



Research Article

Growth Performance and Feed Utilization of African,
Clarias Gariepinus (Burchell, 1822) Fed Varying Levels of
Camel Foot (*Philostigma Reticulatum*) Seed Meal

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ABSTRACT

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This study evaluated the growth performance and feed utilization of *Clarias gariepinus* fed diets with varying replacement levels of toasted *Philostigma reticulatum* seed meal (TPRSM). A total Three hundred and sixty *Clarias gariepinus* fingerlings ranged from (4.78g to 4.83g) were assigned to 6 treatments and replicated 3 times in a completely randomized design in 1mx1m collapsible tank for sixteen (16) weeks, where 20 fish are stocked per culture medium and were fed at 5% body weight. Weights and lengths were measured biweekly and used to calculate the growth and nutrient utilization parameters. Data collected were analysed using a one-way analysis of variance. The results of the experiments showed the control group demonstrated the best performance with the highest-specific growth rate (SGR), condition factor, survival rate, protein efficiency ratio (PER), and lowest feed conversion ratio (FCR) in favor of growth, health, and feed utilization. On the contrary, 50% inclusion rendered the most dismal performance with the lowest SGR, condition factor, and the highest FCR, indicating less efficiency. The 75% and 100% inclusion levels exhibited intermediate responses where 100% of the level recorded comparatively better PER. Net protein utilization (NPU) showed very little variation among all treatments, implying that protein utilization for all treatment levels was unaffected regardless of TPRSM inclusion level. The study concluded that while *Philostigma reticulatum* seed meal can be used in *Clarias gariepinus* diets, higher replacement levels affect growth performance and feed utilization, which is why higher replacement levels should not be allowed.

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INTRODUCTION

Fish is an important source of food and earnings to many people in developing countries. It provides essential nutrients, including protein, omega-3 fatty acids, and vitamins, which are crucial for maintaining good health. Nigeria is one of the highest consumers of fish among the nations of Africa by far, owing to its mixture of large population and relatively high per capita consumption levels (Adeleke *et al.*, 2020). Amidst the potential, fish farming is faced with a major challenge which is the high cost of feed ingredients especially protein and energy sources such as fish meal, Soybean and maize (Irabor *et al.*, 2022). The implications of high cost of feed are universal to both the fish culturists whose concerns are the production levels, operational costs and sustainability of their ventures and the consumers whose consideration is meeting their fish protein per capita within their convenient budgets. As the need to improve and sustain human food security particularly among economically challenged developing countries is highly imperative, aquaculture has been identified as an increasingly suitable option for improving animal protein intake from 40 to about 60% to achieve expected sustainable development goal (Afe and Omosowone, 2019). There has been a remarkable development in the aquaculture feed industry in the past few years. This is partly due to the intensification of aquaculture as the fastest-growing sector of the global animal production industry, with an average annual rate of about 10.3% since 2010 and has produced 89% of the total global volume of animal production within the last 20 years (FAO, 2020). The cost of feed production alone accounts for 40-65% of total operating costs of finfish aquaculture production in Africa, hence the search for cheap and locally available alternative feed ingredients (Bake *et al.*, 2014). Protein is the most important nutrient and expensive component of fish feed and protein sources usually constitute about 60% or more in the cost of aqua feed production (Adesina and Agbatan, 2021). The cost of feed supply is a critical factor as it usually constitutes the total operational cost of sustainable fish farming for all species and thereby largely influences profitability in aquaculture investments (Dossou *et al.*, 2021).

This has necessitated research into alternative protein sources that can lessen the perennial over-dependence on conventional protein sources such as fish meal, soybean cake and groundnut cake, whose escalating costs are gradually getting beyond the reach of many small-scale fish farmers (Adesina and Adetoro, 2023). The vast availability of plant-based protein sources and their relatively affordable costs have made them more viable alternative ingredients (Zulhisyam *et al.*, 2020).

