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Research article

Effects of *Cassia tora* (L) Feed Supplement on Growth and Nutrients Utilization of *Clarias gariepinus* (Buchell, 1882)

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Abstract
This study investigates the dietary sustainability of *Cassia tora* leaf and seed as a substitute for animal protein in the diet of *Clarias gariepinus*. A completely randomized design (CRD) was used. The leaves and seeds were collected from the Federal University, Dutse, Jigawa State, and identified at Bayero University, Kano. The leaves were washed and shade-dried, while the seeds were manually threshed, rinsed, boiled, air-dried, and ground into powder. One hundred and fifty fish were purchased from Phed Agrovet in Kano, acclimatized, and cultured for twelve weeks. The fish were fed diets containing 0%, 25%, 50%, 75%, and 100% of *C. tora* leaves and seeds, separately and in combination, with three replicates per treatment. Fish were fed 5% of their body weight twice daily. Growth performance and nutrient utilization were assessed through parameters like mean weight gain (WTG), specific growth rate (SGR), percentage weight gain (PWG), feed conversion ratio (FCR), and survival rate. The best weight gain (29.32±32) was observed in fish fed 25% leaf and seed meal, while the lowest (16.84±1.86) was in those fed seed meal only. Fish fed 25% leaf and seed had the highest feed intake (55.8±4.97) and specific growth rate (3.8±0.34). Protein content did not differ significantly across treatments, but lipid content was significantly higher in the 25% leaf and seed diet. This study concludes that up to 25% *C. tora* can replace animal protein in the diet of *C. gariepinus* without compromising growth performance.
Keywords: *Cassia tora,* Growth, Feeds utilization, *C. ga*

Introduction
Clarias gariepinus, a species belonging to the family *clariidae* (Adeleke *et al.*, 2020), has gained considerable attention in Nigeria;s fish production industry, outpacing other animal production sectors in term of growth (Udo and Umanah, 2017). Nigeria is considered one of the highest fish-consuming nations in Africa, with relatively high per capita consumption levels (Chan *et al*., 2019; Adeleke *et al.*, 2020). Several cost-focused studies have concentrated on finding alternative animal feed sources that do not compete with human food supplies (Esonu *et al*., 2004; Udedibie *et al*., 2005; Emenalom *et al.*, 2009). One compelling option is the leaf and seed of the sickle pod (*C. tora*), which has significant potential as a cost-effective energy source in monogastric diets, particularly for poultry (Udedibie *et al*., 2005). It is readily available and does not compete with human food or industrial uses (Assam *et al.*, 2017).
Cassia tora is a widely known herbaceous plant (Ukachukwu, 1997), with an estimated annual availability of 30,000 metric tonnes of seeds (Smith, 2001; Augustine *et al*., 2010). It belongs to the family *Fabaceae* (*Caesalpinaceae*), and is also known as sickle senna, coffee weed, coffee pod, or "java bean" (English) and Tafasa (Hausa) (Augustine *et al*., 2010). In Nigeria, *Cassia tora* is mostly found in the northern regions, particularly in uncultivated areas during the rainy season. *Cassia. tora* thrives in a variety of climates and temperatures, though it prefers warmer conditions, and is a good source of energy and protein (Augustine *et al.,* 2010; Bhujel, 2014; Ingweye *et al.,* 2010). Its estimated composition includes carbohydrates (66-69%), protein (14-19%), fat (5-7%), and anti-nutritional anthraquinone (1-2%) (Abdel-Tawwab *et al.*, 2018).
However, the suitability of feedstuffs for use in fish diets can be determined based on their proximate chemical composition (Mzengereza *et al*., 2014). A number of studies have identified phytogenic plants that show potential in resisting pathogens, improving feed efficiency, and enhancing growth performance (Morais *et al.* (2001); Tutas *et al.* (2013); Abdel-Tawwab *et al.,* 2018). This study aims to investigate the potential effects of *C. tora* leaf and seed feeds as a potential replacement for commercial feeds and other feed sources in fish diets.

Materials and Methods

Experimental Design

The complete randomized design (CRD) was adopted. Fifteen circular plastic aquaria, each with dimensions of 37×30×30 cm, were used. Each plastic aquarium had a capacity of 20 liters of water. Ten *C. gariepinus* fingerlings were distributed into each of the fifteen aquaria and fed for a period of eight weeks. Each of the feeds was provided at varying percentages (0%, 25%, 50%, 75%, and 100%) and at two levels: Leaf and Seeds, and Leaves and Seeds.

$$x = \frac{\text{optimum amount}}{100} \times \%$$

Collection and Identification of Plant Materials

The leaves and seeds of *Cassia tora* were collected from Federal University Dutse, Jigawa State, Nigeria. The leaves and seeds of the plant were taken to the Department of Plant Biology, Herbarium Bayero University, Kano, for proper identification and herbarium accession number was deposited (BUK, Herbarium Accession Number, 0307).

Preparation of Leaves

The leaves were picked out from the plant stalks, washed with water and shed dried for three days. The leaves were transferred into a local mortal and ground using pestle. The ground *C. tora* leaves were poured into a sieve and the fine powder were extracted. The powders were kept in a dry case for later used in feed formulation. Part of the *Cassia tora* leaves powder was taken to the Institute for Agricultural Research, Ahmadu Bello University, Zaria, for proximate analysis as conducted by Ayoola *et al*., (2013).

