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Use of Agro-Industrial Waste (Brewer's Dried Grain) to Substitute Maize in the Diet of African Catfish *Clarias gariepinus*

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Abstract

This study was carried out to assess the nutrient utilization and growth response of juvenile catfish fed diet with maize replaced with agroindustrial waste. One hundred and fifty *Clarias gariepinus* juvenile (5.21±0.14g) were randomly assigned to five diets formulated such that brewery waste replaced maize at 0%, 10%, 20%, 30%, and 40%, respectively and fed at 5% body weight. Evaluation of nutrient utilization and growth parameters of the experimental fish followed standard methods as based on feed intake, weight gain, feed conversion ratio, specific growth rate, relative growth rate, daily weight gain, gross feed conversion efficiency, protein efficiency ratio and evaluation of the economic cost. The result showed that there was no significant difference ($p>0.05$) in the weight gain of the fish among treatments. Control (0%) diet had the highest mean weight gain of 9.69g while the least weight gain was obtained from 20% dietary treatment which recorded a value of 7.40g. This experiment revealed that brewer's dried grain can be tolerated by *C. gariepinus* juveniles, there was weight gain at 40% growth rate. Feed intake was affected by the brewer's waste that replaced maize and fish performed well even at the highest level of replacement (40%). The lowest cost for the production of a kg weight gain was from the treatment with replaced maize grain with 40%. Considering the performances of the experimental fish and the cost per kg weight gain, it is advantageous to use brewer's waste as an additional feed in the feed mix or a sole supplementary feed. The study has shown that agro-industrial by-product can replace maize in the diet of *Clarias gariepinus*.

Keywords: Brewer's waste, Catfish, Maize, Performance, Cost effective.

Introduction

Fish farming activity in Nigeria started about 50 years ago (Olagunju *et al.*, 2007) and still in the developing stage because it has not been able to meet the demand of ever increasing population (Ojutiku, 2008). The financial viability of aquaculture investments is highly dependent on the cost of aqua feeds, which generally account for 50–70 % of production cost (FAO, 2011).

Over the last decade, spectacular growth has taken place in aquaculture in the country. Numerous locally available plant and animal materials have been investigated (Falaye *et al.*, 2010, Falaye *et al.,* 2012) out of which good proportions were identified to have possible ingredients as valuable potentials for the fish feed production industry. The selection of such feedstuffs is based on their desirable characteristics which include chemical composition, abundance of supply, relative cheapness and limited concentrations of anti-nutritional factors. It is of great interest to note that a host of these agro-industrial by-products and crop residue that abound in the country can be used as substantial replacement for the conventional ingredients in fish feeds (Falaye, 1992).

A wide range of by-products from plant, animal and industrial processes have been studied and possess nutrient composition which can be exploited as dietary ingredients for warm water species like the Tilapias and *Clarias sp*. Such useful by-products include poultry feathers, rice bran, soyabean hulls and cocoa husks which are discarded as wastes (Falaye, 1988; Falaye *et al.*, 2010; Falaye *et al.,* 2012).

Brewer's dried grain is a by-product of the brewery industry. It is usually dried and sold as feedstuff for livestock. Its nutrient contents vary from plant to plant depending on the type of grain used (Barley, wheat, corn etc). Brewer's dried grain is an excellent source of quality by-pass protein and digestible fibre, with a good amino acid profile and it has a high mineral and B-Vitamin content (Ironkwe and Bamgbose, 2011). Brewers dried grain is a by-product of barley malt, corn or rice that is treated to remove most of the readily soluble carbohydrates, protein, fiber, linoleic acid, vitamins and minerals (Swain and Barbuddhe, 2008). These materials can be fed as wet brewer's grains or dried brewer's grains. Both types have similar feeding characteristics if the wet brewer's grain is fed shortly after it is produced (Swain and Barbuddhe, 2008).

However, as most of the brewer dried grains are agricultural products, they can be readily recycled and reused. The competition for maize as food between human and livestock made it expensive which called for substitute in livestock production.

This study evaluated the nutrient utilization and growth performance of *Clarias gariepinus* fed various inclusion levels of brewer's dried grain; it also investigated the optimal inclusion level of brewers dried grain in fish feed formulation and the economic cost of including brewer's dried grain in the diet of *Clarias gariepinus.*

Materials and Methods

Experimental fish

The fish for the experimental study was *Clarias gariepinus* juvenile obtained from a reliable farm. They were acclimatized for 14days and fed 2mm size Coppens feed (45% CP; 15.9 MJ/kg) within the Departmental laboratory unit of Aquaculture and Fisheries Management, University of Ibadan.