Philostigma reticulatum (kargo) which is a non-conventional feed ingredient that is less exploited as source of protein in fish production. Studies has showed that *Philostigma reticulatum* is a potential alternative for the replacement of some conventional feed ingredient because of its ability to supply high protein (CP: 30.3% undefatted) Bah *et al.* (2023). *Philostigma reticulatum* is one of the non-conventional feed ingredients referred to as a browse plant. Browsing plants form an important component of plants beside grasses. It is one of the cheapest sources of feed for animals in many parts of the world Bah *et al.* (2023). *Philostigma reticulatum* is a leguminous medium size tree which grows wild in the tropics and is one of the commonest species of *Philostigma* (Hochst) in the northern part of Nigeria (Akin *et al.*, 2009), where it is locally known as “Kargo”. It produces large quantity of pods containing seeds that is not currently utilized for poultry except ruminants that eat the entire pod. *Philostigma* seeds contained from 20 to 34% crude protein as described by (Musa and Bichi, 2015).

MATERIALS AND METHODS

Study Area

The study was conducted at Teaching and Research Fish Farm of the Department of Fisheries, University of Maiduguri, Borno State, Nigeria. The study area falls within the semi-arid zone of Northeastern Nigeria, located between latitude 11° 48' and 16° North and longitude 13° 12' and 12° East. The mean monthly temperature is 40.2°C prior to the onset of the rain in June and the lowest 31.3°C during the peak of the rainy period of August (Abatcha *et al.*, 2023).

Processing of *Philostigma reticulatum* Seed

The seeds obtained were processed using three (3) methods: Soaking, Toasting and Fermentation. The method that gave the best result in terms of Crude protein was selected for formulation of the experimental diet. Below are the processes used for processing of the seeds:

- i. **Raw:** A total of One Hundred and Fifty (150g) grams of raw seeds were labelled and kept in a polytene container and labelled as raw.
- ii. **Soaking:** A total of One Hundred and Fifty (150g) grams of raw seeds were soaked in water to the ratio of 1:3 for 48hrs, spread on a tray to be sun-dried and milled and stored in an airtight polythene container and labelled as soaked.
- iii. **Toasting:** A total of One Hundred and Fifty (150g) grams raw seeds were toasted for 10minutes at 85°C using an electric hot plate according to Oladele *et al.* (2009) then milled and stored in an airtight polythene container and labelled as toasted.
- iv. **Fermentation:** A total of One Hundred and Fifty (150g) grams was moistened with water, kept in a container and covered to ferment for 72hrs. The Fermented seeds was spread on a tray to be sun dried, milled, store in an airtight polythene container and labelled as Fermented.
- v. **Justification of choosing processing methods**
Toasting was selected as the processing method for *Philostigma reticulatum* seed meal that increases its nutritional quality and decreases the anti-nutritional compounds present in fish-feed

ingredients. There have been studies indicating that the use of toasting enhances digestibility and availability of nutrients in fish feed. Oladele *et al.* (2009) reported that toasting the seeds would enhance the fish diet of *Canavalia ensiformis*. Bake *et al.* (2016) and Michael *et al.* (2023) reported that toasted flamboyant and *C. ensiformis* seed meals improved digestibility and growth in *Clarias gariepinus*. Anti-nutritional factors decreased in toasted jackbean seeds, as noted by Fagbenro *et al.* (2004). Tiamiyu *et al.* (2016) confirmed that toasting improves *C. ensiformis* seeds, therefore improving fish growth.

Experimental Diets

Five (5) diets with varying replacement levels of 0, 25, 50, 75, and 100% Replacement levels of toasted *Philostigma reticulatum* seed meal—were formulated using Pearson’s square method. This method was selected because it allows quick calculations to determine the proportions of two feed ingredients needed to meet a specific nutrient requirement. The ingredients were ground and measured using a weighing scale balance, as commonly practiced for fish feed preparation. The ingredients were mixed thoroughly, pelleted, dried, labeled accordingly, and stored at room temperature in the laboratory until ready for use. All ingredients were finely ground and incorporated into the diet homogeneously as indicated in table 1.

