

Substitution of mucuna seeds (*Mucuna pruriens*) with soybean seeds (*Glycine max*) in the diet of *Oreochromis niloticus*: growth performance, hematological profile, and economic analysis

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Abstract. This study investigates the growth performance, hematological parameters, and economic profitability of diets for Nile tilapia *Oreochromis niloticus* that replace soybean (*Glycine max*) meal with varying levels of mucuna (*Mucuna pruriens*) seeds. The goal was to evaluate the feasibility of substituting soybean seed with mucuna seed in *O. niloticus* diets. A total of 300 fingerlings (mean initial weight 9.08 ± 0.04 g) were distributed across 15 tanks (20 fish per tank) and fed one of five diets: a commercial control feed (T0), and four experimental feeds containing 20% or 40% of either soybean meal (TS20, TS40) or mucuna meal (TM20, TM40). Feeding was conducted three times daily over 6 weeks, with triplicate tanks per diet. Survival rate was 100% for all groups. Significant differences ($p < 0.05$) were observed in feed conversion ratio (FCR), ranging from 2.29 ± 0.05 (TM40) to 1.18 ± 0.05 (T0), specific growth rate (SGR) from $2.63 \pm 0.01\% \text{ day}^{-1}$ (TM40) to $4.10 \pm 0.07\% \text{ day}^{-1}$ (T0), and protein efficiency ratio (PER) from 1.25 ± 0.04 (TM40) to 2.20 ± 0.09 (T0). Hematological analyses showed hemoglobin values from $4.33 \pm 0.33 \text{ g dL}^{-1}$ (TM40) to $8.16 \pm 0.16 \text{ g dL}^{-1}$ (T0), with TS20 and TM20 diets also showing relatively high levels. Other hematological parameters, including packed cell volume, red and white blood cell counts, mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and mean corpuscular volume (MCV), exhibited significant variation across diets. Results indicate that a 20% inclusion level of mucuna seed (TM20) in *O. niloticus* feed provides optimal growth performance and economic profitability, supporting its use as a partial substitute for soybean meal in aquafeeds.

Key Words: hematological parameters, incorporation, Nile tilapia, rentability, zootechnical parameters.

Introduction. The high cost of aquafeed in Africa is a significant challenge that limits the growth and profitability of the aquaculture industry. This issue largely stems from the reliance on imported feed ingredients, which are expensive due to transportation costs, supply chain inefficiencies, and limited local production capacity. Additionally, the lack of affordable, locally sourced raw materials and inadequate feed processing technology exacerbates the problem, making aquafeed less accessible to small-scale fish farmers and hindering the sector's sustainability and expansion (Rana et al 2009).

In light of the current situation, researchers and entrepreneurs in aquaculture are increasingly utilizing animal and plant by-products in aquaculture feeds to reduce production costs (Monentcham et al 2010; Chabi et al 2015; Vodounnou et al 2016; Wang et al 2017; Vodounnou et al 2024). Soybean (*Glycine max*) is a common ingredient in aquaculture feed. However, relying on soybeans for fish feed poses significant environmental and economic challenges. In Benin, where soybeans are an essential food

source for both humans and livestock, the competition between these two uses is growing. Approximately 46.2% of legume production in Benin consists of soybeans (Kouevi et al 2023). These beans are used in a variety of human food products, such as infant flour and milk (Allavo et al 2024). Nonetheless, a significant portion of soybean production is directed towards animal feed, especially in aquaculture, creating a conflict between the nutritional needs of humans and animals. The increasing demand for soybeans for animal feed in Benin is reducing their availability for human consumption. Additionally, the limited agricultural land and rising export demands further intensify this competition for food resources. *Mucuna* (*Mucuna pruriens*) seeds, which contain approximately 30% protein, are very close in protein content to soybeans, which have around 36%. Both provide suitable proportions of all essential amino acids according to FAO standards (Ravindran & Ravindran 1988). Therefore, mucuna flour is a sustainable alternative to soy because of its nutritional profile. Its incorporation into aquaculture feed could help decrease reliance on soybeans, lower feed costs, and improve fish performance.