Preparation of Seeds

Cassia tora seeds were manually threshed, washed, air-dried, and then boiled at 100°C for 40 minutes. After boiling, the seeds were weighed, oven-dried at 80°C for 24 hours, and cooled in a desiccator for dry matter determination. The dried seeds were pulverized in a laboratory blender and sieved through a 0.5 mm mesh. The resulting flour was stored in screw-capped bottles at room temperature for further analysis. A portion of the seed powder was sent to the Institute for Agricultural Research, Ahmadu Bello University, Zaria, for proximate analysis according to the method by Adejoro *et al.* (2013).

Material Used for Feed Formulation

The composition includes *Cassia tora*, fish meal, soybean, maize, groundnut, vegetable oil, bone meal, vitamin premixes, starch, and salt. The percentage composition of the experimental feeds formulated at different inclusion levels of *C. tora* was set (Table .1).

Preparation of the Feed

The method of Amisah *et al*. (2009) was adopted. Briefly the ingredients were ground into powder, weighed, and thoroughly mixed with a wooden rod. Warm water (60°C) was added to make it into dough. The dough was pelleted using a fabricated hammer mill to form pellets. The pelleted feeds were spread on plastic surfaces and sun-dried, after which they were packed and stored in a dry place.

Fish Source

One hundred and fifty *Clarias gariepinus* juveniles, with an average body weight of 4.3g and a standard length of 6.41cm, and six weeks old, were purchased from a commercial fish hatchery (PHED AGROVET) in Kano. They were transported in an open 20L container to the Department of Biological Sciences, Federal University Dutse, in clean fresh water and acclimatized for seven days, Ayoola *et al.* (2013).

Table 1: Percentage Composition of Various Inclusion Levels of *Cassia tora* in the Experimental Feeds.

Ingredients	(0%)	(25%)	(50%)	(75%)	(100%)
Fish meal	25.02	18.84	12.66	6.48	-
Soya bean	23.51	23.51	23.51	23.51	23.81
Maize	22.75	22.75	22.75	22.75	22.75
Cassia tora	-	6.18	12.36	18.54	24.72
Ground nut	24.72	24.72	24.72	24.72	24.72
Bone meal	01	01	01	01	01
Starch	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Vegetable oil	01	01	01	01	01
Vit. Premix	1	1	1	1	1
Total	100	100	100	100	100

Weighing of Fish

The weighing of the fish was done using a digital weighing balance (CAMRY EK5350) at the beginning of each experiment, as well as once every two weeks during the experiment, in order to adjust the feeding level by using 5% of the fish body weight for the following weeks. Fingerlings were randomly selected from all the replicates in each group weekly and weighed. At the end of the experiment, the individual weights of all the surviving fingerlings from all the groups were measured to acquire their final mean weight after the evacuation of feed through a starving process.

Feeding of Experimental Fish

The fish were fed morning and evening at 5% of their body weight as they grew throughout the experiment period. The inclusion levels were: 0% (control) without *Cassia tora* leaf, seeds, as well as leaves and seeds at 25%, 50%, 75%, and 100% of the *C. tora* leaf and a standard feed. The experiments were performed in replicates of three, and the feed was administered to tanks manually at specific quantities to avoid water pollution.

Feeding Method

Feed conversion was conducted according to Falayi (2009) using the following formulars;

$$Mean\ weght\ gain(MWG) = Mean\ final\ weight\ (MFW) - Mean\ initial\ weight(MIW).$$
$$Mean\ standard\ length\ gain(MSLG) = Meanfinal\ standard\ length(MFSL) - Mean\ initial\ standard\ length(MISL).\ FCR = \frac{F}{(Wt - Wo)}$$

where F = the amount of feed (g), Wt = final weight and Wo = initial weight

$$SGR = \frac{lnFBW - lnLBW}{T} \times 100$$

$$Condition\ Factor(K) = \frac{100 \times W}{L3}$$

Where: K = condition factor, L = length (cm) and W = body weight of fish (g)

$$PER = \frac{Gain\ in\ weight\ of\ fish(g)}{Protein\ intake}$$
$$FCR = \frac{weight\ of\ feed\ (g)}{weight\ gain\ of\ fish\ (g)}$$

$$NPU = \frac{fish\ protein\ gain}{protein\ consume} \times 100$$

$$Survival(\%) = \frac{S1}{S2} \times 100$$

Data Analyses

Data were analyzed using two way analyses of variance (ANOVA) and Duncan's multiple range test (DMRT) was used to rank means where significant at (P<0.05) using SAS 9.1.3 software package.

