate (SGR), food conversion ratio (FCR) and survival. The formulae used were as follows:

Weight gain (WG) = final average weight (g) − initial average weight (g);

Specific growth rate, SGR (% d − 1) = 100 × (ln Wt − ln W0)/t

where Wt and W0 represent final and initial body weights of fish, respectively, and t represents the duration of the feeding trial;

FCR = dry weight of feed (g)/wet weight gain by fish (g)

Survival (%) = number of surviving fish/initial number of fish stocked × 100

Table 1. Composition of experimental diets (g/100 g feed) for *Clarias gariepinus* Juveniles.

Ingredient	T1	T2	T3	T4	T5
Maize (9.23%)	21	20.8	20.6	20.4	20.2
Soybean meal (44.60%)	42.3	42.3	42.3	42.3	42.3
Groundnut cake (42.00%)	2	2	2	2	2
Lemon grass (*C. citratus*) leaf powder (3.94%)	0	0.2	0.4	0.6	0.8
Fishmeal (62.6%)	29	29	29	29	29
Fish Oil	0.5	0.5	0.5	0.5	0.5
Diacalcium phosphate	1	1	1	1	1
Corn Starch (binder)	2	2	2	2	2
Methonine	0.1	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Premix*	2	2	2	2	2
	100	100	100	100	100
Proximate Analysis					
Crude Protein	40.05	40.06	40.06	40.07	40.07
Ether Extract	11.68	11.52	11.49	11.44	11.21
Crude Fibre	2.13	2.41	2.68	2.83	2.97
Ash	8.03	8.31	8.53	8.68	8.83
Moisture	11.1	10.8	11.2	10.3	10.1
Nitrogen Free Extract	27.01	26.9	26.04	26.69	26.82
Energy (Kcal/g)	312.25	311.95	311.65	311.35	311.05

*Premix: composed (mg vitamin and mineral/kg premix): vitamin A 4,800,000 IU, vitamin D_3 800,000 IU, vitamin E4800 mg, vitamin K 800 mg, thiamine 600 mg, riboflavin 2800 mg, vitamin B_3 4800 mg, pyridoxine 600 mg, vitamin B_{12} 4 mg, folic acid 200 mg, cobalt 160 mg, copper 1200 mg, iron 9000 mg, iodine 480 mg, magnesium 2730 mg, manganese 28,000 mg, zinc 20,000 mg.

2.6. Haematological Analysis

At the end of feeding trial haematological studies was carried out on the fishes. Blood samples of about 2.0 ml were collected from three fish randomly selected from each replicate in all the treatments. Blood was collected from the caudal peduncle with heparinized plastic syringe, fitted with hypodermic needle and preserved in dipotassium salt of ethylene-diaminetetraacetic acid (EDTA) bottles for analysis. The Haemoglobin concentration (HB), Red Blood Cell (RBC), White Blood Cell (WBC) count, Mean Corpular volume (MCV) Mean Corpular Heamoglobin (MCH), Mean Corpular Heamoglobin Concentration (MCHC) Platelets (PLT) and Lymphocides (LYM), were determined in the haematology laboratory at MAFLEKUMEN Tiko, Cameroon using 5-part differential Haematology Autoanalyzer (Mindray BC 5300 model).

2.7. Economic Evaluation of Experimental Diets

The cost of feed and fish were the economic criteria under consideration in this study and were based on the current market cost of feed ingredients and market value of a kilogram of fresh fish in Buea, Cameroon at the time of the experiment. The economic evaluations in terms of Cost of feed consumed (CFC), Total investment cost (TIC), Value of fish produced (VF), Incidence Cost (IC), Profit Index (PI) and Benefit Cost Ratio (BCR) were calculated as follows:

Cost of feed consumed (CFC) = Feed cost × Feed intake

Total investment cost (TIC) = Cost of feed + cost of juveniles stocked

Value of fish produced (VF) = Cost of fish × Weight gained

Incidence Cost (IC) or Economic conversion ratio (ECR) = FCR × Cost of Feed

Profit Index (PI) = VF/TCF

Benefit Cost Ratio (BCR) = VF/TIC

2.8. Statistical Analysis

Data were entered into spreadsheets using Microsoft Excel and analyzed using SPSS version 22 software package. These were then used to estimate descriptive parameters like the means, the standard errors of the mean and statistical differences between group means, as well as one-way analysis of variance (ANOVA). Shapiro-Wilk test for normality and Levene's test for homogeneity of variances were used to test whether the data meets the assumptions of ANOVA. When the result was significant, the Turkey's post hoc test was used for multiple comparison. Significant levels were measured at 95% confidence threshold.