Nile tilapia (*Oreochromis niloticus*) is widely regarded as one of the most prominent and extensively cultivated fish species in global aquaculture, particularly in Africa (Djissou et al 2020; Vodounnou et al 2025). Its importance is underscored by its high market demand, ease of reproduction and breeding, rapid growth rate, and relatively simple nutritional requirements, which together contribute to its status as an important species in African aquaculture development (FAO 2024). The increase in the production of *Oreochromis niloticus* correlates with greater demand for both the quantity and quality of feed, leading to higher demand for soybeans (Abdel-Warith et al 2013). This study examines the zootechnical performance, hematological profile, and economic viability of *O. niloticus* when fed mucuna seeds as a substitute for soybean seeds. The aim is to address the competition between human consumption and aquaculture for soybean resources and to promote the use of mucuna seeds in aquaculture feeds.

Material and Method

Experimental site. The experiment was carried out from January to March 2025 at the Research Unit on Aquaculture and Fisheries Management (URAGeP) of the School of Aquaculture (EAq) of the National University of Agriculture (UNA) in the Republic of Benin. URAGeP is located in Adjohoun, Ouémé department, southern Benin (6°46'18.73" N; 2°30'2.32" E).

Soybean and mucuna seed processing. The soybeans and mucuna seeds were first cleaned and then roasted using a technique outlined by Solomon & Taruwa (2011). This method involves heating the seeds in finely textured sand at temperatures ranging from 150 to 160°C, which facilitates even roasting while minimizing the risk of burning. After roasting, the seeds were sifted to eliminate the sand, and any charred grains were removed manually. Following this, the seeds were ground into a fine powder.

Diet formulation. The nutritional requirements of *O. niloticus* were considered in the diets formulation (NRC 2011; Mugo-Bundi et al 2013) (Table 1). Four isocaloric and isoproteic diets were used, in addition to a control diet T0, which was the commercial feed (Gouessant ®)". The experimental diets included TS20, which contained 20% soybean meal and 0% mucuna meal; TM20, which had 20% mucuna meal and 0% soybean meal; TS40, which consisted of 40% soybean meal and 0% mucuna meal; and TM40, which contained 40% mucuna meal and 0% soybean meal. The ingredients were ground and mixed using a 2 mm sieve before being processed into diets. These diets were then stored in boxes at a temperature of 5°C in a refrigerator. Before substituting soy meal with mucuna meal at 20% and 40%, we based our decision on their nutritional composition, which is similar (Table 2). The protein, lipid, carbohydrate, ash, and dry matter contents of the manufactured diets were analyzed according to AOAC (1990) (Table 3).

Table 1

Feed formulations of *O. niloticus*

Ingredients	Treatments				
	T0	TS20	TM20	TS40	TM40
BSFL meal	-	5	5	2	2
Corn flour	-	25	25	22	22
Soybean meal	-	20	0	40	0
Mucuna meal	-	0	20	0	40
Fish meal	-	12	12	5	5
Wheat bran	-	24	24	20	20
Cassava meal	-	6	6	5	5
Dicalcium phosphate	-	1	1	1	1
Lysine	-	2	2	1	1
Methionine	-	2	2	1	1
Premix (vit + min)*	-	2	2	2	2
Soy oil	-	1	1	1	1
Total (%)		100	100	100	100

BSFL = black soldier fly larvae; T0: reference diet composed of commercial tilapia feed (Gouessant®); TS20: diet with 20% of soybean meal, TM20: diet with 20% of mucuna meal, TS40: diet with 40% of soybean meal, TM40: diet with 40% of mucuna meal; * premix (vitamin-mineral) contains (‰): vitamin A, 4,000,000 U.I.; vitamin D, 800,000 IU; vitamin E, 40,000 IU; vitamin K3, 1600 mg; vitamin B1, 4000 mg; vitamin B2, 3000 mg; vitamin B6, 3800 mg; vitamin B12, 3 mg; vitamin C, 60,000 mg; biotin, 100 mg; inositol, 10,000 mg; pantothenic acid, 8,000 mg; nicotinic acid, 18,000 mg; folic acid, 800 mg; choline chloride, 120,000 mg; cobalt carbonate, 150 mg; ferrous sulphate, 8000 mg; potassium iodide, 400 mg; manganese oxide, 6000 mg; copper, 800 mg; sodium selenite, 40 mcg; lysine, 10,000 mg; methionine, 10,000 mg; zinc sulfate, 8000 mg

