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Research Article

Growth and Economic Performance of *Clarias gariepinus* Fingerlings Fed Diets Containing Processed *Mucuna pruriens* Seed Meal

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ABSTRACT

This study was conducted to evaluate the growth and profitability of *Clarias gariepinus* fingerlings fed a diet containing *Mucuna* Seed Meal (MSM). Fingerlings (300) weighing 6.58 ± 1.42 g were randomly stocked in triplicate in 12 hapas (0.5 m × 0.5 m × 1 m) and fed for 56 days on four isoprotein diets at a feeding rate of 10-4%. The first triplicate was fed the control diet (D0) containing 0% MSM, while the other three were fed the experimental diets D30, D40 and D50 in which processed MSM was included at 30%, 40% and 50%. Control fisheries were performed bi-weekly for total counting and taken measurements. The results obtained indicate that growth performance and body composition of fish fed the experimental diets were significantly improved depending to the inclusion level compared to control diet. Diet D50 induced a Weight Gain (WG) of 93. 89 ± 0.17 g, a Specific Growth Rate (SGR) of 4.87 ± 0.01%/day, and a Feed Conversion Ratio (FCR) of 0. 97 ± 0. 02; with significant variations of 26.22 ± 1.15%, 10.27 ± 0.56%, and 24.23 ± 1.30% respectively compared to WG (69.28 ± 0.97 g), SGR (4.36 ± 0.02%/day), and FCR (1.28 ± 0.01) obtained with diet D0. In addition, the whole body composition of pre-adult fish produced with diet D50 was significantly different compared to D0, with nutrient retention (protein=53.92 ± 0.12%, lipid=32.85 ± 0.14%, ash=40.29 ± 0.17 and energy=31.50 ± 0.13%) significantly higher compared to D0 (protein=34.38 ± 0.04%, lipid=29.95 ± 0.01%, ash=29.56 ± 1.86% and energy=21.57 ± 0.11%). Fish fed diet D50 also produced a net return of 12,648.02 XAF, 21.38% higher than the control (9,943.23 XAF). In conclusion, dietary inclusion of 50% MSM gave the best results in terms of fish somatic growth and cost-benefit analysis.

Keywords: Fish wealth; *Mucuna* seeds; Isoprotein; Velvet bean; *Clarias gariepinus* fingerlings; Aquaculture

INTRODUCTION

Fish is one of the most consumed sources of animal protein in Cameroon. Most of the fish consumed comes from imports, while the country possess about 450 km of coastline whose waterways known to harbour immense fish wealth are 80% invaded by foreign fishermen, who divert a good part of the national production of about 326,079 tonnes, coming from fishing to feed the supply circuits towards their countries. Hence, only a tiny part is intended for the local market. To meet the consumption needs of an ever-growing population, the Cameroonian government through its Ministry of Livestock, Fisheries and Animal Industries, issued in 2021 to the various local economic operators 34 technical opinions for the import fishery products, for an overall quota of 249,857 tonnes; corresponding to about 167 billion XAF. In order to reduce fish imports, the government through several facilitation measures such as the non-payment of customs fees for agro-pastoral equipment as well as certain taxes, encourages private investors, both national and foreign, to set up projects commercial and profitable aquaculture in Cameroon. These measures seem to be bearing fruit with a slight increase in aquaculture production which increased from 9,078 tonnes in 2020 to 93,000 tonnes in 2021 with African catfish (*Clarias gariepinus*) as the dominant species. However, aquaculture production still faces a number of challenges, notably the lack of high-quality, low-cost, locally produced feeds that meets the nutritional requirements of the species. Feed, being the most expensive input in fish culture operations, accounts for about 70% of the production cost [1,2]. The high cost of fish feeds is due to the inclusion of fish meal known as the main quality protein source and the most expensive component of fish feed, constituting 40-60% of fish feed production cost [3]. Conventionally, fish meal has been considered to be the major and essential ingredient in fish feed because of its high contents of essential nutrients with balanced

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in amino acid profile and a variety of vitamins and minerals, all necessary for fish healthy growth in captivity [4,5]. In order to reduce the cost of producing fish feed, due to the high cost of fishmeal, without compromising the nutritional quality of the feed, several studies have been carried out to replace fishmeal with other sources of protein or to incorporate non-conventional ingredients, including plant proteins that are not in direct competition with human food. Although plant proteins, particularly those from the leguminous seeds such as lima bean, have been proven to be good candidates for partial replacing fishmeal in the growth diets of *Cyprinus carpio* as well as *Clarias gariepinus* and *Oreochromis niloticus* the main drawback, which is the presence of anti-nutritional factors, can fortunately be reduced to a tolerable limit by using one or a combination of several processing techniques to improve their nutritional value [6-9].