Results

The proximate composition of *Cassia tora* obtained for the leaves, seeds, and a combination of leaves and seeds showed highly significant differences (P ≤ 0.05) in dry matter, crude protein, crude fiber, ether extract, ash content, and nitrogen-free extract. Leaves had higher crude protein (24.22%) and nitrogen-free extracts (37.9%) than seeds. Seeds had higher ether extracts (19.42%) and ash content (12.61%) compared to leaves. The mixed leaves and seeds had a higher crude protein content (26.24%) and nitrogen-free extracts (39.09%), indicating a combination of both components enhances nutrient levels. as shown in Table 2. Percentage proximate composition values of the experimental feeds were significantly different ($p \leq 0.05$) among the feeds except for crude protein. Leaves 0% and Seeds 0% had the highest crude protein (26.83% and 23.23%, respectively), while Leaves 100% had the lowest protein (21.22%), 50% Leaves and Seeds had the highest crude fibre (30.77%), and the inclusion of leaves reduced crude fibre in the seeds. Leaves 25% and Seeds 25% had higher ether extract levels compared to the other treatments (Table 3).

Table 2. Percentage Composition of *Cassia tora*

Parameters	Dry Matter (g)	Crude Protein	Crude Fibre	Either Extracts	Ash	Nitrogen Free Extracts
Leaf	92.98 ± 1.94^a	24.22 ± 3.15^a	19.94 ± 1.21^c	12.41 ± 0.42^c	12.23 ± 0.23^a	37.9 ± 0.57^a
Seeds	94.28 ± 1.2^a	23.6 ± 1.54^a	19.71 ± 0.79^b	19.42 ± 0.28^a	12.61 ± 0.3^d	38.28 ± 0.9^d
Leaves and seeds	97.86 ± 1.2^a	26.24 ± 1.27^a	20.13 ± 0.46^c	15.05 ± 0.15^d	12.08 ± 0.33^a	39.09 ± 0.24^b

Means with different superscript along same column are significantly different ($p \leq 0.05$).

Table 3: Percentage Proximate Composition of Experimental Feeds

Feeds	Dry Matter (g)	Crude Protein	Crude Fibre	Either Extracts	Ash	Nitrogen Free Extracts
Leaves 0%	93.26 ± 1.93*	26.83 ± 5.23*	21.58 ± 1.15*	7.61 ± 0.61*	9.67 ± 0.69*	35.39 ± 2.18*
Leaves 25%	90.88 ± 0.38*	25.11 ± 2.72*	22.35 ± 1.75*	7.56 ± 0.23*	10.81 ± 0.44*	35.73 ± 1.18*
Leaves 50%	91.85 ± 1.45*	23.84 ± 1.49*	19.11 ± 0.47*	5.26 ± 1.17*	11.99 ± 0.37*	35.07 ± 3.19*
Leaves 75%	91.06 ± 0.43*	22.51 ± 1.07*	30.77 ± 6.56*	6.58 ± 1.32*	9.67 ± 0.69*	35.39 ± 2.18*
Leaves 100%	91.34 ± 1.18*	21.22 ± 1.95*	18.73 ± 0.78*	6.35 ± 1.51 *	9.1 ± 0.64*	34.05 ± 1.95*
Seeds 0%	92.82 ± 0.18*	23.23 ± 0.39*	20.95 ± 0.67*	6.06 ± 1.75 *	9.16 ± 0.33*	32.75 ± 0.84*
Seeds 25%	92.35 ± 1.86*	23.6 ± 4.82*	20.06 ± 0.44*	6.28 ± 1.81 *	9.4 ± 0.62*	34.29 ± 3.93*
Seeds 50%	92.81 ± 2.94*	23.79 ± 1.35*	21.38 ± 1.42*	6.28 ± 1.69*	9.04 ± 0.95*	37.29 ± 1.79*
Seeds 75%	93.15 ± 1.02*	23.6 ± 1.22*	19.29 ± 0.35*	6.16 ± 1.23*	9.19 ± 0.44*	36.61 ± 2.07*
Seeds 100%	92.09 ± 1.34*	24.68 ± 0.86*	23.68 ± 7.26*	6.4 ± 1.52*	9.09 ± 0.38*	37.27 ± 0.66*
Leaves and seeds 0%	94.04 ± 4.73*	24.49 ± 2.2*	21.3 ± 1.8*	5.61 ± 0.57*	9.21 ± 0.84*	34.29 ± 4.12*
Leaves and seeds 25%	93.32 ± 4.4*	24.71 ± 1.9*	21.76 ± 1.31*	6.15 ± 1.02*	8.72 ± 0.51*	34.18 ± 4.2*
Leaves and seeds 50%	93.23 ± 3.8*	23.05 ± 4.02*	21 ± 0.93*	6.44 ± 0.98*	9.25 ± 0.29*	34.33 ± 4.05*
Leaves and seeds 75%	93.34 ± 2.56*	25.11 ± 2.63*	20.73 ± 0.71*	6.01 ± 0.89*	9.02 ± 0.57*	36.01 ± 2.57*
Leaves and seeds 100%	94.01 ± 3.16*	21.84 ± 2.1*	19.49 ± 0.91*	6.62 ± 1.44*	8.96 ± 0.54*	37.09 ± 2.17*

Means with different superscripts along the same column are significantly different ($p \leq 0.05$).