3. Results

3.1. Water Quality Parameters

The water quality parameters investigated in this study are presented in Table 2. The pH value ranged from 7.49 ± 0.41 in T3, to 7.66 ± 0.51 in T4. Temperature ranged from 26.2˚C ± 0.24˚C to 26.41˚C ± 0.41˚C in T5, while Dissolved oxygen (DO) ranged from 3.91 ± 0.47 mg/l in T5 to 4.23 ± 0.34 mg/L in T2.The highest Ammonia (NH_3) concentration (5.67 ppm) was recorded in T4 while the highest Nitrate concentration (NO_3^-) was obtained in T5.

Table 2. Water quality parameters of experimental tanks during the experimental period.

	Treatments				
Parameters	**T1**	**T2**	**T3**	**T4**	**T5**
Temperature (˚C)	26.23 ± 0.42	26.26 ± 0.34	26.2 ± 0.24	26.29 ± 0.42	26.41 ± 0.41
pH	7.58 ± 0.44	7.54 ± 0.44	7.49 ± 0.41	7.66 ± 0.51	7.57 ± 0.42
DO (mg/L)	4.16 ± 0.49	4.23 ± 0.34	3.94 ± 0.32	3.95 ± 0.49	3.91 ± 0.47
Ammonia (mg/L)	5.67 ± 2.06	5 ± 1.81	5.33 ± 1.97	5.67 ± 2.06	5 ± 1.81
Nitrites (mg/L)	5.42 ± 3.96	6.67 ± 4.44	5 ± 3.69	6.25 ± 4.33	7.92 ± 2.57

Key: DO = Dissolved oxygen, pH = hydrogen ions concentration.

3.2. Proximate Composition of the Experimental Feeds

The results of proximate analysis of the experimental diet is presented in **Table 3**. Crude protein content was similar amongst treatments with the highest crude protein (C. P) (41.99%) in T1 and lowest value (40.06%) in T5. T5 (5.24%) registered the highest crude fiber while lowest was registered in T1 (4.24%). The highest moisture content was recorded in T4 (11.61%) while the lowest was obtained in T2 (10.40%). The Dry matter ranged from 88.39% in T4 to 89.60% in T1.

Table 3. Proximate composition of dietary feed ingredients with varying inclusion level of lemon grass meal.

	Treatments					
Parameters	T1	T2	T3	T4	T5	LGM
Moisture	10.40	10.55	11.27	11.61	11.39	9.60
CP	41.99	40.09	40.12	40.15	40.06	3.94
CF	4.24	4.98	5.10	5.10	5.24	21.93
EE	16.84	11.87	11.30	11.24	11.27	5.54
Ash	10.32	10.27	10.75	10.81	10.83	7.34
DM	89.60	89.46	88.73	88.39	88.64	90.40
Organic matter	89.68	89.25	89.56	89.64	89.73	92.41

Key: CP = Crude protein, CF = Crude fiber, EE = Ether extract, DM = Dry matter, LGM = Lemon grass meal.

3.3. Growth Performance and Nutrient Utilization of *C. gariepinus* Fed Experimental Diet

The results on growth performance of *C. gariepinus* fed with varying inclusion of lemon grass showed significant difference in the Mean final weight (MFW) with T5 recording the highest value (128.14 ± 4.04 g) while the lowest value was recorded in the control −T1 (87.34 ± 1.34 g) (**Table 4**). The Mean weight gain (MWG), Relative growth rate (RGR) and Specific growth rate (SGR) increase with increase significantly with increased level of LGM across the treatments. However, feed conversion ratio (FCR) ranged from 1.13 ± 0.04 to 1.26 ± 0.06 and was not significantly different (P > 0.05) amongst the treatments. The Survival rate was very high (88.89 ± 3.85 in T1 to 95.56% ± 3.85% in T5) and was not significantly different (P > 0.05) amongst treatments.

Table 4. Growth performance and Nutrients Utilization of *Clarias gariepinus* juveniles fed different levels of *Cymbopogon citratus* leaf meal.