Velvet bean, *Mucuna pruriens* (Fabaceae) is an underutilized legume species that grow naturally everywhere in Cameroon. Biochemical analyses revealed that it contain a high level of crude protein up to 32%, carbohydrates (60.0%), lipid (2.7%) vitamins and minerals which makes it a suitable alternative plant protein source in fish feed [10]. However, the seed coat of *Mucuna pruriens* contains high levels of anti-nutritional factors such as tannin, haemoglutinin, cyanide, trypsin inhibitors and the most important being Levodopa or dihydroxyphenylalanine (DOPA), behenic acid and lectins which limit its use in human nutrition and animal feed [11-13]. However, inactivation or removal of these antinutritional factors by adopting economically viable processing techniques are required to improve the nutritional quality of *mucuna* seeds to its full potential as food. The physical and biochemical processing methods used being soaking, cooking, selective filtration, irradiation, enzymatic treatments, germination and fermentation [14]. Previous studies revealed that processed *mucuna* seeds has been used with success in the diet of broilers and laying birds [15]. In fish nutrition, many studies reported its nutritional potential as ingredient able to substitute efficiently fish meal or other major ingredient in fish feed [16-19].

The present study was therefore conducted to evaluate the growth performance, feed nutrient utilization and retention, as well as whole body bromatological composition and economic efficiency of *Clarias gariepinus* fingerlings fed on different dietary inclusion levels of *mucuna* seed meal.

MATERIAL AND METHODS

Study area and Experimental facility

The study was carried out from April to July 2020, in the technical installations of the laboratory of Fisheries Resources, Department of Aquaculture, Institute of Fisheries and Aquatic Sciences at Yabassi. A total of 330 *Clarias gariepinus* fingerlings of 6.58 ± 1.42 g weight and of 9 ± 0.58 cm total length were purchased from a private fish farm and acclimatized for 7 days. Thirty (30) fingerlings were set aside for the initial whole body biochemical analysis and the others (300) were randomly distributed in 12 hapas (0.5 m × 0.5 m × 1 m, L:W:H and mesh: 1 mm) installed in a pond of 80 m^2.

Mucuna seeds procurement and processing

Mature fresh *mucuna* seeds were harvested in April 2020 in Yabassi in the littoral region of Cameroon. A set of *mucuna* seeds (300 g) was soaked in warm water for 48 h, in a seed/water ratio of 3:10 (kg/L). The soaked seeds were then removed from the water and immediately boiled in water at 100°C for three hours, the water being changed after every hour [20,21]. After boiling, the water was drained and the boiled seeds were soaked again in warm water for ten hours, changing the water every two hours. After draining off the water, the pretreated *mucuna* seeds were dried in an oven at 60°C, ground into a fine powder, then stored in an airtight container and kept at room temperature till the use.

Experimental diets and feeding

Four isoprotein diets (40% crude protein) were formulated, with a control diet (D0) containing 25% fishmeal as the main source of animal protein without *Mucuna* Seed Meal (MSM) and three experimental diets, D30, D40 and D50, in which 30%, 40% and 50% MSM were included (Table 1).

In preparing experimental diets, the dried ingredients were ground into fine particles. After weighing, and mixing manually for 10 minutes, the preparations were moistened with warm water (400 ml/kg), and mixed for another 20 minutes. During the mixing, palm oil was added slowly along with warm water to achieve proper consistency. The resulting mixture was then pelleted into a 2.0 mm diameter pellet using a pellet machine (9KLP-150 pellet feed press machine, serial number JB/T5161-2013, Zhengzhou Xinzheng Yongyang Machinery Equipment, China). The diets were then air dried to a moisture content of approximately 6%, packed in polyethylene bags, sealed and appropriately labelled before stored in a freezer. Each sample of the dried diet was subjected to proximate analysis according to the method of Association of Official Analytical Chemistry [22] to determine the percentage composition of the various components of the diet. Moisture was determined by drying the sample in an air convection oven at 105°C overnight. Crude protein was analyzed by the Kjeldahl method after acid digestion (%crude protein=%nitrogen × 6.25), while crude lipid was determined by extraction with petroleum ether using the Soxhlet method. The ash content in the diet was analyzed by combustion of samples in a muffle furnace at 550°C for 12 h (Table 1).

Experimental design

After random distribution and acclimatisation of the 300 *C. gariepinus* fingerlings in 12 hapas forming four triplicates of 75 fish each, those in the first set of triplicates were fed the control diet (D0) while those in the other three sets of triplicates were fed diets D30, D40 and D50 respectively. Feed was distributed manually four times a day (6 am, 10 am, 2 pm and 6 pm) at a feeding rate of 10-4% of their ichthyo-biomass for 56 days. During the experimental period Temperature (T°C), pH, transparency and Dissolved Oxygen (DO) were measured twice a day (6 am and 5 pm) before feeding (Table 2).

Intermediate sampling was carried out every 14 days, during which all fish in each treatment were counted, weighed and total body length measured after a 24 hour fast. At the end of the experiment, a sample of 6 fish per treatment was taken at random and sacrificed for biochemical analyses of final proximal whole body composition, in accordance with the method of the Association of Official Analytical Chemistry [22].

Table 1: Cost of each ingredient used to formulate the diets and proximal composition of each diet (g/100 g dry mater).

