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EFFECTS OF SUBSTITUTING CORN MEAL FOR CORN COB MEAL ON DIETS ACCEPTABILITY, GROWTH RESPONSE AND COST OF DIETS FED TO CATFISH (*CLARIAS GARIEPINUS*)

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ABSTRACT: *A seventy -day feeding trial was conducted to assess the replacement value of corn cob meal as a dietary replacement for corn meal in diets of Clarias gariepinus. The corn cob was treated with 2% NaOH. The treatment reduced the fibre and increased the protein contents of the corn cob. Six isonitrogenous (40% crude protein) diets were formulated and corn cob meal was included in the diets at 0%, 10%, 20%, 30%, 40%, 50% and 100% inclusion levels designated as diets A, B, C, D, E, F, and G respectively, and diet H (commercial Coppens fish feed). The acceptability of the diets was studied using the time to strike the pellets and the acceptability index. The growth response and cost of diets were estimated. Results indicated that substituting corn meal with corn cob meal in diets fed to C. gariepinus juveniles increased the time taken by fish to strike dietary pellets. The higher the proportion of corn cob meal in the diet, the lower the acceptability of the diet to the fish. The least acceptable diet was diet G. The fish fed diet H recorded better weight gains and specific growth rate followed by the control diet and diet C respectively. There were significant differences between the control diets and the experimental diets (P < 0.05). The cost-benefit analysis showed that catfishes fed the control diets had a comparatively lower cost of diet per unit weight gain than the fish fed the corn cob-based diets. This was closely followed by diet C. This study demonstrated that corn cob meal can be successfully used to replace corn meal in the diets of Clarias gariepinus at inclusion levels of up to 30% but it is efficacious and cost-effective at a 20% inclusion level.*

KEYWORDS: *Clarias gariepinus*, African catfish, corn cob meal, acceptability, growth, cost.

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INTRODUCTION

The African catfish (*Clarias gariepinus* Burchell, 1822) is a widely cultured mud catfish species in Nigeria because of its wide range of water tolerance, fast growth, disease resistance, excellent taste and high market demand (Adewolu *et al.*, 2009). There is high demand for *C. gariepinus* in Nigeria but unfortunately due to the high cost of fish feed, fish farmers have not been able to meet up with the growing demand for the product (Kareem and Ogunremi, 2012).

Feed represents the most expensive cost in aquaculture operations, accounting for over 50% of the total running cost (Eyo, 2003). There is a need to substitute conventional feed ingredients with cheaper and non-conventional ones in order to reduce the high cost incurred in feeding fish. The price of maize has been competitively high because of human use as food and biofuel production (Aletor, 2005). Since corn is expensive as a feed ingredient, the use of nonconventional feedstuffs as a replacement has been reported with growth and better cost-benefit values. There are several unexplored unconventional feedstuffs which would not compete stiffly with human or livestock diets (Ugwu and Mgbenka, 2006).

Attempts have been carried out to search for alternative untraditional low-price by-products which could be used in feeding fish (Anyanwu *et al.*, 2012). Corn cob is a by-product obtained during the production of corn grains. The high fibre content of cobs reduces the digestibility of other ingredients in diets resulting in poor growth. Treatment of cobs with alkali aims at eliminating anti-nutritional factors, improving nutrient digestibility and enriching the quality of protein in corn cobs (Bedford, 1993).

This study was conducted to determine the effects of graded levels of replacement of corn as a source of energy with corn cob on the acceptability of diets, growth performance and cost of diets fed to *C. gariepinus* juveniles.

MATERIALS AND METHODS

Experimental Catfish

One hundred and sixty-eight (168) *Clarias gariepinus* juveniles with a mean weight of 10.05 ± 0.22g were supplied by a private fish farm in Awka, Anambra State and transported to the wet laboratory of the Fisheries and Hydrobiology Research Unit within the Zoological Garden, University of Nigeria, Nsukka. The fish were acclimated for 7 days and fed 5% of their body weight with the standard diet containing 40% crude protein. The experimental setup comprised 8 treatments replicated thrice, each replicate having 7 catfish. Twenty-four (24) concrete ponds measuring 1 x 1 x 1m^3 were used for this study. They were covered with mosquito nets to prevent the escape of fish, as well as the entry of predators and leaves from falling in. All ponds were continuously aerated using an air conditioner compressor. The water temperature, pH and alkalinity during the experimental period ranged between 29.1 – 32.1^{o}C, 6.9 – 7.2 and 104.72 – 112.55 respectively.