Parameters	Treatments				
	T1 (0.0 g/kg LGM)	T2 (2 g/kg LGM)	T3 (4 g/kg LGM)	T4 (6 g/kg LGM)	T5 (8 g/kg LGM)
IW (g)	316.67 ± 3.51	315 ± 3	316.67 ± 2.08	315.33 ± 4.73	314.67 ± 3.51
MIW (g)	21.11 ± 0.23	21 ± 0.2	21.11 ± 0.14	21.02 ± 0.32	20.98 ± 0.23
FW (g)	1165 ± 68.51^{a}	1178.67 ± 53.53^{a}	1268.67 ± 131.15^{a}	1328 ± 110.53^{a}	1835.33 ± 37.07^{b}
MFW (g)	87.34 ± 1.34^{a}	88.4 ± 1.15^{a}	92.74 ± 1.72^{ab}	97.19 ± 2.30^{b}	128.14 ± 4.04^{c}
MWG (g)	66.23 ± 1.13^{a}	67.4 ± 1.07^{a}	71.62 ± 1.58^{ab}	76.17 ± 2.2^{b}	107.16 ± 3.81^{c}
RGR (%)	313.69 ± 2.79^{a}	320.96 ± 5.02^{ab}	339.25 ± 5.23^{b}	362.36 ± 10.49^{c}	510.74 ± 12.49^{d}
SGR (%)	2.37 ± 0.01^{a}	2.4 ± 0.02^{ab}	2.47 ± 0.02^{b}	2.55 ± 0.04^{c}	3.02 ± 0.03^{d}
FI (gfish^{-1})	1063.67 ± 34.78^{a}	1170.67 ± 44.74^{ab}	1250.33 ± 50.72^{b}	1334.33 ± 72.11^{cb}	1713 ± 20.66^{d}
WG (g)	848.33 ± 65.55^{a}	863.67 ± 55.64^{a}	952 ± 129.12^{a}	1012.67 ± 114.74^{a}	1520.67 ± 38.03^{b}
FCR	1.26 ± 0.06	1.36 ± 0.08	1.33 ± 0.15	1.33 ± 0.14	1.13 ± 0.04
Survival (%)	88.89 ± 3.85	88.89 ± 3.85	91.11 ± 7.7	91.11 ± 7.7	95.56 ± 3.85

Mean Values ± Standard Deviation with different superscripts a, b, c are significantly different (P ≤ 0.05) (superscripts a, b, c indicate difference significance); Key: IW = Initial weight, MIW = Mean initial weight, FW = final weight, MFW = Mean final weight, MWG = Mean weight gain, RGR = Relative growth rate, SGR = Specific growth rate, FI = Feed intake, WG = Weight gain, FCR = Feed conversion ratio.

3.4. Haematological Parameters of *C. gariepinus* Fed Experimental Diet

The haematological indices of *C. gariepinus* juveniles fed different levels of Lemon grass (*Cymbopogon citratus*) Leaf meal in this study are shown in Table 5. The recorded values of White blood cell (WBC) from group of fish fed with 0.0% *C. citratus* were significantly higher (P < 0.05) than the groups treated with lemon grass inclusion. The platelets (PLT) values in this study ranged from 17.33 ± 0.58 in T1 to 21 ± 1 × 10^9 L^{-1} in T4 with no significant difference in T1, T2, T3 and T5. The results recorded for Lymphocytes %, Red blood cell, haemoglobin, mean cell volume, mean cell haemoglobin and mean cell haemoglobin concentration were not significantly different among the various treatments.

3.5. Cost Analysis for Economic Efficiency

The results of cost benefit analysis of culture of C. *gariepinus* juveniles using lemon grass-based diet are presented in Table 6. The Lowest Incidence cost (IC) was registered in T5 (1.31 ± 0.04) while T4 registered highest value (1.51 ± 0.16). The Profit index (PI) ranged from 1.47 ± 0.18 in T2 to 2.90 ± 0.38 in T5 while

Benefit cost ratio (BCR) ranged from 0.41 ± 0.06 in T1 to 1.27 ± 0.06 in T5.

Table 5. Haematological indices of *C. gariepinus* juveniles fed different levels of Lemon grass (*Cymbopogon citratus*) Leaf meal.

Parameters	T1	T2	T3	T4	T5
HB (×10⁹/l)	8.8 ± 0.2	9.6 ± 0.36	9.57 ± 0.4	9.5 ± 0.57	9.37 ± 0.47
RBC ($\times 10^{12}$/L)	2.46 ± 0.18	2.59 ± 0.14	2.42 ± 0.11	2.55 ± 0.14	2.47 ± 0.21
WBC ($\times 10^{9}$/l)	26.66 ± 1.34^{a}	21.4 ± 1.24^{b}	20.8 ± 1.06^{b}	21.2 ± 2.22^{b}	22 ± 1.24^{b}
MCV (fl)	128.63 ± 4.29	128.73 ± 2.12	123.63 ± 5.1	126 ± 1.63	127.23 ± 5.34
MCH (pg)	39.13 ± 0.64	37.1 ± 0.62	36.87 ± 1.63	37.23 ± 0.45	37.5 ± 0.72
MCHC (g/l)	30.37 ± 1	28.83 ± 0.38	29.87 ± 0.55	29.6 ± 0.10	29.57 ± 1.18
PLT ($\times 10^{9}$/L)	17.33 ± 0.58^{a}	19 ± 1^{ab}	20.33 ± 1.15^{a}	21 ± 1^{cb}	19.33 ± 1.53^{ab}
LYM (%)	91.53 ± 0.67	90.53 ± 3.12	90.33 ± 0.4	89.3 ± 1.04	91.67 ± 0.95