Table 2

Nutritional composition of mucuna seed meal and soybean seed meal

Composition	Soybean meal	Mucuna meal
Moisture (%)	7.39±0.30	6.05±0.67
Crude protein (%)	36.20±0.28	31.87±0.47
Crude lipid (%)	18.48±0.10	8.17±0.11
Crude carbohydrate (%)	21.19±0.18	43.4±0.45
Crude fibre (%)	12.39±0.41	7.13±0.02
Ash (%)	4.33±0.15	3.36±0.15
Energy (kcal/100g)	395.93±0.66	374.64±3.60

Table 3

Nutritional composition of the experimental diet of *O. niloticus*

Composition	Treatments				
	T0	TS20	TM20	TS40	TM40
Dry matter	94.66	90.02	90.45	90.19	90.58
Ash	8.66	9.12	9.85	9.56	10.02
Protein (%)	38.54	35.76	35.07	35.88	34.94
Lipid (%)	11.87	10.48	10.32	10.87	10.11
Carbohydrate (%)	26.04	23.98	23.51	25.66	24.42
Energy (kcal/kg)	3651.5	3332.8	3272	3439.9	3284.4

Chemical analyses. The diets were analyzed in accordance with AOAC (1990). Dry matter (DM) content was determined by oven-drying the samples at 105°C for six hours until a constant weight was achieved. Crude protein levels were assessed using the Kjeldahl method following acid digestion, with nitrogen content measured and subsequently converted to crude protein using a nitrogen factor of 6.25. Ash content was determined by incinerating the samples in a muffle furnace heated to 550°C, at a constant rate of 50°C every 30 minutes for a total duration of 4 hours, and then cooling in a desiccator. Lipids

were extracted by heating the samples in diethyl ether under reflux at 105°C for 30 minutes using a VELP solvent extraction unit. The ether extract value was calculated as the difference between the initial sample and the residual ether extract.

Experimental design. Three hundred *O. niloticus* fingerlings with an average initial weight of 9.08 ± 0.04 g were randomly distributed in 15 tanks at a rate of 20 fingerlings per tank. Five different treatments were applied, including T0, TS20, TM20, TS40, and TM40. The feeding frequency was 3 times/day (7 am, 1 pm, 6 pm). The experiment was conducted for 6 weeks, and each experimental diet was tested in triplicate. Water was changed daily, and each tank contained 40 liters of water. A week of acclimation period was observed before the experiment. Growth was monitored every 7 days to assess the effect of the formulated feed on *O. niloticus*. All tanks were washed, and the fish were counted and weighed. Physicochemical parameters such as dissolved oxygen, pH, and temperature were monitored three times a day by an Elmetron CP-411 model multi-parameter device (6 am, 11 am, 5 pm).

Feed utilization and zootechnical performance parameters. Feed utilization and zootechnical performance parameters, such as the survival rate (SR), daily weight gain (DWG), specific growth rate (SGR), feed conversion ratio (FCR) and protein efficiency ratio (PER) were calculated:

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

$$DWG (\text{mg day}^{-1}) = \frac{\text{Body mass gain (mg)}}{\Delta t}$$

where: Δt = the duration of the experiment in the number of days.

$$SGR (\% \text{day}^{-1}) = \frac{\text{Ln (final biomass weight) - Ln (initial biomass weight)}}{\Delta t} \times 100$$

where: Ln = natural logarithm;

Δt = the duration of the experiment in the number of days.

$$FCR = \frac{\text{Dry feed fed (mg)}}{\text{Body mass gain (mg)}}$$

$$PER = \frac{\text{Wet body mass gain}}{\text{Crude protein fed}}$$

Blood sample and hematological analysis. The experimental fish were sampled for hematological parameters following the methods of Kori-Siakpere et al (2005). Three (3) mL of blood samples were collected from five fishes from each tank at the end of the experiment. A disposable plastic sterile syringe (2 cm³) with a 21-gauge disposable hypodermic needle was used to draw 3 mL of blood from the caudal vein, and the samples were placed separately in bottles containing 0.5 mg ethylenediaminetetraacetic acid (EDTA) as an anticoagulant and properly labeled. The Neubauer hemocytometer (counting chamber) was used to determine red blood cells (RBC) and white blood cells (WBC), the cyanmethemoglobin method was used to determine the hemoglobin (Hb) concentration, and the microhematocrit was used to determine the packed cell volume (PCV), as described by Kori-Siakpere et al (2005). Additionally, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were calculated using the following formulas:

$$MCV (\mu\text{m}^3) = \frac{\text{Haematocrit (\%)}}{\text{Erythrocyte count}} \times 10$$

$$\text{MCH (Pg cell}^{-1}\text{)} = \frac{\text{Haemoglobin (g dL}^{-1}\text{)}}{\text{Erythrocyte count}} \times 10$$

$$\text{MCHC (g dL}^{-1}\text{)} = \frac{\text{Haemoglobin (g dL}^{-1}\text{)}}{\text{Haematocrit (\%)}} \times 100$$