Purchase and Processing of Feed Ingredients

The dietary ingredients were purchased from Ogige Market, Nsukka and individually processed, while the corn cobs were obtained from Ose Market, Onitsha. A modified

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Wanitwattanarumlug *et al.* (2012) technique was adapted to prepare the corn cob meal, summarized as follows: The cobs were washed in water to remove dust and sun-dried for two days. They were coarse ground using a hammer mill and treated with an alkali solution (2% NaOH) for 24 hours (Table 1). The coarse ground cobs were transferred to a microwave oven and treated at 120°C for 25 minutes. The residues were collected using Whatman filter paper washed with tap water until neutral pH, and dried at 65°C. The dried powder obtained was finely ground, sieved and stored in sealed polythene bags at room temperature till required. The diet ingredients were weighed out and the diet compounded. One kilogram of each experimental diet was weighed out using Mettler electronic balance (PC 2000) into seven basins. The ingredients were homogenously mixed with 250 ml of water per kilogram of diet to produce dough. Each dietary dough was transferred into heat-resistant polythene bags, tightly sealed and properly labeled. The bagged feeds were pressure-cooked at 100ºC for thirty minutes. This facilitated the gelatinization of starch which binds the diet and also activates the dietary nutrients. The different diet dough was run through a meat mincer (Woodland, Japan) fitted with 3 mm dye and the resulting nodule-shaped strands were cut into pellets and oven dried separately at 50ºC for 1 hour. Diet A (control diet) had 0 % corn cob meal. Diets B - G had 10 %, 20 %, 30 %, 40 %, 50 % and 100 % of corn meal substituted with corn cob meal while Diet H was Coppens fish feed (Table 2). All dietary ingredients and prepared diets were analyzed (Table 3) to ascertain their proximate composition (AOAC, 2005).

Diet Acceptability

The acceptability of the diet was accessed using the “time to strike” method described by Eyo (1997). The fish in every treatment was starved overnight to induce hunger. Pellets of diets for each treatment were dropped into the pond, and the time which elapsed from the moment the pellet penetrated through the water and the moment the last fish struck the pellet with its mouth was recorded in seconds. The acceptability index was calculated as the reciprocal of the time to strike.

Growth Studies

For the growth studies, a randomized Latin Square Design of eight treatments replicated thrice was employed with each replicate having seven catfish. The treatments were labelled A to H and each with replicates 1, 2 and 3. Fish in each treatment was fed 5% of their body weight of the specific diet *i.e*., fish in treatment A was fed diet A and Treatment B fed diet B and so on. Weekly records of weights for the treatments were used in adjusting the feeding levels and in the calculation of the specific growth rate. using the formula: $SGR = In\ W_2 - In\ W_1 / t_2\text{-}t_1$ (Chiu, 1989). Where $In\ W_2 - In\ W_1$ = Natural logarithm of initial and final weight over a period (days) $t_2\text{-}t_1$.

Cost Analysis: The cost analysis of feeding *C. gariepinus* juveniles with corn cob meal supplementations was estimated utilizing different levels of corn cob meal inclusion. All the costing was done in Naira (Nigerian official currency) using Nsukka Urban Market price and converted into US dollars based on Nigeria Apex market exchange rate of one US Dollar equivalent to one thousand five hundred Naira ($1 ≈ ₦1500) as at the time of this research.

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Data Analysis

Means and standard error from the different treatments were calculated. One-way ANOVA and F-LSD were employed to test treatment means. Differences were considered to be significant at $P < 0.05$.

RESULTS

Proximate Composition of Untreated and Treated Corn Cob Meal

The results of the proximate analysis of the untreated and sodium hydroxide (NaOH) treated corn cob meal are shown in Table 1. From the results, the untreated corn cob had lower crude protein content (3.5 %) compared to the untreated corn cob (4.81 %). It therefore follows that treatment with sodium hydroxide increased the protein content of the corn cob. However, the fibre content was reduced in the treated corn cob (14.38 %) compared to the untreated corn cob (18.69 %). The treatment increased the fats and ash contents of the corn cob while moisture was greatly reduced.