Table 1: Percentage Compositions of Ingredients with Toasted *P. reticulatum* Seed Meal

Ingredients (%)	Inclusion Levels of Toasted <i>P. reticulatum</i> Seed Meal (%)				
	0(%)	25%	50%	75 %	100%
Soybean meal	35.47	28.74	20.83	11.42	0.00
Fishmeal	35.47	35.47	35.47	35.47	35.47
TPRSM	0.00	9.58	20.83	34.26	50.54
Maize	24.06	21.21	17.87	13.85	8.99
Methionine	1.00	1.00	1.00	1.00	1.00
Lysine	1.00	1.00	1.00	1.00	1.00
Premix	1.00	1.00	1.00	1.00	1.00
Palm oil	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.5	0.50	0.50
Binder	0.50	0.50	0.5	0.50	0.50
Total	100	100	100	100	100

Calculated Analysis (%)					
Crude protein	40.0	37.84	39.93	32.53	39.8
Ether extract	1.78	2.09	2.45	2.82	2.64
Crude fiber	4.59	4.73	4.93	5.14	4.76
Ash	4.1	4.08	4.11	4.17	3.56
Moisture content	7.89	7.73	7.51	5.56	6.57
NFE	41.6	39.14	40.93	34.83	42.3

Key

TPRSM: Toasted *Philostigma reticulatum* Seed Meal

Experimental Set up and Feeding Regime

A completely randomized design was used in this study. *P. reticulatum* seeds were processed using soaking, toasting, fermentation and raw as control. Toasted *P. reticulatum* seed meal replaced soybean at 0, 25, 50, 75 and 100% i. comprises of 6 treatments including commercial ii. diet. The treatments were replicated thrice. iii. Twenty (20) of the experimental fish were iv. weighed and randomly allocated to 1x1x1m collapsible tanks and the water was filled to 5/6 of its volume. The fish were acclimatized and

fed with experimental diets, morning (09:00am) and afternoon (04:00pm) daily at 5% body weight for Sixteen (16) weeks. Fish were weighing monthly for adjustment of feed. The following data was recorded.

- i. Final weight (g)
- ii. Standard Length (mm)
- iii. Total feed applied (g)
- iv. Mortality of each treatment

Growth and Nutrient Utilization Parameters

The following growth indices were determined for each treatment.

i. Mean Weight gain = Final Weight (FW) – Initial weight (IW)

ii. Feed intake = Feed supplied to the fish

iii. Feed Conversion Ratio (FCR) = $\frac{\text{Total feed Consumed}}{\text{Weigh gain}}$

Where: t = rearing period in days, W_1 = Initial weight and W_2 = Final weight.

iv. Condition factor (K) = $\frac{W \times 100}{L^3}$

Where: W = Weight of fish, L = Standard length of fish

v. Percentage Weight Gain (PWG%) = $\frac{\text{MWG (g)} \times 100}{\text{IWG(g)}}$

Where: MWG (g) = Mean Weight Gain and IWG(g) = Initial Weight Gain

vi. Protein intake (PI) = Feed Intake(g) x % Protein in the diet

vii. Survival rate = $\frac{\text{Initial no. of fish stocked}}{\text{number survived}} \times 100$

Water Quality Parameters

Water quality parameters such as pH, Temperature and dissolved oxygen were taken biweekly.

Data Analysis

Data obtained were subjected to One-way Analysis of Variance (ANOVA). Differences between the means were determined using Duncan's Multiple Range Test (DMTR) at 95% confidence level (P= 0.05).

RESULTS AND DISCUSSION**Results****Table 2:** Growth Performance of *Clarias gariepinus* fed varying levels of Toasted *Philostigma reticulatum* seed meal (TPRSM) Diets)

Parameters	Replacement levels of TPRSM (%)						SEM(P<0.05)
	0%	25%	50%	75%	100%	Com. Diet	
Initial Weight (g)	4.80	4.73	4.87	4.76	4.83	4.85	0.31 ^{ns}
Mean Final Weight (g)	212.90 ^a	140.90 ^{bc}	113.57 ^c	109.23 ^c	94.87 ^c	178.77 ^{ab}	16.67
Mean initial length (cm)	7.20 ^a	7.50 ^a	7.90 ^a	7.40 ^{ab}	7.55 ^{ba}	7.30 ^a	0.05
Mean final length (cm)	25.97 ^a	23.00 ^{ab}	22.57 ^b	20.92 ^b	20.33 ^b	26.17 ^a	1.07
Mean Weight Gain (g)	207.20 ^a	136.17 ^{bc}	108.50 ^c	103.90 ^c	90.50 ^c	172.80 ^{ab}	16.58

Means with the same superscripts in the same row are not significantly different (P>0.05)

Key:

TPRSM: Toasted *Philostigma reticulatum* Seed Meal

SEM: Standard error of means

Mean Growth Performance of *Clarias gariepinus* fed varying levels of Toasted *Philostigma reticulatum* seed meal Diets

Table 2 shows the growth performance of fish fed with different replacement levels of toasted *Philostigma reticulatum* seed meal. The mean initial weights of all fish at the commencement of the experiments ranged from 4.78g to 4.83g respectively. There were no significant differences (P>0.05) in the initial weight of fish between all the treatments. The highest mean final weight of 212.90g was observed in control while the lowest of 94.87g at 100% inclusion levels. There is no significant difference (P>0.05) in the final mean weight between the 50%, 75% and 100% inclusion level of TPRSM, but it differs significantly (P<0.05) from other treatments. The highest final mean standard

length of 26.17cm is recorded in the commercial diet and the lowest (20.33cm) was observed at the 100% inclusion level of TPRSM. There is no significant difference (P>0.05) in mean final standard lengths between both control and positive controls (commercial diets). Similarly, there is no significant difference (P>0.05) in mean final standard lengths among 50%, 75% and 100% inclusion level of TPRSM, but significantly differed (P<0.05) among other treatments. The highest (207.20g) mean weight gain was in the control group, followed by the commercial diet (172.80g) and the lowest (90.50g) with 100% inclusion. There is no significant difference (P>0.05) in mean weight gain of 0%, 75% and 100% inclusion level of toasted TPRSM but differed (P<0.05) among other treatment

Table 3: Feed Utilization of *Clarias gariepinus* fed varying levels of Toasted *Philostigma reticulatum* seed meal (TPRSM) Diets)

Parameters	Replacement levels of TPRSM (%)						SEM(P<0.05)
	0%	25%	50%	75%	100%	Com. Diet	
Feed Conversion Ratio (FCR)	1.03 ^b	1.04 ^{ab}	1.47 ^{a^b}	1.05 ^a	1.08 ^{ab}	1.04 ^a	6.09
Protein Efficiency Ratio	2.02 ^a	1.87 ^b	1.63 ^c	1.72 ^c	1.70 ^c	1.88 ^b	23.57
Net Protein Utilization	0.11	0.08	0.06	0.08	0.09	0.07	0.02 ^{ns}
Specific Growth Rate (%/day)	3.92 ^a	3.64 ^{abc}	3.83 ^{bc}	3.30 ^c	3.34 ^c	3.70 ^{ab}	0.12
Condition factor (K)	1.21 ^a	1.14 ^{ab}	0.98 ^c	1.19 ^a	1.13 ^{ab}	0.99 ^{bc}	0.07
Percentage Survival (%)	50.00	40.00	21.67	38.33	41.67	45.00	18.26 ^{ns}

Means with the same superscripts in the same row are not significantly different (P>0.05)

Key:

TPRSM: Toasted *Philostigma reticulatum* Seed Meal

SEM: Standard error of means

Feed Utilization of the of *Clarias gariepinus* fed varying levels of Toasted *Philostigma reticulatum* seed meal Diets

The Feed utilization of fish fed with different replacement levels of toasted *Philostigma reticulatum* seed meal presented in Table 3. The highest (1.47) feed conversion ratio was 50% inclusion while the lowest (1.03) was in control, indicating efficient feed utilization. There is no significant difference (P>0.05) in, feed conversion ratio in fish fed with control and 50% diets but differs (P<0.05) from other treatments. The highest protein efficiency ratio (PER) (2.02) was recorded in a fish fed diet and the lowest was 1.63 at 50% inclusion. There are no significant differences (P>0.05) in PER in the commercial diet and 20% and 50% inclusion of TPRSM. Similarly, no significant difference between there 75% and 100% inclusion levels of TPRSM but significantly, differed (P<0.05) from control diet. Net protein utilization (NPU) values were relatively similar across all groups, indicating consistent protein utilization. There

are no significant differences (P>0.05) in the NPU of fish fed TPRSM among all the treatments. The highest (3.92g) specific growth rate (SGR) was recorded in the fish fed control group while the lowest (3.30g) in 75% inclusion of toasted TPRSM. There is no significant difference (P>0.05) in specific growth rate of fish fed 75% and 100% inclusion level of toasted TPRSM, but significant variations (P<0.05) were recorded among the other treatments. The highest (1.21) condition factor was recorded in the fish fed control and the lowest (0.98) in the fish fed was 50% inclusion level inclusion of toasted TPRSM. There is no significant difference (P>0.05) in the condition factor of fish fed control and 75% inclusion but recorded variations (P<0.05) among other treatments. The survival rates ranged from 21.67% to 50%, with the highest survival rate in fish-fed control while the lowest (50%) survival rate with the 50% inclusion level of toasted TPRSM. There are no significant differences

($P > 0.05$) in the percentage survival rate among all the treatments.