Cost-benefit analysis of experimental diets. Cost-benefit analyses were used to evaluate the economic impact of mucuna meal as a replacement for soybean meal in *O. niloticus* diets. The cost of the formulated diets was calculated based on the cost of the ingredients in each diet except the commercial diet where the market price was used. The ingredient costs were based on prevailing market prices (Table 4). The US dollar to FCFA exchange rate was fixed at FCFA 620. We calculated the cost of the feed required to produce 1 kg of biomass. The study assumed that all other production costs were constant for all dietary treatments and were therefore not considered. The economic conversion ratio (ECR) was calculated using the following equation:

$$\text{ECR} = \text{feed conversion ratio} \times \text{feed cost}$$

Table 4

Feed cost of experiment diet of *O. niloticus*

Ingredients	Treatments					Cost (USD kg ⁻¹)
	T0	TS20	TM20	TS40	TM40	
BSFL meal	-	0.0875	0.0875	0.035	0.035	1.75
Corn flour	-	0.125	0.125	0.11	0.11	0.5
Soybean meal	-	0.184	0	0.368	0	0.92
Mucuna meal	-	0	0.11	0	0.22	0.55
Fish meal	-	0.432	0.432	0.18	0.18	3.6
Wheat bran	-	0.06	0.06	0.05	0.05	0.25
Cassava meal	-	0.042	0.042	0.035	0.035	0.7
Dicalcium phosphate	-	0.015	0.015	0.015	0.015	1.5
Lysine	-	0.1366	0.1366	0.0683	0.0683	6.83
Methionine	-	0.15	0.15	0.075	0.075	7.5
Premix (vit + min)	-	0.1166	0.1166	0.1166	0.1166	5.83
Soy oil	-	0.0383	0.0383	0.0383	0.0383	3.83
Feed cost (USD kg ⁻¹)	2.1*	1.387	1.313	1.0912	0.9432	

* Cost of kg of commercial feed (Gouessant ®).

Data processing. The data were organized and analyzed using Excel software. Key parameters related to zootechnical, physico-chemical, feed utilization, and hematological aspects were calculated, with both the mean and range for each parameter determined. A one-way analysis of variance (ANOVA) was conducted using STATVIEW version 5.01, following the verification of variance homogeneity through Hartley's test. Significant differences among the means were assessed using Fisher's test, with a significance level set at p=0.05.

Results

Physicochemical parameters. The physicochemical parameters of the water were recorded. The average temperature during the experiment ranged from 28.38°C (T0) to 28.42°C (TM40). The average pH ranged from 6.73 (T0) to 6.94 (TS40). The average level of dissolved oxygen was ranging from 6.94 mg L⁻¹ (TM40) to 6.98 (T0) mg L⁻¹.

Zootechnical, feed utilization, and survival parameters of *O. niloticus* fed with the experimental diets. The biomass evolution over time differed significantly among the treatments (Figure 1). Table 5 demonstrates that there were statistically significant

variations in final biomass across all treatments ($p < 0.05$). Diet T0 presented the highest final biomass. No significant difference was observed between the diet TS20 (1003.33 ± 20.88 g) and the diet TM20 (984.00 ± 8.50 g) ($p > 0.05$). Diet TM40 presented the lowest final biomass (596.66 ± 4.84 g). The same trend was observed for the daily weight gain (DWG), which varied from 9.21 ± 0.09 g (TM40) to 21.58 ± 1.00 g (T0).