Table 1: Proximate composition of untreated and treated corn cob meal

Nutrient	Untreated corn cob (%)	NaOH-treated corn cob (%)
Crude protein	3.50	4.81
Carbohydrate	65.87	74.83
Fats	0.71	1.32
Moisture	9.51	2.66
Ash	1.72	2.00
Fibre	18.69	14.38

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Table 2: Composition of dietary ingredients per kilogram of experimental diets

Ingredient	Diet A (0%)	Diet B (10%)	Diet C (20%)	Diet D (30%)	Diet E (40%)	Diet F (50%)	Diet G (100%)	Diet H
Fish meal	250	250	250	250	250	250	250	
Blood meal	100	100	100	100	100	100	100	
Soybean meal	450	450	450	450	450	450	450	
Corn meal	170	153	136	119	102	85	0	
Corn cob meal	0	17	34	51	68	85	170	
Vitamin premix	6.5	6.5	6.5	6.5	6.5	6.5	6.5	
Mineral premix	6.5	6.5	6.5	6.5	6.5	6.5	6.5	
Hemicellulose binder	17	17	17	17	17	17	17	
Total (g)	1000	1000	1000	1000	1000	1000	1000	

[1] Vitamin premix provided the following ingredients per gram of diet, Vitamin A, 4IU; Vitamin DB 2IV; Niacin, 0.088mg; d-pantothenic acid 0.035 mg; Vitamin B12, 0.0009 mg; Vitamin E, 0.055IU; Riboflavin 0.013 mg; Choline chloride, 0.55 mg; Menadione sodium bisulfate complex, 0.01 mg; Pyridoxine hydrochloride, 0.01 mg; Thiamine mononitrate, 0.01 mg; Folic acid, 2.03 mg; Antioxidant, 0.138 mg; Ascorbic acid, 0.176 mg.
[2] Mineral premix provided the following trace elements per gram of diet; Mn 0.087 mg; Mg 10.001 mg; Cu 10.004 mg; Zn 0.666 mg; Co 30.00007 mg.

Table 3: Percentage of nutrient composition per kilogram of experimental diets

	Diet A (0%)	Diet B (10%)	Diet C (20%)	Diet D (30%)	Diet E (40%)	Diet F (50%)	Diet G (100%)	Diet H
Crude protein (%)	40.30	40.27	40.18	40.10	40.02	39.94	39.53	49.61
Carbohydrate (%)	37.22	37.22	37.22	37.22	37.22	37.22	37.22	39.20
Fats (%)	7.30	7.24	7.18	7.13	7.07	7.02	6.74	4.10
Moisture (%)	5.43	5.35	5.27	5.19	5.10	5.02	4.62	3.47
Ash (%)	3.92	3.93	3.95	3.96	3.98	4.04	4.04	2.72
Fibre (%)	2.73	2.94	3.14	3.35	3.56	3.77	4.80	0.90

Acceptability

The mean time it took the catfishes in their different treatments to strike each dietary pellet varied with dietary type from 3.36 ± 0.37 seconds in diet A (0% corn cob meal) to 5.43 ± 0.14 seconds in diet H (Coppens fish feed) (Fig 1). There were observed inconsistencies in the time to strike pellets from diet B (10% CCM) - 9.20 ± 0.24 seconds, diet C (20% CCM) - 9.56 ±

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0.25 seconds, diet D (30% CCM) - 12.43 ± 0.83 seconds, diet F (50% CCM) - 14.20 ± 0.55 seconds, diet E (40% CCM) - 15.30 ± 0.99 seconds and pellets from diet G (100% CCM) - 18.30 ± 0.21 seconds. From the result, diet A had the least time to strike (3.36 ± 0.37 seconds) while the maximum time to strike was recorded in diet G (18.30 ± 0.14 seconds). Thus, the inclusion of corn cob meal reduced the acceptability of the experimental diet. In all the treatments, the time to strike for all dietary pellets was statistically significantly different from the control diet ($P < 0.05$).

The acceptability index followed a similar trend with diet A (0.30 ± 0.03) readily accepted, followed by diets H (0.18 ± 0.00), B (0.10 ± 0.00), C (0.09 ± 0.00), D (0.07 ± 0.00), F (0.06 ± 0.00), E (0.06 ± 0.00) and G (0.05 ± 0.00) (Fig 1). All acceptability indices were statistically significantly different from the control ($P < 0.05$).