The results strongly imply that in Table 4. There was no significant difference ($p > 0.05$) in the MISL. The highest mean length was recorded in leaf meal (0%) with a mean value of 7.42, while the lowest was obtained in leaf meal (75%) with a mean value of 6.36. In MFSL, there was a significant difference ($p \leq 0.05$). Leaves 25% had the highest percentage weight gain (241.2%) and mean body weight gain (13.62 g), indicating better growth performance. Leaves and Seeds 25% also showed an excellent increase in weight gain (268.06%). Leaves 75% resulted in a lower weight gain (59.94%) compared to other feeds, suggesting that higher inclusion of leaves might hinder optimal growth. In Table 5, the results showed a significant difference ($p > 0.05$) in F.I, PER, NPU and FCR. Leaves 25% had the highest protein efficiency ratio (PER: 1.84) and net protein utilization (NPU: 55.14%). Seeds 50% had the best feed conversion ratio (FCR: 1.32), indicating efficient feed conversion. Leaves and Seeds 25% had the highest feed intake (55.82 g), though other feeds had varying levels of nutrient utilization efficiency.

Table 4. Growth Performance of *Claria gariepinus* Fed Experimental Feeds

Feeds	MISL(cm)	MFSL (cm)	MIBW (g)	MFBW (g)	MBWG (g)	PWG (%)
Leaves 0%	7.42 ± 1.34^{a}	14.88 ± 1.36^{a}	5.46 ± 0.55^{a}	18.74 ± 5.57^{a}	14.74 ± 3.36^{a}	40.4 ± 9.96^{a}
Leaves 25%	7.38 ± 1.11^{a}	15.68 ± 2.74^{a}	5.48 ± 0.65^{a}	23.28 ± 0.55^{a}	13.62 ± 4.64^{b}	241.2 ± 34.05^{a}
Leaves 50%	7.38 ± 0.66^{a}	17.18 ± 0.73^{b}	5.29 ± 0.99^{d}	28.14 ± 2.74^{a}	11.12 ± 1.03^{a}	40.4 ± 44.5^{a}
Leaves 75%	6.36 ± 0.77^{a}	16.8 ± 3.37^{a}	4.86 ± 0.6^{a}	19.02 ± 2.58^{d}	11.18 ± 2.53^{a}	59.94 ± 0.79^{a}
Leaves 100%	7.38 ± 0.99^{a}	14.8 ± 3.95^{a}	4.82±10^{a}	18.1 ± 0.66^{a}	10.12 ± 2.58^{a}	50.22 ± 25.61^{a}
Seeds 0%	7.18 ± 0.68^{a}	16.1 ± 3.38^{a}	5.38 ± 0.73^{b}	20.1 ± 2.26^{a}	13.78 ± 3.03^{a}	56.68 ± 10.02^{a}
Seeds 25%	7.8 ± 0.36^{a}	17.68 ± 1.4^{a}	4.38 ± 0.91^{a}	19.3 ± 2.94^{a}	16.78 ± 4.88^{a}	50.5 ± 33.67^{a}
Seeds 50%	7.28 ± 1.08^{b}	17.26 ± 1.8^{a}	4.03 ± 0.36^{a}	18.62 ± 2.85^{a}	10.84 ± 1.93^{a}	52.8 ± 7.46^{a}
Seeds 75%	6.9 ± 0.95^{a}	16.8 ± 0.97^{b}	4.48 ± 0.97^{a}	17.36 ± 0.8β^{a}	13.28 ± 1.84^{a}	31.92 ± 27.18^{a}
Seeds 100%	6.84 ± 0.63^{a}	17.78 ± 0.83^{a}	4.55 ± 0.85^{a}	16.84 ± 1.86^{a}	12.46 ± 2.54^{a}	56.16 ± 49.66^{a}
Leaves and Seeds 0%	7.3 ± 0.6^{b}	17.54 ± 0.47^{a}	5.6 ± 0.58^{a}	19.08 ± 3.47^{a}	12.46 ± 2.54^{a}	83.8 ± 37.86^{a}
Leaves and seeds 25%	6.82 ± 0.41^{a}	17.36 ± 2.43^{b}	4.75 ± 1.01^{a}	29.32 ± 1.73^{a}	17.80 ± 5.13^{a}	268.06 ± 27.04^{a}
Leaves and seeds 50%	6.9 ± 0.69^{a}	17.44 ± 2.38^{a}	4.03 ± 0.28^{a}	20.88 ± 3.17^{a}	13.46 ± 3.8^{a}	89.38 ± 3.77^{a}
Leaves and seeds 75%	7.02 ± 0.6^{a}	17.6 ± 0.72^{a}	4.66 ± 1.44^{a}	17.04 ± 0.25^{a}	13.18 ± 5.56^{a}	70.2 ± 13.97^{a}
Leaves and seeds 100%	7.28 ± 0.76^{a}	16.76 ± 2.92^{a}	4.41 ± 0.44^{a}	19.02 ± 0.76^{a}	13.88 ± 1.79^{a}	44.02 ± 31.3^{a}

Means with different superscripts along the same column are significantly different ($p \leq 0.05$)
MISL = Mean initial Standard length; MFSL = Mean final Standard length; MIBW = Mean initial Body weight; MFBW = Mean final Body weight; MBWG = Mean Body Weight Gain; PWG = Percentage Weight Gain