Ingredients	Cost (XAF/kg)	D0	D30	D40	D50
Fish meal	1000	25	17.5	15	12.5
Mucuna seeds meal	-	-	7.5	10	12.5
Soybean cake	550	25	27.5	28.5	29.5
Groundnut cake	300	25	27.5	28.5	29.5
Wheat bran	225	12	9	8	7
Corn flour	285	11	9	8	7
Vitamin premix 1%	250	1	1	1	1
Bone powder	375	0.5	0.5	0.5	0.5
Palm oil	700	0.5	0.5	0.5	0.5
Total	-	100	100	100	100
Cost of feed (XAF/100g)	-	528.73	462.03	441.6	419.45
Proximate composition (%DM)					
Protein	40.10 ± 0.12	40.05 ± 0.64	39.33 ± 0.25	39.04 ± 0.11	3.3-4.4
Lipid	7.37 ± 0.01	7.65 ± 0.01	7.18 ± 0.72	7.49 ± 0.27	3.3-4.4
Ash	6.25 ± 0.35	6.60 0 ±0.14	6.70 ± 0.14	6.40 ± 0.14	3.3-4.4
Moisture	6.06 ± 0.44	7.17 ± 0.11	5.16 ± 0.36	6.02 ± 0.33	3.3-4.4
Energy (kJ/g DM)	17.26 ± 1.38	17.22± 1.47	17.26 ± 0.35	17.26 ± 0.69	3.3-4.4

Note: 561,773 XAF=1 USD

Table 2: Water quality parameters (Mean ± SD) recorded for 56 days of the experimental period.

Parameters	Rearing period (days)				
	1	14	28	42	56
T°C (°C)	29.01 ± 1.9	29.85 ± 0.76	30.91 ± 1.52	29.42 ± 2.09	30.65 ± 1.42
Transparency (cm)	32 ± 1.2	33± 2.5	35 ± 1.8	34 ± 2.3	33 ± 2.7
pH	6.4 ± 0.09	6.4 ± 0.09	6.4 ± 0.09	6.4 ± 0.09	6.4 ± 0.09
D.O (mg/l)	7.5 ± 0.22	7.5 ± 0.11	7.5 ± 0.01	7.4 ± 0.06	7.4 ± 0.06

Measurement of growth performances, feed efficiency and nutrient retention

Growth performances, feed efficiency parameters, and nutrient retention were assessed by determination of Weight Gain (WG), Specific Growth Rate (SGR), Feed Intake (FI), Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER), Survival Rate (SR) and Nutrient Retention (NR). Calculations were carried out using the following formula:

a) $$WG(g) = W_f - W_i$$

b) $$SGR(\%\text{day}) = \frac{\ln w_f - \ln w_f}{T} \times 100$$

Where: Wf=final weight; Wi=initial weight; Lf=final length; Li= initial length; T=number of days in the experimental period;

$$c)\ SR(\%) = \frac{Final\ number\ of\ fish}{Initial\ number\ of\ fish} \times 100$$

$$d)\ FI\ (g/fish) = \frac{Total\ dry\ feed\ distributed}{number\ of\ fish}$$

$$e)\ FCR = \frac{Feed\ intake}{Fish\ weight\ gained}$$

$$f)\ PER = \frac{Fish\ weight\ gained}{Protein\ feed}$$

$$\text{Where, } Protein\ fed = \frac{Totalfeedconsumed \times Crudeproteininfeed}{100}$$

$$g)\ NR(\%) = \frac{Final\ carcass\ composition - Initial\ carcass\ composition}{Amount\ of\ nutrient\ fed} \times 100$$

Economic analysis: At the end of the experiment, an economic analysis was performed to estimate the net return and cost benefit for each dietary treatment. The cost was based on the current prices of feed ingredients in Cameroon at the time of purchase. The following simple equation was used according to [23]:

❖ NR=I-(CFI+VC),

Where: NR=Net Return, I=incomes from *C. gariepinus* sale, CFC = cost of feed input,

VC=Variable Costs or Costs of harvesting and processing *M. pruriens* seeds.

The benefit-cost ratio was determined as:

❖ Benefit Cost Ratio (BCR)=Total return/Total costs

Statistical analysis: All results were expressed as mean ± SD. The data collected during every fish sampling were Analysed by One-way Analysis of Variance (ANOVA-1) repeated measure followed by Tukey's multiple comparisons test with n=3 replications containing 25 fish each. Differences were regarded as significant when p<0.05; Regression analysis was used to determine the relationship between fish growth and dietary inclusion level of *mucuna* seed meal as well as fish growth and nutrient retention. All statistical analyses were conducted using graphpad Prism version 6.0.

