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Influence of including maize offal in diets on growth, carcass composition and economics of *Clarias gariepinus*

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Abstract

Aiming at finding cheaper and still efficient feed for aquaculture species 56 days feeding trial was conducted on African catfish (*Clarias gariepinus*) post fingerlings, fed on five diets with a 40% crude protein target in which maize was replaced with maize offal meal at 0%, 25%, 50%, 75%, and 100% respectively. Ten fish each were stocked in a plastic aquarium tank containing 20 L of water. The fish were fed at 5% body weight divided into two rations given at the hours of 8-8:30 am and 5-5:30pm. Growth parameters showed increase with increase in maize offal based diets, with observed weight gains of 72.42, 79.00, 95.92, 130.83 and 65.83 for diets 1, 2, 3, 4, and 5 respectively. Feed conversion ratio (recorded best in 75% maize offal based diet substitution, while the poorest was recorded at 25% maize offal diet replacement, followed by the control diet (100% maize diet). 75% maize offal replacement recorded the highest specific growth rate ($p < 0.05$). There was significant difference ($p < 0.05$) in the ash content, crude fiber and energy level in the fish carcass. The cost of feed used throughout the experimental period was not significantly ($p > 0.05$) influenced by the increasing level of maize offal as a replacement for maize in the diets, as the costs were comparable. However, this study reveals that maize offal meal can successfully replaced maize up to 75% in the diet of *Clarias gariepinus* post fingerlings without adverse effect on growth, carcass composition and economics.

Keywords: *Clarias gariepinus*; Maize offal; Growth parameters; Economics of production; Carcass composition

1. Introduction

Maize (*Zea mays*) is a member of the family *Graminae* also known as corn, a cereal crop that grows across a wide range of agro-ecological zones in Nigeria. Due to its rate of acceptability, maize is produced all year round in areas that favour such cultivation [1]. Maize provides a major source of energy in formulated feeds for fish and land animals [2,3]. It commands high prices as a result of its acceptability as food for many organisms including man. In Nigeria, maize has been widely used as the principal energy source in monogastric animals. However, the keen competition for this ingredient between man, industries and livestock makes its cost eats into the profit margin of the average livestock farmer. Thus, feed can account for about 60-80% of the total cost of animal production [4,5]. Locally available ingredients may lead to the formulation of least-cost rations [6]. A maize production figure of 7 million metric (tons is inadequate to meet the needs of the human population of more than 200 million people, let alone be available as feed for fish and other animals [1].

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This brings a need to make use of agro by- products that are considered less useful for human consumption, for fish feed formulation. Vantsawa [7] noted that maize offal still has some nutritional value in spite of its reduced price. Several workers have been carrying out this investigation especially for maize [8, 9, 10, 11, 12]. To boost aquaculture production, Aliyu-A *et al.* [12], Ada *et al.* [4] and Odunze *et al.* [13] separately pointed that *Clarias gariepinus* belonging to the family Clariidae is a candidate for solving fish protein scarcity. It is widely and naturally distributed in all parts of the African continent, and it requires calm waters like those found in lakes, ponds and pools but may also occur in fast flowing streams and rivers African fresh water air-breather capable of tolerating wide fluctuation of dissolved oxygen, and other extreme environmental conditions since it has accessory breathing organ which enables it to breathe air when subjected to active situation or under very dry conditions. This fish species is hardy and can adapt to poor environmental conditions. It is known to grow fast, possess palatable white flesh (meat quality) when eaten fresh and sweet brown flesh when eaten dried [14, 15].

The aim of this research was to search for agro by-product as an energy source that will bring the cost of the fish feed down and increase profitability for the fish farmer. It is also hoped that findings of this research will be of great benefit to the fish culturist because maize offal is considerably cheaper than maize and readily available where starch extraction from maize for other uses is common place.