Table 5: Nutrient Utilization of *clarias gariepinus* fed Experimental Feeds

Feeds	Feed Intake (FI) (g)	Protein Efficiency Ratio (PER) (g)	Net Protein Utilization(NPU)	Feed Conversion Ratio (FCR) (g)
Leaves 0%	31.2 ± 4.97^{d}	1.26 ± 0.83^{a}	40.72 ± 4.45^{d}	1.12 ± 0.41^{d}
Leaves 25%	32.1 ± 1.58^{d}	1.84 ± 0.46^{a}	55.14 ± 10.64^{a}	1.09 ± 1.52^{d}
Leaves 50%	38.8 ± 3.11^{d}	1.74 ± 0.61^{a}	36.86 ± 2.59^{a}	1.56 ± 0.45^{d}
Leaves 75%	33 ± 2.83^{d}	1.06 ± 0.85^{a}	35.44 ± 6.01^{a}	1.5 ± 0.37^{d}
Leaves 100%	34.6 ± 0.89^{d}	1.86 ± 0.86^{d}	33.1 ± 5.31	1.36 ± 0.46^{d}
Seeds 0%	30.6 ± 1.14^{d}	1.14 ± 0.11^{d}	29.62 ± 11.05^{d}	1.16 ± 0.59^{d}
Seeds 25%	34.6 ± 3.65^{d}	1.56 ± 0.46^{a}	59.84 ± 10.95^{d}	1.11 ± 0.54
Seeds 50%	33.6 ± 4.22^{d}	1.52 ± 0.46^{a}	35.56 ± 8.32^{a}	1.32 ± 0.33^{a}
Seeds 75%	32.4 ± 1.14^{d}	1.48 ± 8.69^{a}	30.14 ± 1.65^{a}	1.26 ± 0.21^{a}
Seeds 100%	32.2 ± 0.84^{d}	1.56 ± 0.5^{a}	42.56 ± 5.29^{a}	1.14 ± 0.11^{a}
Leaves and Seeds 0%	33.8 ± 2.77^{d}	2.3 ± 0.4^{a}	25.2 ± 8.91^{a}	1.4 ± 0.5^{a}
Leaves and seeds 25%	55.82 ± 8.97^{d}	1.24 ± 0.05^{a}	59.72 ± 10.78^{a}	1.29 ± 1.52^{a}
Leaves and seeds 50%	32.62 ± 8.97^{d}	1.21 ± 0.11^{a}	31.68 ± 5.53^{a}	1.86 ± 0.57^{a}
Leaves and seeds 75%	31.72 ± 0.67^{d}	1.16 ± 0.45^{d}	34.5 ± 11.25^{a}	1.8 ± 0.35^{a}

Means with different superscripts along the same column are significantly different ($p \leq 0.05$)

There was a significant difference ($p > 0.05$) in specific growth rate, Average growth rate, Survival of rate and there is none in Condition factor. Leaves and Seeds 25% showed the highest specific growth rate (SGR: 3.82%), suggesting the combination of leaves and seeds promotes the best growth rate. Seeds 50% and Leaves 50% resulted in the highest condition factor (1.62 and 1.55, respectively), reflecting better health and robustness of the fish. The survival rate was highest for Leaves 25% and Leaves 0% at 99.94% and 98%, respectively (Table 6).

Table 6. Specific growth rate, Condition factor, Average daily Growth rate and Survival rate of *Clarias gariepinus* Fed Experimental Feeds

Feeds	Specific Growth Rate (SGR) (%)	Condition Factor (F) (g/cm^{3})	Average Daily Growth (ADG) (g)	Survival Rate (%)
Leaves 0%	1.8 ± 0.81^{a}	1.23 ± 0.08^{a}	0.13 ± 0.66^{d}	98 ± 5.48^{d}
Leaves 25%	1.54 ± 0.53^{a}	1.09 ± 0.08^{a}	0.88 ± 0.11^{b}	99.94 ± 8.7^{d}
Leaves 50%	1.22 ± 1.23^{a}	1.07 ± 0.1^{a}	0.77 ± 0.14^{d}	75.8 ± 11.32^{d}
Leaves 75%	1.62 ± 0.98^{a}	1.55 ± 0.53^{a}	0.43 ± 0.19^{b}	74 ± 5.48^{d}
Leaves 100%	1.38 ± 0.82^{a}	1.3 ± 0.47^{a}	0.69 ± 0.31^{d}	65.88 ± 12.59^{d}
Seeds 0%	1.58 ± 0.48^{a}	1.26 ± 0.47^{a}	0.56 ± 0.1^{b}	97.8 ± 8.01^{a}
Seeds 25%	1.38 ± 0.4^{a}	1.21 ± 0.16^{a}	0.56 ± 0.21^{d}	85.8 ± 8.56^{d}
Seeds 50%	1.78 ± 0.4^{a}	1.62 ± 0.32^{a}	0.74 ± 0.16^{b}	76 ± 15.17^{d}
Seeds 75%	1.78 ± 0.4^{a}	1.39 ± 0.27^{a}	0.6 ± 0.14^{d}	68 ± 8.37^{b}
Seeds 100%	1.4 ± 0.35^{a}	1.59 ± 0.48^{a}	0.78 ± 0.04^{d}	78 ± 8.37^{t}
Leaves and Seeds 0%	1.22 ± 0.04^{d}	1.38 ± 0.37^{d}	0.81 ± 0.04^{b}	90.2 ± 6.8^{b}
Leaves and seeds 25%	3.82 ± 0.34^{a}	1.63 ± 0.41^{a}	0.92 ± 0.07^{a}	85.6 ± 10.81^{d}
Leaves and seeds 50%	1.32 ± 0.08^{b}	1.35 ± 0.13^{a}	0.74 ± 0.15^{d}	79.4 ± 7.13^{b}
Leaves and seeds 75%	1.14 ± 0.09^{b}	1.24 ± 0.36^{a}	0.78 ± 0.06^{b}	72 ± 8.37^{b}
Leaves and seeds 100%	1.27 ± 1.23^{b}	1.32 ± 0.44^{a}	0.9 ± 0.07^{d}	70 ± 14.14^{d}