RESULTS

Effects of dietary inclusion of *mucuna* seed meal on growth performance

The growth parameters of *Clarias gariepinus* fingerlings expressed in terms of weight gain and specific growth rate are presented in Figure 1. Fish fed the diet containing *mucuna* seed meal showed the highest growth performance throughout the experimental period. At the end of the feeding trial, fish fed the diet containing 50% *mucuna* seed meal recorded the values of weight gain (93.89 ± 0.17 g) and specific growth rate (4.86 ± 0.01%/d) significantly ($p<0.05$) higher by 26.22% and 10.28% for weight gain and specific growth rate compared to fish fed the control diet (WG=69.27 ± 0.96g and SGR=4.36 ± 0.02%/d). Moreover, the relationship between fish growth and dietary inclusion level of *mucuna* seed meal is illustrated by the linear regression curve shown in (Figure 2).

It clearly appears a very close relationship between fish growth and dietary inclusion level of *mucuna* seed meal with R^2=0.98.

Survival and feed efficiency parameters

Table 3 shows the survival rate and feed nutrients utilization of *C. gariepinus* fingerlings fed different diets at the end of the feeding trial. Just very few mortalities were observed throughout the experimental period in all treatments a survival rate being above 95%. The values of the condition factor were significantly high in fish fed the experimental diets control, with the highest value obtained in treatment D40 (0.76 ± 0.02) significantly ($p<0.05$) high by 13.5% compared to control (0.66 ± 0.05). The FCR (1.28 ± 0.01) of the fish fed control diet was significantly ($p<0.05$) high by 25.78%, 24.22% and 24.22% compared to diets D30, D40 and D50 respectively. The PER of the fish fed the experimental diets significantly difference ($p<0.05$) from the control. The values of PER of fish fed diets D30 (2.63 ± 0.06), D40 (2.62 ± 0.02) and D50 (2.64 ± 0.04) were significantly ($p<0.05$) high by 25.85%, 25.57% and 26.14% respectively, compared to that of fish fed diet D0 (1.95 ± 0.01).

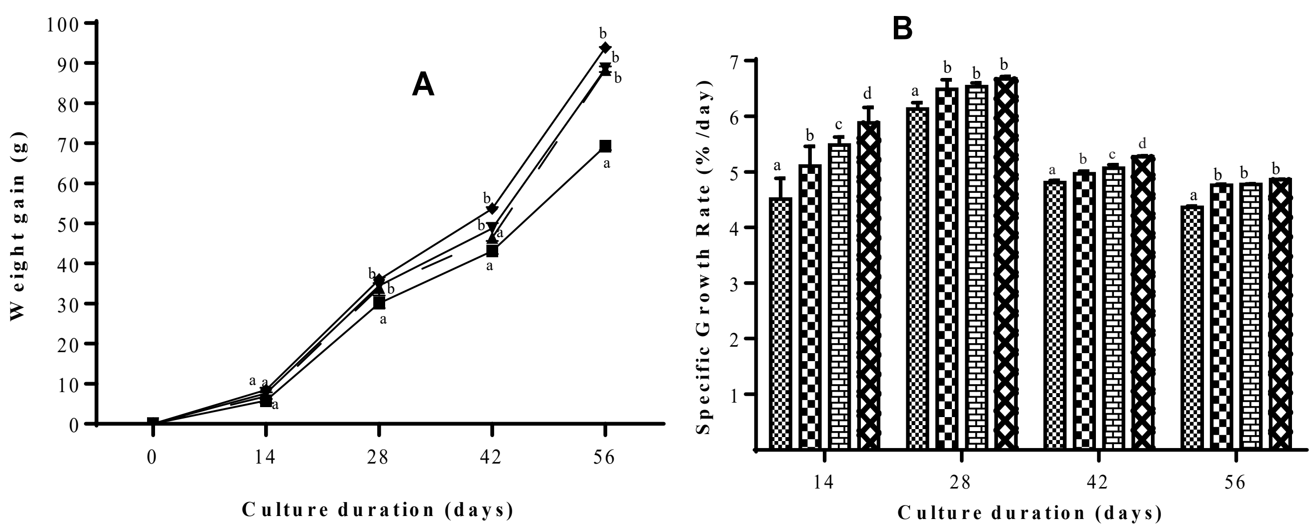

Figure 1: Effects of dietary inclusion level *mucuna* seed meal on weight gain (A) and specific growth rate (B) of *Clarias gariepinus* fingerlings for 56 days. Means on the same sampling period carrying different superscripts are significantly different from each other at p<0.05. **Note:** ( ): D0; ( ): D30; ( ): D40; ( ):D50; ( ):D0; ( ):D30; ( ):D40; ( ):D50

