RESEARCH ARTICLE

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Utilization of Tigernut (*Cyperus esculentus* L.) Meal as Dietary Supplement by African Catfish (*Clarias gariepinus* Burchell, 1822)

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Abstract
Two hundred and fifty five *Clarias gariepinus* fingerlings with average body weight of 5.0 ± 1.0 g were allotted to five isoproteic diets (CP = 40%) in which tigernut replaced maize at 0%, 25%, 50%, 75% and 100% respectively. The catfish fingerlings were divided into five groups of 45 fish per treatment and fed at 3% biomass for 20 weeks. Result showed significant ($p < 0.05$) differences in feed intake and specific growth rate but no significant ($p > 0.05$) differences in feed conversion ratio (FCR) and body weight changes among the dietary treatments. This indicates that tigernut meal can be tolerated as replacement for whole maize in African catfish diets without compromising production/yield.

Keywords: Chronic; African catfish; performance; tigernut; biomass.

1. Introduction

The role of fish as the cheapest source of animal protein particularly in rural communities of developing countries has been well documented [1]. The aquaculture industry has been globally recognized as the fastest growing food production industry [2] where it contributes more than 19 million metric tons of fish and shellfish yearly to the world's fish [3]. In Nigeria, fish contributes 40% of the animal protein consumption [1, 4].

In spite of this potential, aquaculture in most developing nations including Nigeria is faced with inadequate supply of quality fish feed at economic price. This problem is worse during the dry season of the year when the cost of feedstuffs, most especially cereals, usually soared because the natural demand for out-weighed the supply. In an attempt to solving this problem of high feed cost, a lot of research efforts have been geared into alternative novel ingredients in formulating practical diets for farmed fish [5–7].

The primary focus of these researchers was geared towards substituting and/or replacing the orthodox cereals such as maize and millet which often are staple food by Nigerians and major raw-material in beer-brewing industry. Tigernut (*Cyperus esculentus*) is a non-conventional feedstuff that is cultivated primarily for its oil that is rich in omega 3 fatty acid and the vegetable milk [8]. *C. esculentus* is relatively cheap compared with maize and the crude protein content ranged between 7% and 9.2% depending on the variety [8]. Tigernut like other plants has been reported to contain some phytotoxins such as alkaloids, trypsin inhibitors, tannins, phytase and saponins that are deleterious when fed in high dosage to monogastrics [9]. Nevertheless, some of these toxins can be curtailed through processing such as fermentation, toasting among others. This research unlike most other works was designed to evaluate the long-term (chronic) effect of feeding raw tigernut based diets to African catfish on performance using feed intake, body weight changes and FCR as parameters.

2. Methods

2.1. Source and processing of the ingredient

The tigernuts used for the study were purchased from the open market at "AMA-HAUSA" in Owerri, Imo State, Nigeria. The tigernut seed were sundried for 4–5 days and passed through a hammer mill, to produce tigernut meal. The drying process was to reduce excess moisture so as to prevent rancidity of the material and growth of moulds.

Other conventional feed ingredients such as maize, fish meal, soya bean meal, wheat offal, bone meal, palm kernel meal (PKM), vitamin-premix and salt were procured from Zion farm feed mills, Egbu, Owerri, Imo State, Nigeria. A sample of tigernut meal and trial diets were subjected to proximate analysis (Tables 1 and 4) using standard procedures [10]. The tigernut meal was further subjected to phytochemical analysis for anti-nutritional inhibitors using standard methods (Table 2).

Table 1: Proximate composition of tigernut meal (%DM).

Parameters	Concentration (%)
Moisture content	7.62
Crude protein	8.44
Ether extracts	27.71
Crude fiber	11.69
Ash	3.51
Nitrogen free extract (NFE)	41.03

Table 2: Anti-nutrients of raw tigernut meal.