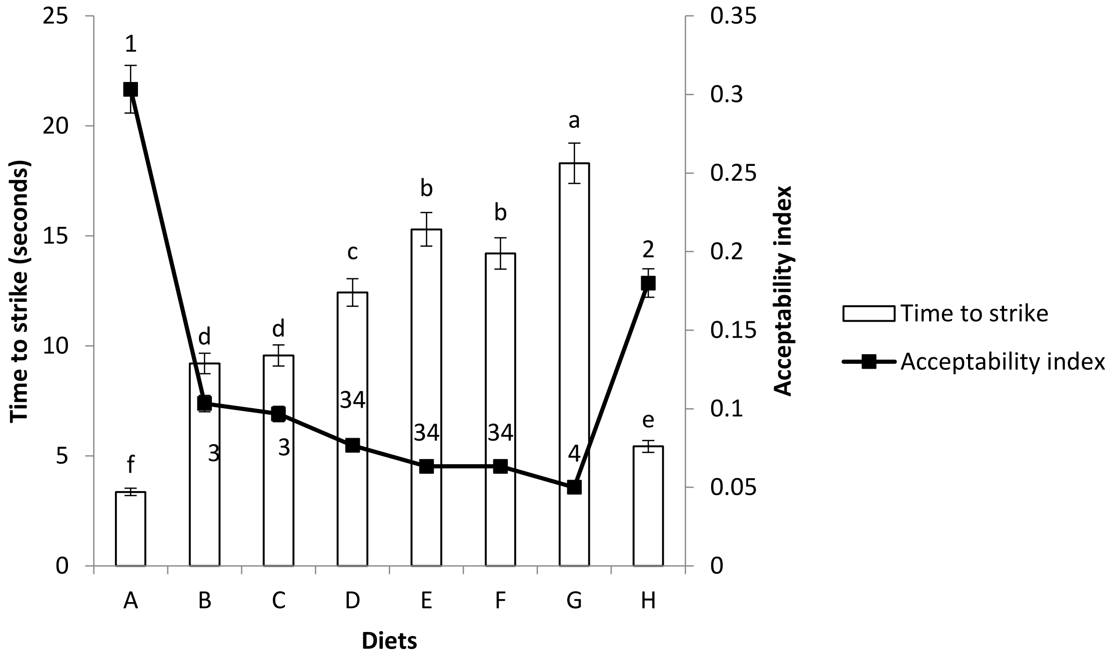

Fig 1: Time to strike and acceptability index of graded levels of corn cob meal-based diets fed to *Clarias gariepinus* juveniles.

Values with different letters on top of the bars are significantly different ($P < 0.05$)

Values with different numbers on the line are significantly different ($P < 0.05$)

Growth Response

The effects of increasing substitution of corn meal for corn cob meal in diets fed to *C. gariepinus* juveniles for ten weeks showed growth differential with different dietary types (Figure 2). Diet H (57.80 ± 1.04g) had the best mean weight gain. The overall mean weight gain at the end of the tenth week for the catfishes fed diet G (100 % CCM - 11.90 ± 0.11g) was low when compared with the mean weights of catfishes fed diets A to F. The results for other treatments were: Diet A - 49.40 ± 0.15g, Diet C - 44.60 ± 0.60g, Diet B - 37.70 ± 0.32g, Diet D - 34.70 ± 0.58g, Diet E - 32.60 ± 0.20g and Diet F - 31.40 ± 0.15g. Treatment means for diets B to H were significantly different from the control ($P < 0.05$). The specific growth rate

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of *C. gariepinus* juveniles fed diets with corn cob meal substituted for corn meal (Figure 3) indicated that catfishes fed the control diet (diet A, 2.40 ± 0.01) had higher specific growth rate when compared with other treatments. Specific growth rate of catfishes as influenced by the substitution of corn meal for corn cob meal in their diets were 20 % CCM diet (diet C, 2.31 ± 0.04), 10 % CCM diet (diet B, 2.06 ± 0.01), 30 % CCM diet (diet D, 2.03 ± 0.02), 40 % CCM diet (diet E, 1.93 ± 0.02), 50 % CCM diet (diet F, 1.88 ± 0.02) and 100 % CCM diet (diet G, 1.03 ± 0.01). All treatment means for specific growth rates of catfishes fed except treatment C (20 % CCM) were statistically significantly different from the control ($P < 0.05$).