FCR obtained during the experiment varied significantly ($p < 0.05$) across the treatments. It ranged from 2.29 ± 0.05 (TM40) to 1.18 ± 0.05 (T0). Diet T0 presented the highest FCR, and diet TM40 showed the lowest FCR (Table 5). No significant difference was observed between the diet T0 (1.18 ± 0.05) and the diet TS20 (1.31 ± 0.01). The same trend was observed between TS20 (1.31 ± 0.01) and TM20 (1.37 ± 0.06) ($p > 0.05$). Regarding feed efficiency, a comparable trend was noted, the value ranging from 0.63 ± 0.00 (TM40) to 0.84 ± 0.03 (T0) (Figure 2). Similarly, the SGR varied significantly ($p < 0.05$) with the treatments. It varied from 2.63 ± 0.01 (TM40) to 4.10 ± 0.07 % day^{-1} (T0). The highest SGR was obtained with diet T0, and TM40 showed the lowest results of this parameter (Table 5). No significant difference was observed between the diet TS20 (3.80 ± 0.05 % day^{-1}) and the diet TM20 (3.76 ± 0.02 % day^{-1}) ($p > 0.05$). The PER showed a significant difference ($p < 0.05$) in all the treatments. It ranged from 1.25 ± 0.04 (TM40) to 2.20 ± 0.09 (T0). But no significant difference was observed between T0, TS20, and TM20 (Table 5). There was no significant difference in the SR ($p > 0.05$). No mortality occurred during the study, resulting in a SR of 100.00 ± 0.00 %.

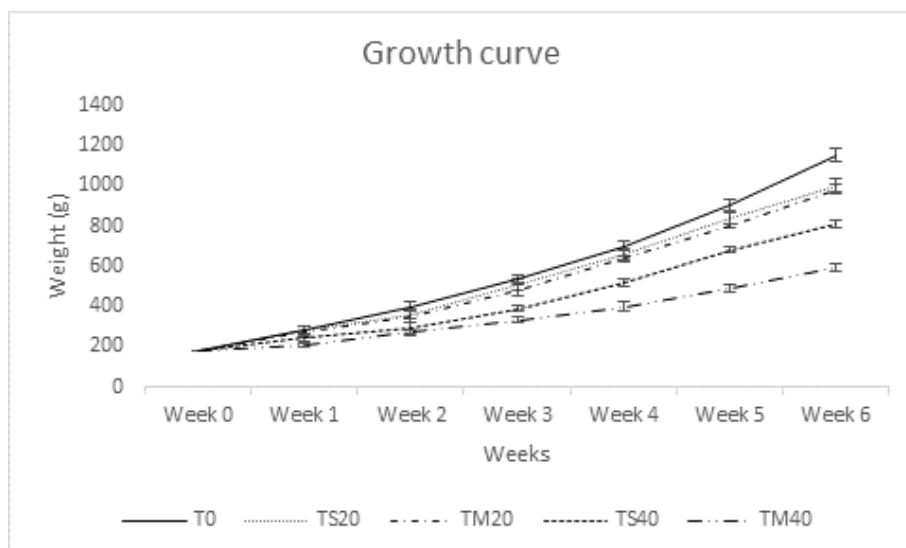


Figure 1. Growth evolution of *O. niloticus* fed with the experimental diets.

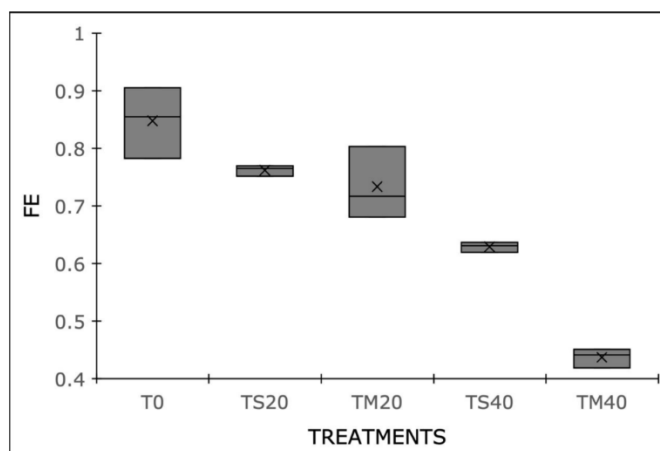


Figure 2. Box plot of feed efficiency of *O. niloticus* during experimentation.

Cost-benefit analysis of experimental diets. The ECR showed a significant difference ($p < 0.05$), ranging from 1.73 ± 0.01 for treatment TS40 to 2.48 ± 0.15 for treatment T0. No significant differences ($p > 0.05$) were found among the treatments TS20, TM20, and TS40, indicating a favorable production cost for *O. niloticus* in this study (Figure 3).