Parameters	Quantity
Tannin (%)	1.59
Saponin (%)	1.23
Phytase (mg/g)	18.12
Phytin phytase (mg/g)	6.11
Phenols (%)	1.31

2.2. Experimental fish and design

A total of 225 catfish fingerlings (*Clarias gariepinus*) with mean weight 5.0 ± 1.0 g were purchased from a commercial hatchery at Owerri, Imo State, Nigeria. They were acclimatized and fed commercial feed for 7 days. Forty five fingerlings were randomly assigned to each of the five isonitrogenous experimental diets in a completely randomized design. Each treatment group was further divided into 3 replicates of 15 fish in a Hapa net (measuring $1\,m \times 1\,m \times 1\,m$) suspended by Bamboo poles in an outdoor cistern ($4\,m \times 5\,m \times 1.2\,m$). The fish were starved 24 hours prior to commencement of the trial. Water chemistry was usually monitored and maintained [11].

2.3. Experimental diets

Five isonitrogenous diets (CP = 40%) were formulated such that tigernut meal replaced maize at 0%, 25%, 50%, 75% and 100% respectively. Other feed ingredients were of the same quantities for all the diets. The feeds so formulated (Table 3) were passed through pelleting machine with sizes 2 mm and 4 mm for the first 10 weeks and thereafter respectively. Pelletized feeds were sundried until crispy (between 3 and 4 days depending on the sun intensity). The feeds were fed to the fish at 3% body weight shared into two, between 7–8 am and 4–6 pm daily throughout the duration of the experiment which lasted for 5 months. The feeds were analyzed for proximate composition [10].

Table 3: Composition of experimental diets fed to African catfish (*C. gariepinus*).

Ingredients	Tigernut dietary inclusion (%)				
	0	25	50	75	100
Maize	25.0	18.75	12.50	6.25	–
Tigernut	–	6.25	12.50	18.75	25.0
Soya bean meal	25.0	25.0	25.0	25.0	25.0
Fish meal	20.0	20.0	20.0	20.0	20.0
Groundnut meal	10.0	10.0	10.0	10.0	10.0
Blood meal	10.0	10.0	10.0	10.0	10.0
Spent grain	5.0	5.0	5.0	5.0	5.0
Bone meal	2.0	2.0	2.0	2.0	2.0
Vitamin-premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vegetable oil	2.0	2.0	2.0	2.0	2.0
Salt	0.25	0.25	0.25	0.25	0.25
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

2.4. Data collection

The entire fish in each Hapa were batch weighed at the commencement of the trial and weekly thereafter using a digital weight balance. Weighed fish were usually returned into their respective Hapa's thereafter. Feeding was adjusted weekly according to the new body weight. Stale water was usually drained off the pond as and when required and the pond refilled from the borehole water at the farm complex.

2.5. Statistical evaluation

Data collected were subjected to one way analysis of variance as described by Snedecor and Cochran [12] and where significant difference was indicated such mean was compared using Duncan multiple range test [13].

3. Results

The gross composition of the trial diets is shown in Table 4. Results of the nutrients assay of the experimental feeds revealed that the crude protein concentration decreased from 40.11% in control diet (0%) to 37.34% in tigernut based diet (100%). Similar trend was observed with soluble carbohydrate NFE concentration which decreased with increased tigernut inclusion in the diets.

Table 4: Proximate composition of tigernut based diets fed to catfish (*C. gariepinus*).

Parameters	Tigernut dietary inclusion (%)				
	0	25	50	75	100
Moisture content	8.93	9.12	9.76	9.17	9.75
Ash	9.26	8.79	9.78	10.37	10.90
Crude fat	1.48	5.34	5.84	6.54	7.30
Crude fiber	4.28	4.31	4.84	5.52	5.96
Crude protein	40.11	40.06	38.60	38.36	37.34
NFE	35.94	32.38	31.15	30.04	28.75

3.1. Feed intake

The mean total feed intake of the trial catfish were 1139.06, 965.90, 1211.02, 934.70 and 938.25 g for 0%, 25%, 50%, 75% and 100% dietary treatments respectively. There were significant differences ($p < 0.05$) among the treatments. Nevertheless, the correlation between feed intake and body weight gain, FCR and feed intake for experimental fish were 0.561 and 0.691 (56.1% and 69.1%) respectively implying that there was a strong positive correlation between feed intake and body weight gain and feed conversion ratio. These correlations were also statistically significant ($p < 0.05$).

3.2. Body weight changes

There was no significant difference ($p > 0.05$) in body weight gain among the treatment groups. The mean weight gains of the fish were 284.07, 283.83, 317.54, 288.87 and 259.97 g for 0%, 25%, 50%, 75% and 100% dietary treatments respectively.