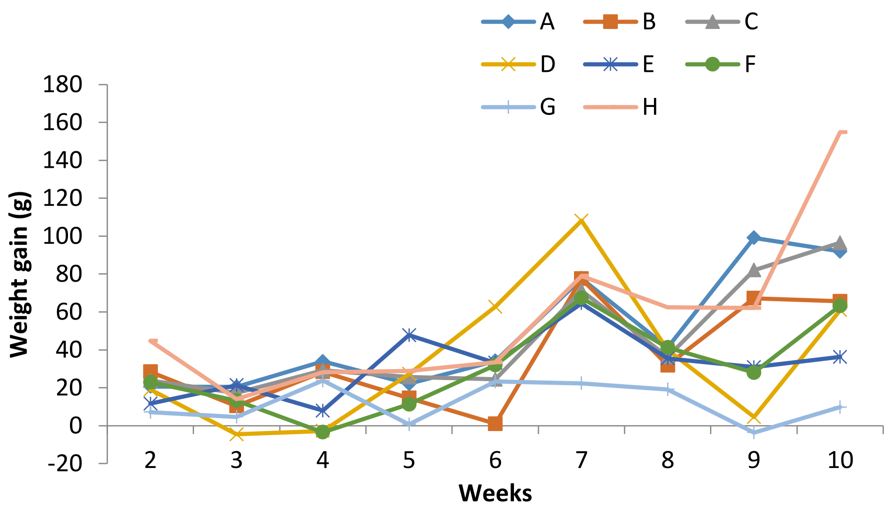

Fig 2: Weight gain of *C. gariepinus* fed diets supplemented with graded levels of corn cob meal.

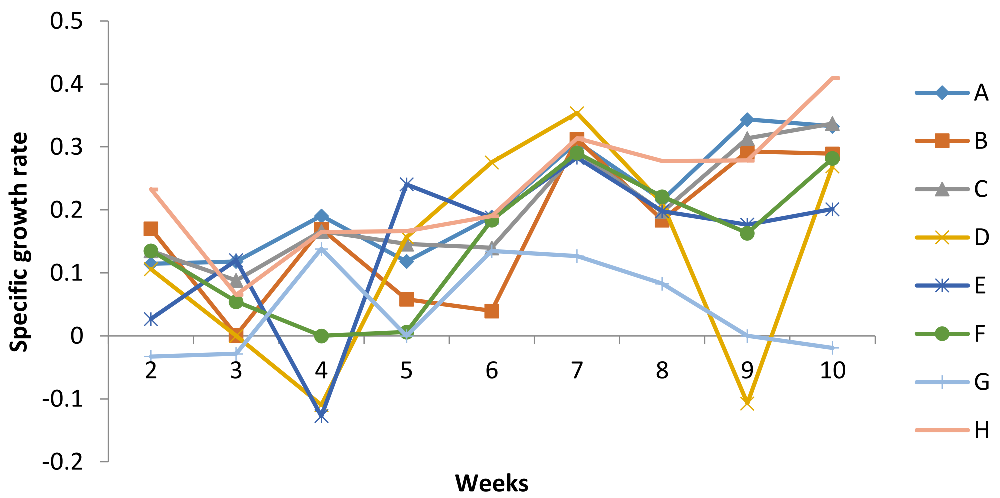

Fig 3: Specific growth rate of *C. gariepinus* fed diets supplemented with graded levels of corn cob meal.

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Cost Analysis

The cost analysis of feeding *C. gariepinus* juveniles with a corn cob meal-based diet showed a cost differential corresponding with levels of corn cob meal (CCM) inclusion (Table 3). The highest cost of diet occurred in diet A, 0 % CCM (₦ 1705.0 or $ 1.13 per kilogram of diet). Other cost differentials per kilogram of diet were: diet B (10 % CCM - ₦ 1687.5 or $ 1.12 per kg), diet C (20 % CCM - ₦ 1670.0 or $ 1.11 per kg), diet D (30 % CCM - ₦ 1652.5 or $ 1.10 per kg), diet E (40 % CCM - ₦ 1635.0 or $ 1.09 per kg), diet F (50 % CCM - ₦ 1617.5 or $ 1.07 per kg) and diet G (100 % CCM - ₦ 1530.0 or $ 1.02 per kg).

All dietary cost differentials were statistically significantly different from the control ($P < 0.05$).