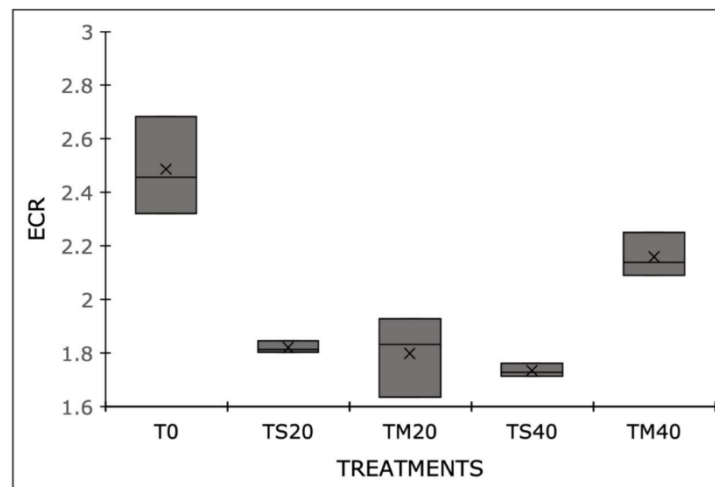


Figure 3. Box plot of the economic conversion ratio of *O. niloticus*.

Hematological analysis. The hematological profile exhibited significant differences among the treatments ($p < 0.05$) (Table 6). Hb levels ranged from 4.33 ± 0.33 g dL⁻¹ (TM40) to 8.16 ± 0.16 g dL⁻¹ (T0). However, no significant difference ($p > 0.05$) was observed between T0, TS20, and TM20. PCV ranged from $18.33 \pm 0.88\%$ (TM40) to $29.16 \pm 0.44\%$ (TS20). No significant difference ($p > 0.05$) was observed between T0 and TM20. RBC counts ranged from 4.86 ± 0.98 cells μL^{-1} in the TM40 group to 8.66 ± 0.16 cells μL^{-1} in the T0 group. No significant differences ($p > 0.05$) were observed between the T0, TS20, and TM20 groups. Similarly, no significant difference ($p > 0.05$) was found between the TM20 and TS40 groups. For the WBC counts, the values ranged from 13.50 ± 0.28 cells μL^{-1} in the TS20 group to 16.83 ± 0.29 cells μL^{-1} in the TM40 group. Similarly, no significant difference ($p > 0.05$) was noted between the T0 and TS20 groups, nor between the TS40 and TM40 groups. Regarding MCH, it ranged from 30.16 ± 1.30 pg cell⁻¹ (TM40) to 34.33 ± 1.45 pg cell⁻¹ (TM20). No significant difference ($p > 0.05$) was observed between all treatments except TM20 and TM40 ($p < 0.05$). The MCHC ranged from 24.00 ± 1.15 g dl⁻¹ (TS40) to 28.33 ± 1.44 g dl⁻¹ (T0). No significant differences ($p > 0.05$) were observed between all treatments, except for T0 and TM40, as well as between T0 and TS40 ($p < 0.05$). MCV ranged from 71.33 ± 0.66 μm^3 (TS40) to 81.00 ± 3.46 μm^3 (TS20). No significant differences ($p > 0.05$) were observed among all treatments except T0, TM20 and TS40, and between TS20 and TS40 ($p < 0.05$).

Table 5

Zootechnical performance of *O. niloticus* fed with the experimental diets

Parameters	T0	TS20	TM20	TS40	TM40	F-value	P-value
IBW (g)	182.00±1.00 ^a	181.00±0.57 ^a	181.33±1.33 ^a	182.00±0.57 ^a	182.00±0.57 ^a	0.29	0.87
FBW (g)	1153.00±46.07 ^a	1003.33±20.88 ^b	984.00±8.50 ^b	812.00±6.35 ^c	596.66±4.84 ^d	83.97	< 0.0001
DWG (g day ⁻¹)	21.58±1.00 ^a	18.27±0.46 ^b	17.83±0.18 ^b	14.00±0.13 ^c	9.21±0.09 ^d	87.23	< 0.0001
FCR	1.18±0.05 ^a	1.31±0.01 ^{ab}	1.37±0.06 ^b	1.59±0.02 ^c	2.29±0.05 ^d	101.28	< 0.0001
PER	2.20±0.09 ^a	2.13±0.01 ^a	2.09±0.01 ^a	1.75±0.01 ^b	1.25±0.04 ^c	37.83	< 0.0001
SGR (% day ⁻¹)	4.10±0.07 ^a	3.80±0.05 ^b	3.76±0.02 ^b	3.32±0.01 ^c	2.63±0.01 ^d	180.08	< 0.0001
SR (%)	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00		

The values are expressed as the means±standard deviations. Values with the same alphabetical letters in the same row are not significantly different at $p > 0.05$.