Experimental design

Fifteen aquaria tanks with dimensions of 0.4m x 0.3m x 0.1m were used for the practical assessment of this study. Each tank was filled with dechlorinated tap water, stocked with 10 fish and replicated on the basis of similar body weight using a digital scale (Camry EK5055 Max. 5kg/11lb d=0.1g/0.05oz). Each tank was monitored for growth performance, survival and water quality parameters, which was changed regularly during the experimental period of 74 days.

Processing of test ingredients

The brewery waste and other ingredients were obtained from a reliable feed mill. Raw soybean obtained from Bodija market, Ibadan was roasted before grinding at the mill. These were later milled, mixed and analysed for their proximate analysis.

Experimental diets

Five experimental diets were formulated to include Brewers dried grain. Treatment I (control) Treatments II, III, IV and V had brewer's dried grain different inclusion rates of 10%, 20%, 30% and 40% respectively, at the isonitrogenous level of 35% crude protein. The feeds were formulated using Pearson's square method. The ingredients were measured using electric sensitive weighing balance. The feed ingredients were pelletized using a pelleting machine. Each of the diets was fed at 5% body weight twice daily (9:00h and 17:00h); feeds ration were adjusted weekly after determination of the mean body weight.

Proximate composition

The proximate or Weende analysis of fish and feed was carried out according to Olvera *et al*., (1994) to know finished feedstuffs and as a requirement to be met during formulation.

Table 1: Percentage composition of the experimental diet of *Clarias gariepinus*

Ingredients	Treatment I 0%	Treatment II 10%	Treatment III20%	Treatment IV 30%	Treatment V 40%
Fishmeal	6.92	6.92	6.92	6.92	6.92
Groundnut cake	29.77	29.77	29.77	29.77	29.77
Soya bean meal	29.08	29.08	29.08	29.08	29.08
Maize	29.23	26.31	23.38	20.46	17.54
Brewer dried grain	_	2.92`	5.85	8.77	11.69
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Di-Calcium PO4	1.50	1.50	1.50	1.50	1.50
Fish Premix	1.00	1.00	1.00	1.00	1.00
Fish oil	2.00	2.00	2.00	2.00	2.00

PO4: Phosphate

Proximate analysis of fish carcass

All experimental samples of fish carcass before and after the feeding trial were analysed for their proximate composition according to methods of AOAC (1990).

Growth parameters

The growth parameters were expressed as weight gain, mean weight gain, relative growth rate, daily growth rate and specific growth rate. Nutrient utilization indices were expressed as feed conversion ratio, protein efficiency ratio, and gross feed conversion efficiency. These growth and nutrient utilization parameters were calculated thus;

Mean Weight Gain (M W G) = $W_f - W_1$

Where W_f = Final average weight,

W_1 = Initial average weight (g)

Relative Growth Rate (RGR)
= weight gain / initial weight gain x 100

$$\frac{Specific\ Growth\ Rate\ (SGR)}{T} = (Log_e W_2 - Log_e W_1) \times 100$$

Where W_1 : = Weight (g) at stocking

W_2 = Weight (g) at the end of the experiment,

T = Duration of experimental days

Log_e = Natural logarithms

$$Feed\ Conversion\ Ratio\ (FCR) = \frac{Feed\ Intake\ (g)}{Fish\ weight\ gain\ (g)}$$

$$\Pr otein\ Efficiency\ Ratio\ (PER) = \frac{Weight\ gain\ (g)}{\Pr otein\ \text{int}\ ake}$$

Where: Protein Intake = Feed intake x Crude Protein of feed

Daily Weight Gain = MWG/No. of experimental days

Gross Feed Conversion Efficiency (%) = 1/ Feed Conversion Rate x 100

Economic Analysis

The economic analysis was computed to estimate the cost of feed required to raise a kilogram of fish using the various experimental diets. The cost of feed was based on the current prices of the feed ingredients at the time of purchase. The cost of producing brewery waste meal was put as a processing cost. The economic evaluations of the diets were calculated from the method of Mazid *et al*., (1997).

$$Profit\ Index = Value\ of\ Fish\ (\#)/Cost\ of\ feed\ (\#)$$

$$Incident\ of\ \cos t = Cost\ of\ Feed\ (\#)/mean\ weight\ gain\ of\ fish\ produced\ (g)$$

$$Net\ Profit = Total\ Cost\ of\ fish\ cropped\ (\#) - Total\ Expenditure\ (\#)$$

$$Benefit:Cost\ ratio\ (BCR) = Total\ Cost\ of\ fish\ cropped\ (\#)/Total\ Expenditure\ (\#)$$

Statistical Analysis

All data were subjected to one-way analysis of variance (ANOVA) using the SPSS version 17. A significant difference (P<0.05) occurred, treatment means were compared using Duncan Multiple Range Test (Duncan, 1955).