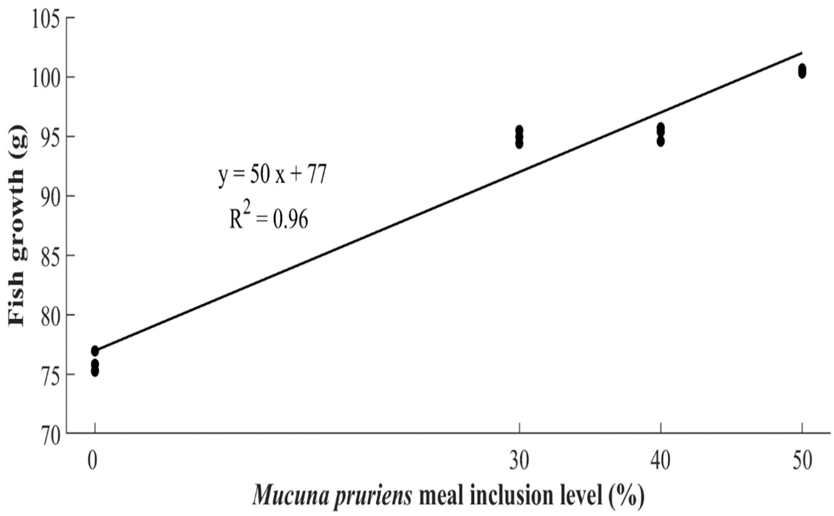

Figure 2: Regression analysis between fish growth and dietary inclusion level of *mucuna* seed meal. Equation and coefficient of determination are specified.

Table 3: Survival rate and feed nutrients utilization of *Clarias gariepinus* fingerlings after 56 days of feeding.

Parameter	D0	D30	D40	D50	p
Ni	75	75	75	75	-
Nf	73	72	74	73	-
Wi (g)	6.59 ± 0.01	6.58 ± 0.02	6.58 ± 0.02	6.59 ± 0.01	Ns
Wf (g)	75.86 ± 0.97^{a}	94.95 ± 0.54^{b}	95.23 ± 0.58^{c}	100.48 ±0 .17^{d}	***
Li (cm)	9.50 ± 0.01	9.52 ± 0.02	9.52 ± 0.06	9.51 ± 0.01	Ns
Lf (cm)	22.61 ± 0.66^{a}	23.27 ± 0.28^{a}	23.24 ± 0.24^{b}	24.25 ± 0.61^{c}	**
FI (g/fish)	88 ± 1.21^{a}	84 ± 2.40^{a}	86 ± 1.16^{a}	91 ± 1.25^{a}	Ns
PI (g/fish)	35.35 ± 0.49^{a}	33.52 ± 1.00^{a}	33.74 ± 0.46^{a}	35.46 ± 0.49^{a}	Ns
K	0.66 ± 0.05^{a}	0.75 ± 0.02^{b}	0.76 ± 0.02^{b}	0.71 ± 0.06^{ab}	*
SR (%)	97.00 ± 0.01^{a}	96.00 ± 0.01^{a}	99.00 ± 2.31^{a}	97.00 ± 2.31^{a}	**
FCR	1.28 ± 0.01^{a}	0.95 ± 0.02^{b}	0.97 ± 0.01^{b}	0.97 ± 0.02	**
PER	1.95 ± 0.01^{a}	2.63 ± 0.06^{b}	2.62 ± 0.02^{b}	2.64 ± 0.04^{b}	**

Note: Values are mean ± standard deviation of three replicates of 25 fish each. Mean within the row with different superscripts are significantly different each other at p<0.05. Ns, p≥0.05; *, p<0.05; **, p<0.01; ***, p<0.001.
Ni=initial number of fish; Nf=final number of fish; Wi=initial body weight of fish; Wf=final body weight of fish; Li=initial length of fish; Lf=final length of fish; FI=Feed Intake; PI=Protein Intake; SR=Survival Rate; K=condition factor; FCR=Feed Conversion Ratio; PER=Protein Efficiency Ratio.

Whole-body proximate composition and nutrients retention

Table 4 presents the whole body composition and nutrient retention of the fish in different treatments. Apart the moisture content which value is significantly (p<0.05) high in the initial fish compared to those obtained after 56 days of feeding, opposite effects were however noticed regarding other macronutrient contents such as ash, protein, lipid and energy. Statistical analysis between treatments at the end of the feeding trial overall revealed a significant (p<0.05) increase in the whole body ash, protein, lipid and energy content of fish fed the experimental diets compared to the control, with remarkable effects on the retention of the aforementioned macronutrients. The highest retention values of ash (54.94 ± 1.40) and lipid (42.17 ± 0.01) were obtained with treatments D40 and D30 respectively compared to other treatments especially the control (ash=29.56 ± 1.86 and lipid=29.95 ± 0.01). However, fish fed diet D50 expressed the highest values of protein retention (53.92 ± 0.12) and energy retention (31.50 ± 0.13) with a significant (p<0.05) high of 36.24% and 31.52%, respectively compared to protein retention (34.38 ± 0.04) and energy retention (21.57 ± 0.11) obtained in fish fed the control diet. In addition, the linear regression analysis between fish growth and protein retention, energy retention and lipid retention presented in

Figure 3 revealed that there is a close and highly significant ($p<0.05$) relationship between fish growth and protein retention ($R^2=0.96$) and energy retention ($R^2=0.97$). On the contrary, there was a weak and non-significant relationship ($p>0.05$) between fish growth and lipid retention according to the low value of the coefficient of determination obtained ($R^2=0.26$).