This is coupled to the fact that its production is dwindling [3]. Several attempts have been made to replace or supplement the maize component of fish feed with cheaper non-conventional energy sources; [2, 3, 5, 6, 11, 16, 17]; Maize offal is component after the starch concentrate. In many occasions, the offal is regarded as a waste component of the maize. Effort is made here to ascertain effect of maize offal on the growth, carcass composition and the economics of maize offal use in diets of *Clarias gariepinus*.

2. Material and methods

2.1. Study area/ Collection of experimental fish

300 live *Clarias gariepinus* post fingerlings were obtained from the University of Calabar Fish Farm. The fish were acclimatized in large plastic holding tanks for a period of two weeks. During acclimation, the fish were fed with COPPENS industrial feed. The study was carried out in the wet Laboratory of the Department of Fisheries and Aquatic Science, Cross River University of Technology, Cross River State. Twenty fish were stocked in each of the fifteen transparent plastic aquaria (60×30×15cm), representing five treatments and three replicates per treatment.

2.2. Feed formulation

Feed preparation was done with the following locally available feed ingredients: Fishmeal, cow blood meal, soybean meal, maize, maize offal, palm kernel cake, palm oil, fish oil and vitamin & mineral premix. Cassava starch was used as a binder. The composition of the feed ingredients of the various test diets is presented in Table.1.

Table 1 Ingredient composition of the experimental diets.

Ingredients (g/100g)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Fishmeal (65% cp)	32.00	32.00	32.00	32.00	32.00
Soybean meal (45 % cp)	16.00	16.00	16.00	16.00	16.00
Blood meal (80 % cp)	12.00	12.00	12.00	12.00	12.00
Maize (10% cp)	20.00	15.00	10.00	5.00	0.00
Maize offal (10% cp)	0.00	5.00	10.00	15.00	20.00
Palm kernel cake (7 % cp)	10.00	10.00	10.00	10.00	10.00
Fish oil	3.00	3.00	3.00	3.00	3.00
Palm oil	3.00	3.00	3.00	3.00	3.00
Vitamin/mineral premix	2.00	2.00	2.00	2.00	2.00
Binder	2.00	2.00	2.00	2.00	2.00
TOTAL	100.00	100.00	100.00	100.00	100.00
Calculated crude protein level (%)	40.30	40.30	40.30	40.30	40.30

Soybean was toasted and like other ingredients milled into fine powdery form and weighed as per the formulation in Table 1. The weighted ingredients were thoroughly mixed and then pelleted using pelleting machine. The pelleted feeds were sundried to reduce moisture content to about 10% for storage at 40C in the fridge ready for use.

Note that this same nutrients composition was used by Okey *et al.* [11].

2.3. Other experimental Protocols

Fish were fed twice a day at 5% body weight divided into two rations given at 8.00-8.30 am and the other half at 5.00-5.30pm. The study lasted for 56 (8 weeks) days after the acclimation period. During the period of the study, the fish were batch-weighed in an interval of two weeks and the feed adjusted accordingly to maintain the feeding rate.

Data collected were used to assess growth performance using the following criteria, which were used also by several workers [10, 17, 18, 19]

$$\text{Percentage weight gain (PWG)} = \frac{W_f - W_i \times 100}{W_i}$$

Where W_f = final weight; W_i = initial weight of fish

$$\text{Specific growth rate (SGR)} = \frac{(\ln W_f - \ln W_i) \times 100}{T}$$

Where T= Number of days the experiment lasted

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed consumed (g)}}{\text{Fish weight gain (g)}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Weight gain (g)}}{\text{Protein intake (g)}}$$

The total length of a sample of five fish per replicate was taken and used to determine the condition factor K using the relationship

$$(K) = \frac{\text{Body weight in grams} \times 100}{\text{Body length in cm}}$$

At termination of the experiment, a total of two fish per aquarium were sacrificed; their liver weights and body weights taken. This was used for hepatosomatic index assessment as

$$\text{HIS} = \frac{\text{Liver weight} \times 100}{\text{Whole body weight}}$$

$$\text{Survival rate (SR \%)} = \frac{\text{Initial number stocked} - \text{Number of fish dead}}{\text{Initial number stocked} \times 100}$$

2.3.1. Proximate analysis

The proximate analysis of *Clarias gariepinus* carcass and experimental diet were carried out using the official method of analysis of the association of official analytic chemist [20].The carcass and diet analysis was done in the central research laboratory, Faculty of Agriculture and Forestry, Wildlife and natural resources, University of Calabar, Nigeria.