Table 6

Hematological profile of *O. niloticus* fed with experimental diets

Parameters	T0	TS20	TM20	TS40	TM40	F-value	P-value
Hb (g dL ⁻¹)	8.16±0.16 ^a	7.50±0.57 ^a	7.00±0.28 ^a	5.50±0.29 ^b	4.33±0.33 ^c	31.25	< 0.0001
PCV (%)	26.16±1.09 ^a	29.16±0.44 ^b	26.66±0.33 ^a	22.50±0.29 ^c	18.33±0.88 ^d	37.72	< 0.0001
RBC (cells μL ⁻¹)	8.66±0.16 ^a	8.16±0.16 ^a	7.66±0.44 ^{ab}	6.50±0.29 ^b	4.86±0.98 ^c	8.87	0.0025
WBC (cells μL ⁻¹)	14.33±0.44 ^{ab}	13.50±0.28 ^a	15.26±0.26 ^{bc}	16.00±0.29 ^{cd}	16.83±0.29 ^d	18.89	0.0001
MCH (Pg cell ⁻¹)	33.73±0.63 ^{ac}	31.00±0.57 ^{ac}	34.33±1.45 ^a	31.16±1.87 ^{ac}	30.16±1.30 ^c	2.08	0.1576
MCHC (g dL ⁻¹)	28.33±1.44 ^{abc}	27.00±1.04 ^{abc}	26.00±1.15 ^{abc}	24.00±1.15 ^b	24.50±1.15 ^c	2.26	0.1352
MCV (μm ³)	79.68±0.84 ^{abc}	81.00±3.46 ^b	80.33±2.92 ^c	71.33±0.66 ^d	77.66±1.45 ^{abc}	3.40	0.0529

The values are expressed as the means±standard deviations. Values with the same alphabetical letters in the same row are not significantly different at $p > 0.05$.

Discussion

Water quality. The average water temperature ranges from 28.38 to 28.42°C, which aligns with the optimal conditions reported in the literature. Optimal growth for *O. niloticus* occurs between 28 and 32°C (Abo-State et al 2014; Khallaf et al 2021). The recorded pH values, between 6.73 and 6.94, are also suitable for *O. niloticus*. Although a pH range of 7 to 8 is traditionally recommended for the rearing of this species (Khallaf et al 2021), recent research suggests that *O. niloticus* can tolerate lower pH levels, exhibiting satisfactory adaptation and growth in waters with pH values spanning 5 to 8 (Hassaan et al 2019). The dissolved oxygen concentrations, ranging from 6.94 to 6.98 mg L⁻¹, are above the critical threshold of 5 mg L⁻¹ needed for optimal tilapia growth. Ngoepe et al (2021) demonstrated that dissolved oxygen levels below 6 mg L⁻¹ can hinder the growth and feeding efficiency of *O. niloticus*. Additionally, Tran-Duy et al (2012) found that oxygen concentrations falling below 3 mg L⁻¹ resulted in a significant decrease in feed consumption and growth.

Growth and nutrient utilization performance. The results of this study highlight significant differences between diets using mucuna seeds and soybeans on the growth performance, feed utilization, survival rate, hematological profile, and economic profitability of *O. niloticus*.