Mean with different superscript along same column are significantly different ($p \leq 0.05$)

Table 7. Carcass Composition of *Clarias gariepinus* Fed Experimental feeds

Feeds	Moisture (%)	Ash (%)	Lipids (%)	Proteins (%)	Carbohydrates (%)
Leaves 0%	31.37 ± 5.55^{a}	1.48 ± 0.33^{a}	12.39 ± 4.03^{a}	30.64 ± 16.58^{b}	29.22 ± 3.07^{d}
Leaves 25%	24.01 ± 2.58^{a}	1.4 ± 0.09^{a}	13.71 ± 4.62^{a}	35.99 ± 6.49^{b}	25.28 ± 3.76d
Leaves 50%	26.35 ± 2.05^{a}	1.36 ± 0.2^{a}	10.1 ± 0.76^{a}	32.05 ± 2.31^{b}	19.51 ± 19.06^{d}
Leaves 75%	25.8 ± 2.01^{a}	1.54 ± 0.4^{a}	10.22 ± 1.88^{a}	27.12 ± 5.26^{d}	14.42 ± 12.14^{b}
Leaves 100%	26.86 ± 0.68^{a}	1.51 ± 0.34^{a}	11.16 ± 2.32^{a}	30.24 ± 3.33^{b}	16.11 ± 15.12^{b}
Seeds 0%	23.56 ± 1.78^{a}	1.64 ± 0.27^{a}	11.68 ± 3.43^{a}	41.69 ± 7.96^{d}	31.18 ± 1.82^{b}
Seeds 25%	23.4 ± 1.75^{a}	1.45 ± 0.35^{a}	11.31 ± 1.65^{a}	29.02 ± 2.83^{b}	32.81 ± 2.63^{d}
Seeds 50%	23.95 ± 2.87^{a}	1.42 ± 0.31^{a}	12.33 ± 1.28^{a}	27.5 ± 2.87^{d}	29.79 ± 5.22^{b}
Seeds 75%	22.54 ± 1.07^{a}	1.53 ± 0.34^{a}	12.62 ± 2.9^{a}	29.72 ± 3.04^{d}	12.39 ± 2.8^{d}
Seeds 100%	22.7 ± 1.08^{a}	1.35 ± 0.32^{a}	12.46 ± 3.36^{a}	26.96 ± 4.21^{d}	19.6 ± 7.23^{b}
Leaves and seeds 0%	23.52 ± 2.04^{a}	1.46 ± 0.13^{a}	11.53 ± 2.1^{a}	39.88 ± 3.99^{b}	34.54 ± 6.77^{d}
Leaves and seeds 25%	22.31 ± 0.86^{a}	1.58 ± 0.27^{a}	11.71 ± 2.09^{a}	50.45 ± 2.2^{b}	31.95 ± 1.46^{d}
Leaves and seeds 50%	22.76 ± 0.6^{a}	1.44 ± 0.39^{a}	11.86 ± 2.2^{a}	28.51 ± 3.42^{d}	31.43 ± 3.24^{b}
Leaves and seeds 75%	22.36 ± 0.54^{a}	1.66 ± 0.3^{a}	11.79 ± 0.96^{a}	31.8 ± 2.67^{b}	33.59 ± 4.98^{d}
Leaves and seeds 100%	22.07 ± 0.61^{a}	1.58 ± 0.23^{a}	10.19 ± 3.73^{a}	32.28 ± 3.1^{b}	14.88 ± 6.53^{b}

Mean with different superscript along same column are significantly different ($p \leq 0.05$)

Furthermore, in Table 7, the results of carcass composition of *Clarias gariepinus* fed experimental feeds showed that, there were no significant differences ($p > 0.05$) among the feeds in moisture, proteins, carbohydrate and ash contents of leaf meals, seed meals, and leaf and seed meals, respectively, there were no significant difference in lipid contents. Seeds 0% had the highest protein content (41.69%), followed by Leaves and Seeds 25% (50.45%). Leaves 25% and Leaves and Seeds 25% showed the highest carbohydrate content (32.81% and 34.54%, respectively), indicating that these feeds were more carbohydrate-rich. Leaves 50% and Leaves and Seeds 50% had lower fat content (10.1% and 11.86%, respectively). Across all tables, it appears that formulations with a combination of *Cassia tora* leaves and seeds, particularly at a 25% level, consistently promote better growth performance, nutrient utilization, and carcass quality in *Clarias gariepinus*. However, for survival rate and certain nutrient efficiencies (like protein utilization), the leaves 0% formulation also performed well. These results suggest that integrating both leaf and seed components at moderate levels may yield optimal growth and health outcomes for fish in aquaculture systems.