2.3.2. Water quality monitoring

Water quality parameters were checked every day between 7.00- 7.30am. Temperature was measured using mercury in-glass thermometer, the water pH was taken, and dissolved oxygen was also determined by using digital meter model 3505 JENWAY. The water was changed every 2 days throughout the period of the experiment.

$$\text{Percentage moisture} = \frac{(Y - Z) \times 100}{x}$$

Where X and Y are the sample weight and the weight of dish + sample respectively prior to drying, and Z the weight of dish + sample after drying. Y-Z is the loss in weight of sample after drying.

$$\text{Percentage ash} = \frac{(Y - Z) \times 100}{x}$$

Where:

X= sample weight prior to drying; Y= weight of dish and contents after ashing; Z= weight of empty dish.

The percentage crude protein was calculated as follows:

$$\% \text{ crude protein} = \frac{\text{titre} \times 14.01 \times \text{Normality of acid} \times 100 \times 6.25}{1000 \times \text{weight of sample}}$$

Where 6.25 is a general factor suitable for products in which the protein of specific protein is not well defined. 14.01 is a constant and titre is the volume after titration.

The percentage crude fat was calculated as follows:

$$\% \text{ crude fat} = \frac{w_2 - w_1 \times 100}{S}$$

Where:

W1 = weight of empty evaporating dish; W2 = weight of evaporating dish + content after drying; S = sample weight before drying.

The percentage crude fiber was calculated as follows;

$$\% \text{ crude fiber} = \frac{w_2 - w_1 \times 100}{w_1}$$

Where:

W1 = sample weight before drying; W2 = weight of residue after drying; W3 = weight of residue after ashing

2.4. Determination of carbohydrate content of *Clarias gariepinus* carcass

The percentage carbohydrate content of the fish sample was determined by summing up the percentages of moisture, ash, crude protein, fat (ether extract) and subtracting from 100 ([21]). The difference in value was taken as the percentage total carbohydrate content of the sample. The total carbohydrate of the leaf sample is contained in two fractions, the crude fiber and the nitrogen free extract.

2.5. Economic analysis

Based on the price of each raw material and the amount that was required to make the different diet, the cost of each diet was established. The economic evaluation of the diets was calculated using the method of George et al [22] as follows:

Estimated Investment Cost Analysis (EICA) = Cost of feeding + Cost of Fish stocked

Profit Index (PI) = Value of Fish / Cost of feeding

Benefit Cost Ratio (BCR) = Total sales / Total expenses

Incidence of Cost (IC) = Cost of feed / Weight of fish produced

2.6. Statistical analysis

The data collected throughout the experimental period were subjected to one way analysis of variance (ANOVA) test using SPSS (Version 18.0) for windows on PC. Where significant differences were indicated, means were tested using Least Significant Difference (LSD) test at 0.05% level of significance [23].