Table 4: Water Quality Parameters

Parameters	Inclusion Levels of TPrSM(%)					Ref. Diet	SEM
	0%	25%	50%	75%	100%		
pH	7.55 ^a	7.53 ^a	7.51 ^a	7.57 ^a	7.50 ^a	7.53 ^a	Ns
Temperature (⁰ C)	29.35 ^a	29.30 ^a	29.34 ^a	29.21 ^a	29.24 ^a	29.26 ^a	Ns
Dissolve Oxygen (mg/L)	5.50 ^a	5.72 ^a	5.50 ^a	5.57 ^a	5.41 ^a	5.72 ^a	Ns

Means with the same superscripts in the same row are not significantly different ($P > 0.05$)

Water Quality Parameters

The Water quality parameters (pH, temperature and dissolves oxygen) are presented in table 4.6. The results recorded no significant differences ($P > 0.05$) among the treatments. The pH level ranged from (7.50) to (7.57), temperature ranged from (29.21°C) to (29.35°C) while the dissolved oxygen ranged from (5.41 mg/L) to (5.72 mg/L) respectively.

DISCUSSION

Growth Performance and Feed Utilization of *Clarias gariepinus* fed varying levels of Toasted *Philostigma reticulatum* diet

The growth performance analysis indicates that the initial mean weights of the fish were statistically similar across all treatments, suggesting a uniform starting point. This aligns with the findings of Abdullahi *et al.* (2023), who reported that the initial mean weights of the experimental groups and the control were not significantly different ($P > 0.05$). This uniformity at the start of the experiment highlights the effectiveness of the randomization process. The final mean weights, however, showed significant variation, with the control group and the toasted TPRS group achieving the highest final mean weights, followed by the commercial diet. The final mean weights gains of 90.50g and 207.20g in 100% inclusion and control diets respectively are higher than 7.41g and 17.56g of Cassia *fistula* seed meal fed to *Hetrobranchus bidorsalis* fish reported by Ndirmbita *et al.*, 2022 which is also lower than 22.60g – 26.21g recorded in *Clarias gariepinus* by Sogbesan *et al.* (2017) and this is higher than 2.5g – 7.73g in *Clarias gariepinus* as documented by Micheal (2015). The difference in the results from what was obtainable in other studies could be differences in species, rearing duration or environmental factors.

Growth performance and nutrient utilization of fish showed a significant decline as the inclusion of *Philostigma reticulatum* seed meal increased. Fish fed with a toasted *Philostigma reticulatum* diet performed worse than the control group, which aligns with the findings of Olukunle *et al.* (2015) and Tiamiyu *et al.* (2016). Fagbenro *et al.* (2004) previously suggested that biological indicators such as growth performance, survival, feed utilization efficiency, nutrient availability, and the presence of gross or sub-clinical abnormal signs are fundamental measures for assessing the efficacy and adequacy of diets. This suggests that while *Philostigma reticulatum* seed meal can be used as a feed ingredient, higher replacement levels may negatively impact growth performance, possibly due to residual anti-nutritional factors (Kenneth *et al.*, 2020). This observation is also in agreement with the findings of (Abd El-Hack *et al.*, 2022). Mudi *et al.* (2024) observed that growth performance was negatively impacted when watermelon seed meal replaced soybean meal beyond a certain level, due to residual anti-nutritional factors. Similarly, Deyab *et al.* (2009) stated that sesame seed meal could replace fish meal protein up to 50% without adverse effects, although reduced growth performance was noted due to anti-nutritional factors like phytic acid.