Mean Values ± Standard Deviation with different superscripts a, b, c are significantly different (P ≤ 0.05); HB = Haemoglobin; RBC = Red blood cells; WBC = White Blood Cells; MCV = Mean cell volume, MCH = Mean corpuscular haemoglobin, MCHC = Mean corpuscular haemoglobin concentration PLT = Platelets, LYM = Lymphocytes.

Table 6. Cost implications of feeding *C. gariepinus* juveniles different levels of Lemon grass (*Cymbopogon citratus*) based diets for 60 days.

Ingredient	Treatment				
	T1	T2	T3	T4	T5
Feed cost (FCFA/g)	0.418 ± 0	0.418 ± 0	0.418 ± 0	0.419 ± 0	0.419 ± 0
CFC (FCFA/g)	9.87 ± 0.04	9.88 ± 0.76	9.89 ± 0.55	9.89 ± 0.21	9.90 ± 0.07
TIC per juvenile (FCFA)	209.87 ± 0	209.88 ± 0	209.89 ± 0	209.89 ± 0	209.90 ± 0
VF (FCFA/g)	165.58 ± 0	168.50 ± 0	179.05 ± 0	190.43 ± 0	267.90 ± 0
IC (ECR)	0.53 ± 0.06	0.57 ± 0.06	0.56 ± 0.06	0.56 ± 0.06	0.47 ± 0.06
PI	16.77 ± 0.02	17.05 ± 0.18	18.11 ± 0.42	19.25 ± 0.38	27.06 ± 0.38
BCR	0.79 ± 0.06^{a}	0.80 ± 0.05^{a}	0.85 ± 0.14^{a}	0.91 ± 0.13^{a}	1.28 ± 0.06^{b}

Mean Values ± Standard Deviation with different superscripts a, b, are significantly different (P ≤ 0.05); Key: FC = Feed cost; CFC = Cost of feed consumed; TIC = Total investment cost; VF = Value of fish; IC = Incidence Cost; ECR =Economic conversion ratio; PI = Profit index; BCR = Benefit cost ratio. Cost of 1 juvenile = 200, FCFA; Value of 1 kg fish = 2500 FCFA; Cost of 1 Kg Maize = 200 FCFA, 1 Kg Soybean Meal (44.6%) = 400 FCFA; 1 Kg Groundnut cake (42%) = 390 FCFA 1 kg Lemon grass leaf Powder (11.2%) = 350 FCFA; 1 Fishmeal (62.6%) = 500 FCFA; 1 kg Fish oil = 500; 1 Kg Diacalcium Phosphate = 300; 1 Kg Corn starch = 300, I Kg Methionine = 1400 FCFA; ! Kg Lysine = 800 FCFA; I Kg Premix = 2000 FCFA; 1 USD = 500 FCFA.

4. Discussion

The range dissolved oxygen, temperature, pH, falls within the ranges reported by Ndimele and Owodeinde [13] as the best for tropical fishes. This may indicate that the water quality parameters in the present study were not affected by the diet.

The moisture level of the lemon grass powder was found to be 9.60%. Moisture content is among the most vital and mostly used measurement in the processing, preservation and storage of food. So the results support the practice of storage of the leaves in dehydrated form as the low moisture content of these leaves will prevent microbial attack and allow high storage capacity.