3. Results

The result showing the proximate composition of treatment diets is shown in Table 1. The fishes that were fed 75% maize offal based diet had greater appetite (daily feed intake), better feed conversion ratio (FCR) and protein efficiency ratio (PER) than those fed 25% maize offal based diet and control. See Table 2. As displayed in Table 3, there was no significant difference ($p > 0.05$) in the carcass of the fishes fed different treatment diets except for ash content, crude fiber and energy levels. Ash content was significantly different with increase in maize offal based diet. Fish fed 100% maize offal based diet was significantly higher ($p < 0.05$) with a recorded mean value of 16.09, and the lowest mean value of 3.64 was recorded in the control treatment. The fiber content of those subjected to the control, 50% and 100% maize offal based diet were not significantly different ($p > 0.05$), but were significantly different from those in 25% maize offal based diet substitution, with the lowest mean value of 0.01. The mean values of the fiber content in the fish carcass along the various treatments were relatively lower than the values recorded in the treatment diets. The economics of substituting maize with maize offal as analyzed is displayed in Table 5 with the highest gain at 75 % substitution.

Table 2 Proximate composition of treatment diets

Feed composition	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Moisture content	4.49±0.01	4.52±0.10	4.34±0.90	4.49±0.96	4.08±0.22
Dry matter	95.51±2.81	95.48±2.17	95.66±2.67	95.51±2.90	95.92±1.06
Crude ash	9.94±2.96	10.18±1.30	11.07±0.84	10.22±0.45	10.93±1.36
Crude protein	33.95±5.31	32.65±7.45	29.10±4.01	27.65±7.27	29.75±3.55
Crude fibre	1.68±0.39 ^{bcd}	2.10±0.11 ^b	1.58±0.13 ^{bcd}	1.85±0.18 ^b	2.53±0.09 ^a
Carbohydrate	37.69±2.62	36.55±1.59	45.91±7.78	42.29±5.24	40.96±3.59
ME (Kcal/kg)	396.01±20.08	402.80±26.16	372.04±96.68	401.26±66.08	388.59±38.84
Crude fat	12.25±1.46 ^a	14.00±0.30 ^a	8.00±1.15 ^b	13.50±1.12 ^a	11.75±1.82 ^a

Means with different super script along the row are significantly different ($p < 0.05$)

Table 3 Carcass composition of *Clarias gariepinus* post fingerlings fed different levels of maize offal diet for 56 days

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Moisture content	76.76±0.74	78.51±0.80	81.07±1.84	75.49±4.10	77.55±2.36
Dry matter	23.24±0.74	21.49±0.80	18.93±1.84	24.48±4.15	22.45±2.36
Ash content	3.64±2.08 ^c	3.92±0.73 ^c	11.16±0.52 ^b	15.26±0.98 ^{ab}	16.09±2.95 ^a
Crude protein	37.88±2.35	42.39±4.74	42.59±5.01	33.18±0.33	34.99±5.07
Crude fiber	0.03±0.01 ^a	0.01±0.01 ^b	0.03±0.01 ^a	0.02±0.00 ^{ab}	0.03±0.01 ^a
Carbohydrate	15.47±3.06	12.96±6.81	11.80±2.93	14.34±5.75	9.46±1.68
ME (Kcal/kg)	391.05±16.25 ^a	394.44±26.94 ^a	356.95±24.52 ^{ab}	304.40±23.62 ^b	330.75±15.17 ^b
Crude fat	19.74±1.51	19.22±5.93	15.49±5.72	12.72±3.85	16.99±2.12

Means with different superscript along the row are significantly different ($p < 0.05$)