Table 5 presents the detailed economic data from the study. The highest cost-benefit ratio (9.75) was obtained for fish fed the control diet, which was higher by 8.41%, 29.23% and 36.20% compared to fish fed diets D30 (8.93), D40 (6.90) and D50 (6.22) respectively. The cost-benefit analysis indicated positive net returns for all experimental diets as a function of the level of dietary inclusion of *mucuna* seeds; with appreciable increases in net return of 18.15%, 19.26% and 21.38% for fish fed diets D30, D40 and D50 respectively compared to those fed the control diet.

Table 4: Proximal composition (% or kJ/g WW) of *Clarias gariepinus* juveniles obtained after 56 days of feeding.

Parameters	Initial	D0	D30	D40	D50	p
Whole body Composition (% or kJ/g DW)						
Moisture	74.70 ± 0.57[c]	72.49 ± 0.50[b]	71.31 ± 0.55[b]	70.00 ± 0.52[b]	69.33 ± 0.12[b]	***
Ash	1.75 ± 0.01[c]	2.30 ± 0.14[b]	2.27 ± 0.01[b]	3.34 ± 0.09c	2.45 ± 0.01[b]	**
Protein	16.34 ± 0.11[c]	17.41 ± 0.01[b]	18.34 ± 0.03[b]	19.71 ± 0.36[c]	20.13 ± 0.04[d]	***
Lipid	1.25 ± 0.01[c]	2.67 ± 0.01[b]	2.94 ± 0.01[c]	2.42 ± 0.05[b]	2.31 ± 0.01[b]	***
Energy	4.32 ± 0.15[c]	4.70 ± 0.03[b]	4.98 ± 0.01[bc]	4.94 ± 0.12[b]	5.21 ± 0.02[c]	**
Nutrient Retention (% dry feed)						
Ash		29.56 ± 1.86[a]	36.79 ± 0.01[b]	54.94 ± 1.40[c]	40.29 ± 0.17[b]	**
Protein		34.38 ± 0.04[a]	48.49 ± 0.10[b]	52.32 ± 1.03[c]	53.92 ± 0.12[c]	**
Lipid		29.95 ± 0.01[a]	42.17 ± 0.01[b]	35.92 ± 0.69[c]	32.85 ± 0.14[c]	**
Energy		21.57 ± 0.11[a]	30.67 ± 0.01[b]	29.82 ± 0.76[b]	31.50 ± 0.13[b]	**

Note: Values are mean ± standard deviation of three replicates of 35 fish each. Mean within the row with different superscripts are significantly different each other at $p<0.05$. Ns, $p\geq0.05$; *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$.

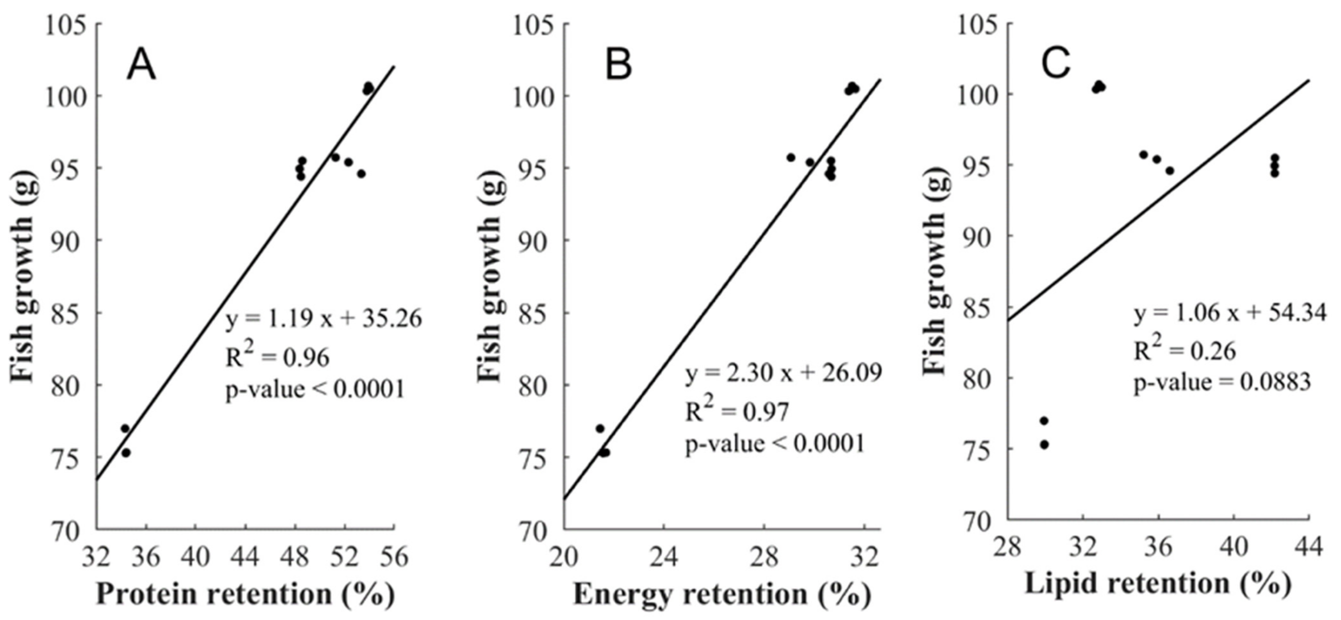

Figure 3: Regression analysis between Fish growth and body nutrients like (A): Protein; (B): Energy; (C): Lipid retention (%) after 56 days of feeding trial. Equation and coefficient of determination are specified.