Jimoh, *et al.* (2014) stated that one of the major limitations of using alternative plant protein sources in fish feeding is a decrease in palatability and the presence of anti-nutrition factors in the ingredient. The reduction in feed intake due to the unpalatability may lead to deterioration in growth performance and feed utilization (Riche *et al.*, 2004). Michael *et al.* (2023) also reported a reduction in growth and nutrient utilization in fish fed with *Canavalia ensiformis* seed meals was

observed due to the presence of anti-nutritional factors.

The best feed conversion ratio (FCR) of (1.03) in this study was recorded in the control diet using *Clarias gariepinus* which is an indication of an optimum level of utilization of the diet by the *Clarias gariepinus* fingerlings. Michael *et al.*, (2023) also reported best feed conversion ratio in control which corresponds with Wang *et al.* (2021) who stated that the lower the FCR, the better the feed utilization by the fish and observations made by (Bake *et al.*, 2020) in related fish using *Canavalia ensiformis* Seed Meals. Ndirmbita *et al.*, (2022) also revealed lower FCR of (1.21) compared to other replacement levels of Cassia *fistula* seed meal in the diet of *Hetrobranchus bidorsalis*. This trend suggests that the control diet was more efficiently converted into biomass compared to diets with higher TPRSME inclusion (Hasan *et al.*, 2024)

The protein efficiency ratio (PER) followed a similar pattern, with the control group showing the highest PER of (2.02), indicating better protein utilization efficiency. This is in agreement to (Michael, 2023) who reported 2.07 PER in the control diet of *C. gariepinus*. This is different from what was revealed by (Ndirmbita *et al.*, 2022) on *Hetrobranchus bidorsalis* diet, this may be due to the species of fish used for the experiment. Bake *et al.*, (2016) also reported PER of (1.93) to (2.12) on *Senna obtusifolia* seed meal on *C. gariepinus* diet. Orire *et al.*, (2023) revealed that lower inclusions of processed *Moringa Oleifera* (1.62) to (2.12) which is similar to what was observed in this study. Net protein utilization in the study indicates that as the inclusion level of toasted *Piliostigma reticulatum* seed meal increases, the NPU generally decreases. This suggests that higher levels of this seed meal in the diet may lead to less efficient protein utilization. The control diet, with no inclusion of the seed meal, shows the highest NPU (0.11), indicating that the fish are able to utilize the protein in the control diet more effectively. The reduction in NPU at higher Replacement levels could be due to several factors, such as the presence of anti-nutritional factors in the seed meal, which might interfere with protein digestion and absorption. Overall, while the toasted *Philostigma reticulatum* seed meal can be used as a protein source, its inclusion at higher levels seems to negatively impact the efficiency of protein utilization in *Clarias gariepinus*. This aligns with the findings of other studies that have

reported similar trends with alternative protein sources in fish diets Sankian *et al.* (2017).

The condition factor (K), which reflects the overall health and well-being of the fish, the K in the study ranges from (0.98) to (1.21). This is within the range (0.85) – (1.39) observed by Hassan *et al.*, (2023) using soaked *Boscia senegalensis* in *Clarias gariepinus* diet, this slightly difference from what was recorded by Abdullahi *et al.*, (2023) who revealed condition factors (2.06) – (2.18) using *Lemna paucicostata* on *Oreochromis niloticus*. Hassan *et al.*, (2023) disclosed condition factors of (0.85) – (1.39) of fish fed the dietary treatments and the control which are within the range of this study. The results in the study suggest that higher replacement levels of toasted TPRSME may compromise the health and growth efficiency of the fish which is in line with what was recorded by (Kaya and Bilguven, 2024) this might be due to residual anti-nutrients in the experimental diets. This further supports the need for balanced Replacement levels to maximize growth performance (Ayele, 2015).

The survival rate shows a general decline with increasing levels of toasted *Philostigma reticulatum* seed meal. The control diet, with no inclusion of the seed meal, has the highest survival rate at 50.00% while the lowest is 21.67% in 50% inclusion level. The result suggests that higher replacement levels of the seed meal may negatively impact the survival of *Clarias gariepinus*. The lowest survival rate is observed at the 50% inclusion level (21.67%), indicating a significant reduction in survival compared to the control. The mortalities observed could be more likely related to stress caused by sampling and handling, which would have more profound effects on smaller fish (Devic *et al.*, 2018). Nyadjeu *et al.* (2020) reported 84% survival rate in dietary supplementation with garlic and ginger on *Clarias gariepinus* post-larvae similarly, Kutte *et al.* (2024) revealed 98.77% survival rate in fish fed a 50% rice chaff diet of *Clarias gariepinus* fed diets containing processed rice chaff.