Table 4 Growth performance of *Clarias gariepinus* post fingerlings fed different levels of maize offal based diet for 8 weeks.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Initial mean weight (g)	2.65±0.22	2.50±0.32	2.96±0.54	2.63±0.10	2.62±0.53
Final mean weight (g)	6.51±0.75	6.71±1.67	6.65±0.85	9.85±1.77	7.12±1.45
Percentage weight gain(PWG)	55.63±4.16	85.18±111.27	71.96±22.98	136.62±28.61	63.22±33.14
Specific growth rate(SGR)	3.30±0.18ab	3.01±0.73b	3.41±0.46ab	3.65±0.45a	3.15±0.38ab
Weight gain (WG)	72.42±15.42	79.00±93.65	95.92±63.11	130.83±69.59	65.83±35.15
Protein efficiency ratio (PER)	7.28±0.22	8.43±4.93	10.52±1.64	13.52±1.91	8.62±1.64
Feed conversion ratio (FCR)	3.15±0.01	3.37±1.47	3.02±0.44	2.52±0.34	3.04±0.63
Initial condition factor (ICF)	0.82±0.18	0.77±0.16	1.18±0.18	0.96±0.38	0.97±0.17
Final condition factor (FCF)	0.46±0.18	0.59±0.17	0.49±0.05	0.66±0.05	0.57±0.11
Hepatosomatic index (HSI)	7.04±0.09	7.56±0.70	6.99±0.83	6.93±0.15	7.01±0.17
Survival rate (SR)	96.07±5.25	95.00±5.98	95.33±4.81	96.67±4.50	95.33±4.81

Means with different super script along the row are significantly different (p<0.05).

Table 5 Economic analysis of *Clarias gariepinus* post fingerlings fed different levels of maize offal based diets.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Initial cost of fish (N)	25	25	25	25	25
Projected wt. of fish (kg)	0.25±0.01	0.27±0.16	0.30±0.05	0.38±0.05	0.26±0.05
Value of fish (700/kg)	173.13±5.35	192.73±112.56	214.20±33.49	262.03±36.84	179.43±34.08
Wt. of feed used (kg)	0.78±0.00	0.77±0.00	0.91±0.00	0.93±0.00	0.76±0.00
Cost of feed/kg	431.79	424.77	417.75	410.73	403.71
Cost of feed used (N)	336.79±0.00	327.07±0.00	380.14±0.00	381.97±0.00	306.81±0.00
EICA	361.79±0.00	352.07±0.00	405.14±0.00	406.97±0.00	331.81±0.00
Profit index	0.52±0.02	0.59±0.34	0.57±0.09	0.69±0.10	0.59±0.11
Incidence of cost	1.37±0.04	1.43±0.63	1.26±0.18	1.04±0.14	1.23±0.26
Benefit cost ratio	0.48±0.02	0.55±0.32	0.53±0.08	0.65±0.09	0.55±0.10

Means with different superscript along the row are significantly different (p<0.05)

4. Discussion

The crude protein (c.p) of the diet targeted was 40% and the crude protein of the formulated diets fall within the range of 15-40% recommended by Lovell [32] for *Clarias gariepinus* fingerlings. The result above shows that there was significant difference (p<0.05) in the crude fiber of the experimental diets. The control diet, 25%, 50%, and 75% maize offal based diets were not significantly different (p>0.05) in crude fiber content, but were significantly different (p<0.05) from 100% maize offal based diet substitution. Crude fiber values of the diets increased progressively as dietary inclusion of maize offal increased, where 100% maize offal based diet substitution had the highest recorded mean value of 2.53. The energy value decreased with increase in the level of offal in the diets. This is because maize offal is low in energy and as the level of inclusion increased the energy level of the feed decreases while the fiber level of the diet increases [24]. This energy level did not fall below energy requirement of the fish. Energy availability was optimal. According to ALiyu-A et al. [12] and Brown et al. [31] when carbohydrate is in optimal availability, there will be no diversion to the use of protein and other food substances for the provision of metabolic energy. With sufficient

carbohydrate source, a protein level of 30 % in the feeds can lead to optimal growth. Since protein has not become the source of energy provision, the protein is left alone to carry out its functions of tissue building [12].

There were no significant differences in the concentrations of carbohydrates in the carcass of fish given different levels of maize offal. Mohanty [25] opted that carbohydrate is not for storage. It is responsible for the provision of metabolic energy. So it is dispensed immediately it is made available. So at all times, it is not supposed to build up. The concentration observed here is therefore normal. According to Mohanty, [25], fish is a good source of all nutrients except carbohydrates and vitamin C.