Table 5: Effects of dietary inclusion of *Mucuna pruriens* seeds meal on economic efficiency.

Parameter	D0	D30	D40	D50
Cost of feed (XAF/kg)	528.73	462.03	441.6	419.45
Costs of harvesting and processing 500g of *mucuna* seeds	0	2,000	2,000	2,000
Total cost of feed (XAF/kg)	528.73	762.03	841.6	919.45
Total feed intake (kg/75 fish)	2.15	2.01	2.12	2.21
Total cost (XAF/75 fish)	1,136.77	1,531.68	1,784.19	2,031.98
Weight of fish stocked (kg/75 fish)	0.49	0.49	0.49	0.49
Weight of fish harvested (kg/75 fish)	5.54	6.84	7.05	7.34
Fish yield (kg 56 days^{-1})	5.04	6.34	6.55	6.84
Unit price of fish (XAF/kg)	2,000	2,000	2,000	2,000
Total return (XAF/75 fish)	11,080	13,680	14,100	14,680
Net return (XAF/75 fish)	9,943.23	12,148.32	12,315.81	12,648.02
Difference in net return (XAF)	0	2205.09	2,372.58	2,704.79
Increase in net return (%)	0	18.15	19.26	21.38
Benefit-cost ratio	9.75	8.93	6.9	6.22

DISCUSSION

The aquaculture sector is undergoing impressive development to meet growing consumer demand. However, in order to improve the sustainability and profitability of current production practices, the issue of fish nutrition requires particular attention. Fishmeal, one of the most important ingredients in aquaculture feeds is however, a limited resource [24]. One of the main challenges is therefore to reduce its use by including plant protein sources in aquafeeds while maintaining rapid fish growth and sustainable aquaculture production. Furthermore, although it is known that *mucuna* seeds contain anti-nutritional factors, the main one being L-DOPA, several pre-treatment methods, such as soaking, boiling and re-soaking, improve its nutritional value while reducing the level of L-DOPA from 68% to 88%, as well as other anti-nutritional factors such as phytic acid, trypsin, protease and alpha-amylase inhibitors to a level tolerable by monogastric species [13,25]. Thus, the pre-treatment methods applied in the present work would have contributed to effective detoxification of *mucuna* seeds. In addition, the bromatological analysis of the diets showed that the various formulated diets were balanced enough to meet the nutritional requirements of *Clarias gariepinus* fingerlings in terms of proteins, lipids, minerals and energy. Thus, the few mortalities observed during the study would not be caused by the physico-chemical parameters, much less by the quality of the feed distributed, but rather, to some extent, by the stress induced by handling.

Growth performance results, illustrated by weight gain and specific growth rate, showed higher values in *Clarias gariepinus* fingerlings fed diets containing different levels of *mucuna* seed meal inclusion. These results are in total contradiction with those obtained by [8], who showed that feeding juvenile *Clarias gariepinus* with diets containing raw and processed *M. pruriens* seed meal produced the best growth indices in fish fed the diet containing raw *mucuna* seeds; This is highly paradoxical given that almost all phytochemical and nutritional studies have shown that raw *mucuna* seeds are less rich in macronutrients but they contain high levels of anti-nutritional factors than processed seeds, resulting in stunted growth in fish due to reduced palatability and digestibility of the feed [15,14,9]. Similarly, the results of the present work on the growth performance of *Clarias gariepinus* fingerlings do not corroborate those of [18] who obtained poor growth performance in *Oreochromis niloticus* fingerlings fed on diets containing fermented and unfermented *Mucuna pruriens* seed meal compared to the control. The same trend in results was obtained by [16] in *Cyprinus carpio* fingerlings fed diets containing raw and boiled *Mucuna pruriens* seeds. The non-conformity of the results of the aforementioned studies with those of the present work can be explained not only by the difference in the species used but also by the methods of pre-treatment applied to the *mucuna* seeds, since according to [15], One of the most appropriate detoxification methods for *mucuna* seeds is soaking followed by boiling before soaking again, as was done in the present study, although the time allowed for each stage was not identical. In contrast, the results of the present study corroborating those obtained by [19] on the growth response of *Heterobranchus longifilis* fingerlings to roasted and boiled *mucuna* seed diets were partly attributed to the phylogenetic proximity between the two experimental species and also to the partial similarity of the pre-treatment methods used to detoxify the *mucuna* seeds.