The study indicates that the growth of *O. niloticus* fingerlings is affected by the type of diet provided. The control diet (T0), which consisted of a commercial feed, yielded the best growth performance. These findings align with the research conducted by Ng et al (2003), and by Tacon & Metian (2008), which showed that commercial feeds formulated with high-quality ingredients and balanced essential nutrients lead to optimal growth in farmed fish. Diets incorporating 20% soybeans (TS20) and 20% mucuna (TM20) demonstrated performance levels that were comparable to the control diets, with observed feed conversion rates of 1.18, 1.31, and 1.37, respectively. There was no significant difference ($p > 0.05$) among these rates. These findings can be attributed to two main factors: the roasting treatment that both soybean and mucuna beans undergo at temperatures above 120°C, and the relatively low incorporation rate of 20% in their feed. These results align with the findings of Fagbenro & Davies (2001), Abdel-Warith et al (2013), and Gad et al (2024) concerning the use of soybeans in aquaculture. These authors indicate that soybeans can replace up to 45% of animal meal in aquaculture feed without significantly harming growth. Concerning the mucuna seed, the research conducted by Okomoda et al (2017) demonstrated that incorporating 20% mucuna into feed resulted in good zootechnical performance. Similarly, Nyadjeu et al (2023) found that incorporating up to 50% mucuna in the diet of *Clarias gariepinus* also yielded positive results. However, several studies have emphasized the importance of treating mucuna seeds before adding them to aquaculture feed (Siddhuraju & Becker 2001, 2002; Ebeniro & Orji 2012; Nyadjeu et al 2023). Mucuna seeds, when not pre-treated, can negatively impact the zootechnical performance of fingerlings due to their anti-nutritional factors. These anti-nutritional factors include lectins, tannins, and L-DOPA, known to hinder digestibility and nutrient absorption (Emiola et al 2003; Siddhuraju & Becker 2003; Dahouda et al 2009). This explains the poor performance observed with the treatment that included 40% mucuna, which resulted in a FCR greater than 2. This result does not support the work of Nyadjeu et al (2023), which showed good zootechnical performance for incorporating up to 50% of mucuna in the diet of *C. gariepinus*. This difference may be due to the species' diet. Indeed, the ability to tolerate and digest an ingredient can also be influenced by the dietary habits of the species (Liu et al 2022; Li et al 2023). However, the use of mucuna seeds in aquaculture feed requires significant pre-treatments beyond roasting (Ebeniro & Orji 2012).

Concerning the survival rate in this study, there were no significant differences between the different treatments. The survival rate was 100% for all diets. This indicates that, although the substitution of soybean meal with mucuna meal may hinder growth and feed efficiency, it does not cause mortality in *O. niloticus*. Well-processed mucuna proteins are safe for fish feed and do not have any toxic effects (Farougou et al 2006). The high survival rates also indicate the excellent breeding conditions maintained during the

breeding process. Indeed, a high survival rate depends not only on the diet but also on breeding conditions and fish farming environment (Devic et al 2018).

Economic performance. The economic profitability of our study indicates that incorporating 20% and 40% soybeans, along with 20% mucuna, yields positive economic results. Despite the strong zootechnical performance of the control feed, which is a commercial feed, it is more expensive for production compared to the treatments with 20% and 40% soybeans and the incorporation of mucuna at 20%. These findings support the work of Abdel-Warith et al (2013) and Gad et al (2024), who recommended using soybeans in aquaculture feed for improved economic profitability. Similarly, the study confirms the results of Okomoda et al (2017), which demonstrated good profitability with a 20% incorporation of mucuna.

Hematological analyses. Analysis of the hematological profile showed significant differences between the treatments. The T0, TS20, and TM20 treatments displayed the highest values for Hb, PCV, and RBC, in contrast to TM40, which recorded the lowest values. The low values of Hb, PCV, and RBC observed in the TM40 treatment can be attributed to the poor zootechnical performance obtained in this treatment, likely due to the nutritional quality of the feed. The incorporation of 40% mucuna in this feed probably increased the anti-nutritional factors in this diet. According to studies by Adeyemo (2005), the reduction of Hb, PCV, and RBC may be associated with the presence of toxic and anti-nutritional elements in the diet. Our results also corroborate those of Mohammed et al (2017), where the poor performance of Hb, PCV, and RBC is strongly correlated with the nutritional quality of the diets. In reference to the high levels of WBC observed within the TM40 treatment, it is important to note that this result may be attributed to either a defensive mechanism of the fish's organs against microbial threats or a potential compromise of the immune system. An inadequate diet weakens the immune system. Our results support the studies of Saleh et al (1998), which stipulated that the increase in WBC may be associated with microbial infections, the presence of foreign bodies in the environment, or low immunity.

Conclusions. The present study demonstrates that it is possible to substitute soybean meal with mucuna meal in the diet of *Oreochromis niloticus*. The ideal rate of 20% is recommended with roasted mucuna to achieve results similar to 20% roasted soybeans. From an economic and hematological perspective, treatments containing 20% soybeans and mucuna have yielded the best results, compared to those of imported feeds. Other pre-treatments, such as fermentation and germination of mucuna seeds, could further reduce anti-nutrients and increase the incorporation rate.

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Conflict of interest. The authors declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper

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