Discussion

The proximate composition in percentage of leaf, seed, and leaf and seed (Table 3) showed that the parameters of the experimental feeds, which include dry matter, crude protein, crude fiber, ether extracts, ash, and nitrogen-free extracts, were highly significantly different ($p \leq 0.05$).

It is clearly evident that the higher values obtained in leaf and seed could be due to exposure to sunlight and the method of processing. Bolorunduro (2002) and Robinson *et al*. (2001) described that feed ingredients with crude protein greater than 20% are referred to as protein sources, which makes *Cassia tora* one. This finding is similar to that of Abdullateef *et al.* (2016), who reported the highest crude protein in the proximate of *Senna obtusifolia* seeds and stated that processing techniques influence the levels of proximate components.

There was no significant difference ($p \leq 0.05$) in DM, CF, EE, and Ash among the experimental feeds, but there was a significant difference in CP and NFE. This could be due to the heterogeneous nature of some of the samples (leaf and seed) and the method of processing. This is in agreement with the findings of Umar *et al*. (2017). The crude protein level in diets may exceed 40%, while maintenance may contain as little as 25-35%. The moisture content ranged from 6.7% to 8.4% in feeds, which was not high. This clarified that the feed was properly dried to prevent fungal growth. Typical way to deal with forming feed for basic stomach creatures is to use ingredients that will maintain dietary fiber levels Robinson *et al.* (2001). These levels would be in the range of 3-6% crude fiber for catfish feed. The experimental fish in all treatments exhibited significant weight gain, suggesting their ability to efficiently convert dietary protein into additional muscle mass. Variations in the inclusion percentage of *C. tora* feeds led to differences in feed palatability. Feeds that are readily consumed, efficiently digested, and provide the necessary protein in terms of both quality and quantity are essential for promoting growth (Giri *et al.*, 2003). Adesina *et al*. (2013) observed that weight gain and the rate of species growth are typically regarded as the most crucial metrics. Enhancing protein digestibility may be attributed to the decrease in various anti-nutrients during the pretreatment process, which are recognized for their ability to form complexes with proteins (Peres *et al*., 2003; Keremah and Beregha, 2014). These findings differ from the work of Arage *et al*. (2015), who conducted thermal treatments on soybeans.

However, as the inclusion level of *Cassia tora* increased in the feeds, there was a reduction in the average final weight gained, average weight gain, and specific growth rate of the experimental fish. This could be attributed to the higher fiber content and oil levels in the experimental meals, which increased proportionally. Peres *et al*. (2003) and Lawal *et al*. (2013) observed a decrease in weight gain when feeding *C. gariepinus* with high levels of fiber inclusion in sun-hemp seed diets. The global evaluation of various alternative protein sources as partial or complete substitutes for fish meal in fish diets has been extensively conducted. Protein efficiency ratio (PER) is influenced by the non-protein energy intake in the diet and serves as a reliable indicator of the protein-saving impact of lipids and/or carbohydrates (Tibbets *et al.,* 2005). In this study, the (PER) of the experimental fish showed a significant difference ($p \leq 0.05$) across all treatments. Moreover, the PER values increased among the experimental fish in relation to the quantity of total feed intake. Similar observations were made by Dharmakar *et al.* (2022), Xu *et al.* (2022), and Ashiru *et al*. (2015). The significant difference ($p < 0.05$) in PER value observed with the 25% *Cassia tora* treatment suggests optimal utilization of inherent nutrients in the diet at this concentration, which was not achievable at higher inclusion levels. This finding corresponds with observations of Dada and Olugbemi (2013) and aligns with findings noted by Adejumo (2005), who reported the highest PER value when replacing maize with fermented millet at a 20% inclusion level.

The Net Protein Utilization (NPU) serves as a measure of the protein utilized in forming the fish carcass relative to the total protein intake, representing the quality, digestibility, and utilization of the protein provided to the fish. The variance in NPU values among fish fed various experimental feeds in this research insignificance ($p > 0.05$). However, it's worth noting that the NPU value obtained from the 25% *C. tora* inclusion level was greater than those from other treatments. This observation aligns with findings outlined in the reports of Egesi *et al*. (2016), who recorded the highest NPU at a 25% inclusion level of earthworm meal.

A notable distinction was observed with a significance level of $p \leq 0.05$: fish fed a diet consisting of 25% *Cassia tora* (leaf and seed). This finding is consistent with suggestions by previous authors that a combined protein source is better than a single protein source for fish feeds (Ugwumba *et al.*, 2001; Sogbesan *et al.*, 2005). According to Francis *et al*. (2001), it also exhibited the highest mean specific growth rate (SGR) at 3.8. This could potentially be attributed to varying percentages of inclusion in the feeds.