The higher the consumption and absorption of the maize offal based diets, the lower the energy level in the carcass of the fish. In other words, there was an inverse relationship between the dietary consumption and the energy deposited in the fish carcass. It has been reported that feed intake of monogastrics including fishes is a function of the dietary energy requirement. That is, animals will continue to eat until the energy requirement is met [26].

Whole maize has high level of carbohydrates. Maize offal has the carbohydrate content reduced because some starch has been removed or extracted for other uses. The remaining carbohydrate level favours growth parameters. It is noted that high carbohydrate level is not good for fish nutrition as it leads to fat deposition by stimulating lipogenic enzymes [11]. Excess carbohydrates has even been reported to cause mortality, reduced feed efficiency and growth rate [27]. Another factor which is important in nutrition is the attractiveness of the feed. Food could be available with optimal nutrient content for optimal intake; it must have attractants in terms of smell and visibility. It is only after the food must have been ingested that the question of digestibility and assimilation come in.

Also, there was significant difference ($p < 0.05$) in the crude fat content of the experimental diets. The control diet, 25%, 75% and 100% maize offal based diet were not significantly different ($p > 0.05$), but were significantly different ($p < 0.05$) from 50 % maize offal based diet which recorded the lowest mean value of 8.00, as against the highest recorded mean of 13.5 in 75% maize offal based diet substitution. This value agreed with Onu *et al* [28] who recorded similar observations in poultry.

An advantageous economic use of maize offal here agreed with the findings of Vantsawa *et al* [7], who reported similar findings in terms of cost savings using dusa to replace maize in pullet diets. For Onu *et al*. [28] every farmer aims at reducing cost of production and maximize profit. In *Clarias* species, different workers had successfully replaced corn starch with cassava starch due to its digestibility. Talthawan *et al*. [28] pointed out that amylopectin is responsible for easy digestion in cassava. For instance, Olurin *et al*. [8] has substituted up to 50 % of corn with cassava starch in fingerlings; Olukunle [30]) replaced corn starch with sweet potato peels and whole root in fry *Clarias* species while Abu *et al* [16] was able to replace corn starch with cassava starch up to 66 % with favourable results.

The result above shows that the profit index and benefit cost ratio was less than 1 for all levels of replacement. Therefore, the feed was not economical or profitable. This was generally based on economic situation as of the time because there were up surge of prices of feeds with no change in the price of fish produced per kilo which led to the decrease in the profit index and benefit cost ratio.

The non-competition between maize offal meal and humans is an advantage due to reduced cost. The study revealed that maize in catfish (*Clarias gariepinus*) diets cannot be entirely replaced with maize offal, but may be used at dietary level not beyond 75% inclusion for catfish production. 75% maize offal based diet substitution was best in weight gains, feed utilization and all other growth parameters, as compared to the control based diet of 100% maize inclusion. 50% maize offal based diet substitution also did credibly well in all the growth parameters after 75% maize offal based diet substitution. In the economic analysis, 75% maize offal based diet also did best in the profit index and benefit cost ratio with the highest sum of N381.97 for the total cost of feed used throughout the experimental period, next to 25% and 100% maize offal based diets substitution with N327.07 and N306.81 respectively for the cost of the total feed consumed by the fishes throughout the 56 days feeding trail, which explain that an increase in the maize offal based diet brought about an increase in the profit index and benefit cost ratio.

5. Conclusion

Results of this study indicates that maize offal meal can be tolerated by *Clarias gariepinus* post fingerlings up to 75% replacement without adverse effect on the growth and nutrient utilization. Due to findings that excess carbohydrates do not favour meat quality, maize offal should be used in place of whole maize for it equally cut cost of feeds.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest. The authors contributed appropriately for the completion of this work. This work is a B.Sc. project work of Mr Kenneth Igbang Sunday. It was supervised by Proessor Stephen Ncha Ochang and written by Professor Fidelis Bekeh Ada.

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