Table 3: Ingredient composition (g/kg) and cost analysis of varied levels of substitution of corn meal with corn cob meal in diets fed *C. gariepinus*

Ingredient	Control Diet A	10% CCM Diet B	20% CCM Diet C	30% CCM Diet D	40% CCM Diet E	50% CCM Diet F	100% CCM Diet G	Coppens Diet H
Fish meal	250 (₦350)	250 (₦350)	250 (₦350)	250 (₦350)	250 (₦350)	250 (₦350)	250 (₦350)	
Blood meal	100 (₦325)	100 (₦325)	100 (₦325)	100 (₦325)	100 (₦325)	100 (₦325)	100 (₦325)	
Soybean meal	450 (₦400)	450 (₦400)	450 (₦400)	450 (₦400)	450 (₦400)	450 (₦400)	450 (₦400)	
Corn meal	170 (₦275)	153 (₦247.5)	136 (₦220.0)	119 (₦192.5)	102 (₦165)	85 (₦137.5)	- (₦0)	
Corn cob meal	- (₦0)	17 (₦10)	34 (₦20)	51 (₦30)	68 (₦40)	85 (₦50)	170 (₦100)	
Vitamin premix	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	
Mineral premix	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	6.5 (₦90)	
Hemicellulose binder	17 (₦175)	17 (₦175)	17 (₦175)	17 (₦175)	17 (₦175)	17 (₦175)	17 (₦175)	
Total (g)	1000 (₦1705.0)	1000 (₦1687.5)	1000 (₦1670.0)	1000 (₦1652.5)	1000 (₦1635.0)	1000 (₦1617.5)	1000 (₦1530.0)	(₦2000.0)
US ($)	($1.13)	($1.12)	($1.11)	($1.10)	($1.09)	($1.07)	($1.02)	($1.33)

DISCUSSION

One possible source of carbohydrates for fish which has not been extensively utilised is corn cob meal, a by-product of the corn processing industry. Converting agro-waste into utilisable energy would help in reducing pollution due to improper disposal of agro-industrial wastes. The reduction in fibre and increased protein in the treated corn cob relative to the untreated

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corn cob is in consonance with reports of Hamad *et al*. (2010) and Alkhazraji *et al*. (2012). The incorporation of corn cob meal in the diet fed to *C. gariepinus* resulted in decreased palatability of the diets. This decrease in feed acceptability is probably due to high levels of fibre content in the diets which made it unpalatable to the fish when compared to the control and coppens fish diets. This finding agrees with the reports of Agbabiaka *et al.* (2011) for *C. gariepinus* fed dried rumen digesta as a dietary supplement.

Data on the growth performance of the catfish revealed that the mean weight gain decreased with an increase in levels of corn cobs in the diets compared to the control group. The least weight gain which occurred in fish-fed diet G (100% corn cob meal) corroborated with the findings of Bichi and Ahmad (2010) for *C. gariepinus* fed varying dietary levels of processed cassava leaves and those of Agbabiaka *et al*. (2012) for *C. gariepinus* fed tiger nut meal. This could be attributed to the inherent high fiber content of corn cobs which was reported to be poorly utilized by the catfish juveniles. *C. gariepinus,* being mostly omnivorous, could not effectively digest non-starch polysaccharide diet like the herbivorous fish species (Agbabiaka *et al.,* 2011). This also agrees with the report that feeds intake of monogastric animals is influenced greatly by dietary fibre characteristics (Fetufe *et al.*, 2007).

The differences in growth observed between the experimental diets are an indication of the variation in the feed utilization. The values for the specific growth rate obtained in this study are in consonance with that reported by Agbabiaka *et al*. (2012) for *C. gariepinus* fed tiger nut meal. The decrease in growth response with an increase in corn cob meal supplementation is due to high levels of fibre content in the diets which made it unpalatable when compared to the control diet and Coppens fish feed.

CONCLUSION

This study revealed that corn cob can make considerable contributions to the growth of the African catfish (*C. gariepinus*). It has the potential to partially replace corn in a feeding regime and thereby, reduce feed cost to the fish farmer whose most important production cost comes from feed. From the above findings, it is recommended that given standard culture conditions, corn cob meal, a relatively abundant and unexploited alternative could be successfully used to replace corn meal at up to 30 % with the optimal performance at a 20 % level of inclusion in the diet fed *C. gariepinus*, a common culture species among fish farmers in Nigeria. This will reduce the hardship encountered by farmers in sourcing for fish feeds which are mostly imported and usually expensive. Incorporation of corn cob in fish diets could also serve as one of the ways of handling environmental pollution arising from wrongly disposed corn cobs.

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