The findings of this study regarding the aforementioned observation support the notions of Musa *et al.* (2012), Augustine *et al.* (2020), Diarra *et al*. (2019), and Aderolu *et al*. (2011); however, they differ from the findings of Alegbeleye *et al.* (2012). The specific growth rate reported by Francis-Floyd (2014) exceeds the one found in our study.

Nevertheless, the condition factor (K) of the experimental fish fed different *Cassia tora* meals was not significantly different (p > 0.05) among the diets. The mean condition factor indicates that fish in all the treatments were in good condition throughout the study period, as they remained stable. The essence of measuring fish condition factor lies in assessing the overall health, fitness, and well-being of fish populations, providing insights into environmental conditions, habitat quality, population dynamics, and the efficacy of management strategies. This is similar to the work of Ahmed and Abdelati (2009) and Atawodi *et al*. (2008), but contradicts the findings of Falayi (2009) and Adesina *et al*. (2013). Edward *et al*. (2010) reported that all well-fed fish in their study exhibited values above 1, indicating effective feed utilization that contributed to enhanced growth and overall health.

The Average Daily Growth Rate (ADR) observed in this study was similar to that of Ndimele and Owodeinde (2012), Tiamiyu *et al*. (2015), Tutas *et al*. (2013), and Abdullateef *et al.* (2016), who induced *C. gariepinus* and *Heterobranchus bidorsalis* with synthetic hormone (ovaprim) and pituitary glands of male and female *C. gariepinus.* The average daily growth rate found in this study was opposite to that recorded by Zamal *et al*. (2008) of 14.00% in 15% Ipil-Ipil leaf meal. There was no significant difference (p > 0.05) in survival rate (SR) of experimental fish fed different diets. The survival rate observed in this study was higher than that reported by Dayal *et al.* (2012) in India, achieving a maximum survival rate of 62%, and similar to rates documented by Dedeke *et al*. (2013), reported lower survival rates for *Clarias gariepinus* compared to juveniles fed on *Moina dubia* and mixed zooplankton. In a study investigating the effects of stream and tap water on *C. gariepinus*, Idi-Ogede (2012) reported a 39% mortality rate in tap water setups. The elevated mortality in tap water setups might be attributed to abrupt fluctuations in water quality parameters.

Nutritional studies, protein requirements receive significant attention because it is the nutrient needed in the greatest quantity for growth and development, and it is also the costliest ingredient in formulations (Ajonina and Nyambi, 2013). Dietary lipids function as an available source of energy for fish and supply essential fatty acids needed for fish growth and survival. Fish generally require omega-3 fatty acids rather than omega-6 fatty acids, unlike terrestrial animals which require omega-6 fatty acids (Abdullateef *et al.,* 2016). Dietary lipid is regarded as the primary component in fish diets required to support growth but can proportionally increase feed costs (Ahmad *et al*., 2012).

The present study showed an increase in protein levels across the treatments, along with an average increase in carbohydrates and a significant decrease in moisture. This could be attributed to the high protein content of *C. tora*, which is consistent with the findings of Amerah *et al.* (2014) and Assam *et al.* (2017). The carcass crude protein of fish fed different dietary levels in this study was higher than that observed by Bake *et al*. (2016) for *C. gariepinus* fed different dietary levels of toasted *S. obtusifolia* seed meal. This suggests that boiled *S. obtusifolia* seed resulted in improved growth outcomes for *C. gariepinus* juveniles, compared to the toasted seed fed to *C. gariepinus* fingerlings in the study by Bake *et al*. (2016). This difference is likely due to the presence of anti-nutrients in the seed and the feed utilization differences at the fingerling stage.

Recent research has shown that substantial use of vegetable oils as energy sources in fish diets has resulted in favorable growth responses in fish as state by Aderolu and Akinremi, (2009). The results obtained from this study demonstrate that the lipid sources used have good nutrient composition. This observation implies that there were no palatability challenges and that their utilization was adequate, similar to the work of Aderolu and Akinremi (2009) on the utilization of coconut oil and peanut oil in catfish diets.

Multiplying the increase in lipids has been associated with increased efficiency of metabolism. Similar results were also observed in gilthead bream fingerlings (Pamino *et al*., 2018). Additionally, earlier reports on fish such as *Ictalurus punctatus* (Raj *et al*., 2007), *Salmo gairdneri* (Gatlin, 2010), and *Sciaenops ocellatus* (Robinson and Li, 2008) showed that the dietary lipid requirement of fish ranged from 6% to 11%, which corresponds with the findings of this research.

CONCLUSION

The percentage composition of *Cassia tora* (leaf and seeds) shown that the contents of the plant possessed maximum amount of proteins and lipids that will promote growth and development of the experimental fish, the experimental feed formulation showed significant different at ($p \leq 0.05$). The growth performance where significant the *Clarias gariepinus* showed compromising development at 25% inclusion levels. Nutrients utilization and other parameters indicate significance different at ($p \leq 0.05$). Therefore, *Cassia tora* leaf and seeds in combinations or separately can be used to replaced feed supplement in the dietary of *Clarias gariepinus.*

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