3.3. Feed conversion ratio

The FCR of the catfish were 4.01, 3.40, 3.81, 3.23 and 3.61 for 0%, 25%, 50%, 75% and 100% dietary treatments respectively. The group on 75% dietary inclusion of tigernut had the best FCR while the control diet recorded the least value. There was no significant difference ($p > 0.05$) among the treatment groups.

3.4. Specific growth rate

The highest value of 1.24 was recorded from catfish fed 50% tigernut based diet while the least 1.18 was recorded for catfish group fed diet with 100% tigernut inclusion. There were significant differences ($p < 0.05$) among the treatment groups.

Table 5: Performance of *C. gariepinus* fed tigernut based diets.

Parameters	Tigernut dietary inclusion (%)				
	0	25	50	75	100
Initial weight of fish (g)	5.93^{a}	6.17^{a}	5.96^{a}	6.03^{a}	6.03^{a}
Final weight of fish (g)	290.00	290.00	323.00	295.00	266.00
Weight gain of fish (g)	284.07^{a}	283.83^{a}	317.54^{a}	288.87^{a}	259.97^{a}
Total feed intake (g)	1139.06^{ab}	965.90^{bc}	1211.02^{a}	934.70^{c}	938.25^{c}
FCR	4.01^{a}	3.40^{a}	3.81^{a}	3.23^{a}	3.61^{a}
Specific growth rate (%/day)	1.21^{ab}	1.19^{b}	1.24^{a}	1.21^{ab}	1.18^{b}
Protein efficiency ratio	10.24^{a}	12.00^{a}	10.41^{a}	11.93^{a}	10.06^{a}

^{abc}Means within rows with same superscripts are not significantly different ($p > 0.05$).

4. Discussion

The crude protein of all the diets fall within the recommended range of 35%–40% for African catfish [14–17]. The general increase in the body weight of the experimental fish in all the treatments is an indication that all the treatment diets were adequate in dietary protein and other nutrients required by African catfish, similar results were obtained when tilapia fingerlings were fed on different grains [18], and *C. gariepinus* fingerlings were fed cocoyam and tigernut based diets [19, 4] respectively.

The greatest body weight gain of fish (317.54 g) recorded at 50% dietary inclusion of tigernut may be due to synergetic effect between the utilization of polysaccharides in maize and tigernut tubers by the catfish, and was able to convert it into muscle for growth. Similar reports were obtained when cassava leaves were fed to tilapia (*Oreochromis niloticus*) at 66.7% [20, 21]. The best utilization of wild variegated cocoyam in catfish diet was also recorded at 66% dietary level [22]. This agrees with the literature that channel catfish (*Ictalurus punctatus*) utilized polysaccharides for growth better than disaccharides.

The study on boiled cocoyam fed to weaning piglet [23] gave similar growth performance when compared with the control diet (maize based diet) even up to 50%, while another research [24] also reported that the mixture of rice mill by-products at 50% substitution improves growth of rabbits, better than the control (maize based diet).

Nevertheless, the correlation between feed intake and body weight gain, FCR of experimental fish were 0.561 (56.1%) and 0.691 (69.1%) respectively implied that there was a strong positive correlation between feed intake, body weight gain and FCR. These may perhaps explain reason for statistically similar specific growth rate and FCR of the trial catfish ($p > 0.05$). This result is not in agreement with earlier report [4] that recorded a decline in growth of African catfish juveniles fed tigernut based diets beyond 50% dietary level.

It may also mean that the fish were able to tolerate the tigernut at older age with better physiological adaptation compared to the juvenile stage when the earlier study was conducted. Similar results have been reported in poultry which tolerate higher fibre at finisher stage compared to starter phase [25].

5. Conclusion

Since there were no statistical differences in body weight gain and FCR of African catfish fed tigernut based diets compared to control, and all experimental fish were able to attain the minimum 200 g recommended as table size fish, the test ingredient can safely be recommended as a substitute for maize in African catfish diets without compromising production/yield. However, it will reduce the production cost and cost per kilograms of fish.

Competing Interests

None declared.

Authors' Contributions

Both authors had read the final draft of the manuscript. LAA designed the experiment, performed the laboratory and statistical analyses. CFE wrote the protocol and carried out the feeding trial.

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