The crude fibre obtained from lemon grass was 21.93% which is comparatively lower than the 26.52% reported by Adebayo *et al.* [2]. Crude fiber content increased from T1 to T5 this is due to the increase inclusion level of *C. citratus* in the diet of catfish. According to De Silva and Anderson [14], fiber content in the diet of fish should not exceed 8% - 12% as increase in fiber content would consequently lead to the decrease of the quantity of a usable nutrient in the diet, which may lead to in poor performance. The value (4.24% - 5.24%) obtained in this study falls within the recommended range. All the experimental diets were accepted by the fish which showed that the inclusion level of *C. citratus* meal in the diets had no adverse effect on the palatability of the diets. Weight gain and specific growth rate are usually considered in aquaculture as the most important measurement of productivity of diets. There was increase in Mean weight gained (MWG), and specific growth rate (SGR) of the experimental fish as the inclusion level of *C. citratus* increased across diets. The best growth performance and feed utilization in this study was obtained at highest inclusion level (LGM 8.0 g/kg) in T5. Adeniyi [15] in a similar study, showed that dietary LGM above 10 g/kg reduced growth performance of *C. gariepinus* fed *C. citratus* based diet and suggested that *C. citratus* contains bioactive phyto-components and has proven to have antimicrobial activity, which might have induced the growth of beneficial gut microflora and the digestibility of nutrients resulting in enhanced growth and nutrient utilization. Haemoglobin levels 8.8 ± 0.2 to 9.6 ± 0.36 g/dl observed in this study were within the normal range reported by Omitoyin [16]. Haemoglobin has the physiological function of transporting oxygen to tissues of the animal for oxidation of ingested food so as to release energy for the other body functions as well as transport carbon dioxide out of the body of animals [17]. It is major and reliable indicator of various sources of stress [18] and is found to decrease in the presence of anti-nutritional factors [19]. In this study, no significant difference in Hb concentration was observed between the control and fish fed *C. citratus* feed base. The results of White blood cells (WBC) recorded in this experiment ranged from 20.8 ± 1.06 to 22 ± 1.24 × 10^9/l among the group of fish fed *C. citatus* with the group containing 8 g/kg inclusion level of *C. citratus* recording highest value of WBC. However, the values observed were significantly lower compared to the control group with 0.0% *C. citratus*. The lymphocyte count recorded ranged from 89.3% ± 1.04% to 91.67% ± 0.95% with highest value observed in the control group and in the group fed 0.8% *C. citratus*. White blood cells (WBC) and lymphocytes are reported to be the defense cells of the body [20]. Douglas and Jane [21] demonstrated that the amount present in the body of an animal has implication in immune responses and the ability of the animal to fight infection. High WBC count is usually associated with microbial infection or the presence of foreign body or antigen in the circulating system [22]. Lower values of WBC in treated groups as compared to the control could be an indication of reduced metabolic stress since these lower values are accompanied by improved growth rate and feed conversion ratio. The aquarium of environment contains a lot of bacteria, fungi and other parasites since un-chlorinated water was used in this experiment. Infections by microbes and parasites in the natural aquarium environment are bound to increase white blood cell count [23] and therefore metabolic stress in all experimental groups. A lower WBC count in the *C. citratus* treated groups. would indeed be indicative of a health benefit, suggesting the treatment has reduced chronic stress or inflammatory burdens on the fish, allowing their immune system to operate more efficiently without needing to maintain a high state of alert. In other words, it could be explained that *C. citratus* added to the feed is not toxic but reduces exposure of fish to indigenous waterborne infections and stress. This Health benefit of *C. citratus* to fish is confirmed by Duarte da Silva *et al.* [24].

Inclusion of lemon grass meal powder in the diets of *C. gariepinus* in this study reduced the incidence of cost (IC), while Profit index (PI) and Benefit cost ratio (BCR) were increased. Incidence of cost (IC) is also known as the economic conversion ratio (ECR). It indicates the cost of feed for producing 1 kg of fish flesh: hence, the lower the value of ECR, the better for productivity. Incidence of cost is lowest at the inclusion level of 8 g/kg (T5) while the BCR is more than 1 at the same inclusion levels of 8 g/kg diet. This is indicating profitability of the investment in the production of *C. gariepinus* at these levels. El-Dakar *et al.* [25] obtained similar results on incidence cost and profit index of hybrid tilapia fed diets incorporated with basil leaf powder compared to the control fish. Improved economic efficiency in the production of *C. gariepinus* fed with diets treated with onion and walnut leaf has also been reported by [26].

5. Conclusion

It could be concluded that Lemon grass (*Cymbopogon citratus*) stimulated nutrient utilization and consequently enhanced the growth performance, survival rate, haematological profile and economic productivity of *Clarias gariepinus* juveniles. Inclusion of lemon grass in the diet of *Clarias gariepinus* will minimize the dependence on synthetic growth promoters, reduce exposure of fish to indigenous waterborne infections and stress and reduce the cost of feeding of fish since it is cheap and readily available. Therefore, 8 g of Lemon grass per kg diet is recommended for optimum growth performance and economic efficiency of *Clarias gariepinus* production.

6. Ethics Approval

This study was approved by the University of Buea Institutional Animal Care and Use Committee (UB-IACUC).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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