A balanced aquaculture feed is one that meets the nutritional requirements of a farmed species at a specific stage in its development. In addition to maintaining the vital and reproductive functions of the species, it also contributes to its rapid growth. In the present study, the better growth performance observed in fish fed diets containing *mucuna* seed meal was due, on the one hand, to good assimilation of the nutrients contained in the experimental diets and, on the other hand, to the pharmacological properties of *Mucuna pruriens* through its anabolic properties, as has been suggested by certain authors [26]. Feed utilization parameters such as feed conversion ratio, protein efficiency ratio and condition factor obtained in experimental fish corroborate the results previously obtained by [6] and [7], respectively after substituting fish meal by lima bean seed meal in the diet of fingerlings *Cyprinus carpio*, *Clarias gariepinus* and *Oreochromis niloticus* reared in ponds system. These results are in line with numerous studies which have shown that although *mucuna* seeds contain a great concentration of toxic substances, the application of appropriate detoxification methods makes its nutrients contained available and accessible, in particular the proteins whose relatively high profile in essential amino acids such as methionine and lysine are essential for the growth of *Clarias gariepinus* fingerlings [27, 28]. According to the results of the present study, *mucuna* seeds, if properly processed, can be used as an alternative source of protein in the formulation of fish feeds, in particular grower feeds for *Clarias gariepinus*, at inclusion levels of up to 50%, without negative effects on fish growth and nutrient accumulation in the body.

Results on the whole-body composition of *Clarias gariepinus* post-juveniles obtained at the end of the feeding trial revealed significantly higher values of body protein, lipid, ash and energy in fish fed on experimental diets compared to control. These results being in accordance with previous studies on the use of leguminous seeds as alternative source of nutrient in fish diets [29], indicate that even though all diets were isoproteics, the ones formulated with *mucuna* seed meal would have been more valorized. [29] reported that alternative protein source like legumes, because they have medium protein content with suitable amino acid profile, high digestible protein and energy levels, and appropriate minerals and vitamins for the most cultured aquatic species, improve the nutritional quality of feed by boosting up essential amino acids, minerals and vitamins bioavailability and increasing digestibility of protein and energy. Accordingly, significantly high fish protein, lipid, ash and energy retention observed in experimental fish compared to control could be justified by better experimental feeds nutrient utilization efficiency than the control feed. These results corroborate previous findings that have established a direct link between the feed nutrients utilization efficiency by fish and their level of retention in the body [30]. Indeed, body nutrient retention refers to the proportion of dietary nutrients stored in body tissues during the rearing process and is characterized by the somatic growth of the fish.

The aim of every aquaculture investor is to make profits at the end of the production cycle. Since feed cost, known as the main source of expense, has also been recognized as the major constrain to the development of aquaculture sector, provision and inclusion in farmed fish diets of alternative ingredients that will be able to improve the nutritional quality of feed, reduce the length of the production cycle and therefore improve economic returns is also one of the priorities for aquaculture nutritionists. The results on the economic performances showed that although the cost of experimental feeds was high compared to the control feed due to the cost of labour and processing, it however decreased with the inclusion level of *mucuna* seed meal. This result can be easily explain by the price difference in the cost of fish meal and *mucuna* seeds as it was previously mentioned by [8] after evaluating the growth and economic performance of *Clarias gariepinus* juveniles fed diets containing *mucuna* seed meal. In this study, the cost benefit analysis did not take into consideration the cost of both hapas construction and pelleting feeds as these were considered a constant. However, the values of the benefit cost ratio and net return obtained indicated that as the dietary inclusion of *mucuna* seed meal increase, the benefit cost ratio decrease while the net return increase. The benefit cost ratio determine the extent of the profit and according to [31] a benefit cost ratio above 1 implies profitability and the farther away from 1, the more the profitability. In the present work, fish from all treatments gave a benefit cost ratio well above 1. These results present the same tendency with those obtained by [32] *Clarias gariepinus* fingerlings; indicating that all diets are cost-effective. Paradoxically to the benefit cost ratio that decreased with the dietary inclusion level of *mucuna* seeds due to the influence of both the cost of labour and processing, the net return increased with the dietary inclusion level of *mucuna* seeds. These results do not agree with the findings of [33] who observed a decrease in the net return of Nile tilapia fingerlings fed with diets containing several levels of soybean substitution by Guar korma. These results can therefore be justify by the increase of the harvested fish biomass depending to dietary inclusion level of *mucuna* seed meal; confirming thus the nutritional properties of *mucuna* seeds and their ability to effectively improve the growth of *C. gariepinus* fingerlings at inclusion rates of up to 50%.

CONCLUSION

The present study showed that the inclusion of up to 50% processed *mucuna* seed meal in a grow-out feed improves growth, feed utilization and nutrient retention in *Clarias gariepinus* fingerlings, as well as the economic performance of the fish at the end of production, with little negative impact on fish survival. Thus, *mucuna* seed meal can be considered a promising ingredient in the formulation and manufacture of aquaculture feeds that could help not only to improve the nutritional quality of feeds, but also to reduce production costs and time while increasing the profit margin of aquaculture producers.

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