Water Quality Parameters

The water quality parameters in your study are crucial for understanding the environment in which the fish were raised. The pH levels, which measure the acidity or alkalinity of the water, were very consistent across all inclusion levels of *Philostigma reticulatum* seed meal, ranging from (7.50) to (7.57), with no significant differences ($P > 0.05$) among all treatments. This consistency in

pH is important as it ensures a stable environment for *Clarias gariepinus*, which thrives slightly acidic to neutral pH levels (Imam *et al.*, 2019)

The temperature of the water was also consistent across all inclusion levels, ranging from (29.21°C) to (29.35°C), with no significant differences ($P>0.05$) among treatments. This stable temperature is within the optimal range for the growth of *Clarias gariepinus*, which typically thrive in warm water conditions (Mbagwu *et al.*, 2022). Maintaining a stable temperature is crucial for metabolic processes and overall health of the fish.

The dissolved oxygen (DO) levels in your study were consistent across all inclusion levels of *P. reticulatum* seed meal, ranging from (5.41mg/L) to (5.72 mg/L), with no significant differences ($P>0.05$) among treatments. This indicates that the seed meal did not significantly affect the oxygen levels in the water. DO levels above (5mg/L) are generally considered adequate for most freshwater fish species, including *Clarias gariepinus* (Imam *et al.*, 2019). Adequate DO levels are essential for respiration and overall fish health. These findings suggest that the inclusion of *P. reticulatum* seed meal in the diet of *Clarias gariepinus* does not adversely affect the water quality parameters, maintaining a stable and suitable environment for the fish. This is consistent with previous studies that have shown the importance of maintaining optimal water quality for the growth and survival of *Clarias gariepinus* (Mbagwu *et al.*, 2022).

CONCLUSION AND RECOMMENDATIONS

The growth and feed utilization study of *Clarias gariepinus* that were fed different levels of toasted *Philostigma reticulatum* seed meal (TPRSM) gave rise to several key findings. In the beginning, the initial weight of fishes was statistically similar across all treatments, showing a uniform starting point and good random sampling. However, significant variability was observed for the final average weights, with the control and toasted TPRSM group having the highest final average weights, followed by the commercial diet.

Growth performance and nutrient utilization declined with increasing levels of inclusion of seed

meal-from-*Philostigma reticulatum*. Growth performance of fishes fed the diet with toasted *Philostigma reticulatum* seed meal was poorer than those of the control, indicating that higher levels of substitution may negatively influence growth performance due to residual anti-nutritional factors. The best feed conversion ratio (FCR) and protein efficiency ratio (PER) were registered in the control diet, which indicated maximum utilization of the diet offered to *Clarias gariepinus* fingerlings.

With increasing levels of inclusion of the toasted *Philostigma reticulatum* seed meal, net protein utilization (NPU) declined, thus indicating reduced efficiency of protein utilization at higher inclusion. Condition factor (K) and survival rate declined with increasing levels of toasted TPRSM, indicating the potential of these anti-nutrients to compromise health and growth efficiency.

Water quality parameters were constant regardless of the level of inclusion, thus indicating that including *Philostigma reticulatum* seed meal did not adversely affect the water quality.

In conclusion, toasted *Philostigma reticulatum* seed meal can be used as a protein source in the diet of *Clarias gariepinus*, but its use at higher levels adversely affects

Implications for Aquaculture

The outcome of the research tells us that toasted *Philostigma reticulatum* seed meal can serve as a protein source in *Clarias gariepinus* diets, but at higher inclusion levels, it adversely affects growth, feed utilization, and survival rates. This could be due to the presence of residual anti-nutritional factors. Consequently, it is recommended that the inclusion of toasted seed meal from *Philostigma reticulatum* should not be more than marginal levels in fish diets for optimum growth performance and feed efficacy.

This observation highlights the need for a careful balance with respect to alternative protein sources so as to enhance growth performance and the health and welfare of fish. Research should focus on exploring alternative means of processing for the enhancement of nutritional quality and the reduction of anti-nutritional factors.

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