Table 2: Proximate composition (% dry matter) of the experimental brewery dried grain and maize

Parameters	Brewery Dried Grain	Maize
Dry Matter	91.40	95.11
Crude Protein	19.60	9.77
Crude Fiber	11.00	4.13
Ether Extract	6.97	4.35
Ash	5.09	7.91
Moisture Content	10.12	10.05
C.H.O	37.89	66.28

Table 3: Mean value of water quality analysis amongst experimental treatments

Parameters	Treatment I	Treatment II	Treatment III	Treatment IV	Treatment V
Dissolved Oxygen (Mg/L)	4.51	4.41	4.44	4.2	4.4
Temperature ^{O}C	22.33	24.25	24.33	24.08	24.33
pH	7.26	7.01	6.93	7.04	7.04

Result

The proximate composition of the analysed experimental ingredient as indicated in Table 2 showed that all the experimental diet had higher protein content than the control diet, while carbohydrate is higher in the control than the experimental diets.

Water quality parameters

The physio-chemical parameters of the experimental water are as presented in Table 6. Temperature ranged between 21.0 ^{O}C and 26.0 ^{O}C with a mean of dissolved oxygen which ranged between 3.79 and 5.76 mg/l with a mean of 4.51mg/l, while pH ranged between 6.51 and 8.54. In treatment 1 the highest dissolved oxygen was recorded at 4.5 mg/l and the highest pH at 7.24, the lowest dissolved oxygen was recorded at 4.2mg/l in treatment IV and the lowest pH is recorded at treatment III. The highest temperature is recorded at 24.33 ^{O}C in treatment V and the lowest temperature of 22.33^{O}C recorded at treatment I presented in Table 3.

Growth performance

The mean weights of the fish in each treatment are presented in Table 4. There was no significant difference (p>0.05) in the initial mean weight of the fish used in the experiment. The highest mean final weight of 15.98± 2.16g was recorded in *Clarias gariepinus* juvenile fed with control diet while the lowest mean final weight of 10.98± 1.95g was recorded treatment II, with the inclusion level of 20% brewers dried grain. The highest mean weight gain of 9.69±2.11g in the control diet and lowest mean weight gain of 7.40±1.94g in 20% brewers dried grain inclusion level was recorded in the experimental fish. There was no significant difference (p>0.05) in the mean weight gain among treatments.

There was a significant difference (p<0.05) in the specific growth rate among the treatments. The highest specific growth rate of 0.56±0.05g in the control diet and lowest specific growth rate of 0.39±0.09g in treatment II, 20% brewers dried grain inclusion level was recorded in the experimental fish.

There was no significant difference (p>0.05) in the gross feed conversion efficiency among the treatments. The highest gross feed conversion efficiency (GFCE) of 52.66±0.09 was in the control diet and the lowest gross feed conversion efficiency of 31.42±10.67 in treatment II, 20% inclusion level of brewers dried grain was recorded in the diet of *Clarias gariepinus.*

There was no significant difference (p>0.05) in the daily weight gain among the treatments. The highest daily weight gain of 0.11±0.025g was in the control diet and lowest daily weight gain of 0.08±0.023g in treatment II, inclusion level of 20% brewer's dried grain was recorded in the diet of *Clarias gariepinus.*

There was a significant difference (p<0.05) in the relative growth rate among the treatments. The highest relative growth rate of 165.41±4.17g was in the control diet and lowest relative growth rate of 77.02±34.15g in treatment II, with inclusion level of 20% brewer's dried grain in the diet of *Clarias gariepinus.*

There was no significant difference (p>0.05) in the feed conversion ratio among the treatments. The highest feed conversion was recorded at 1.89±0.003 in the control diet and the lowest feed conversion ratio at 3.93±2.842 in treatment IV, with inclusion level of 30% brewer's dried grain in the experimental fish.

There was a significant difference (p<0.05) in the feed intake among the treatments. The highest feed, 168.47±2.44g intake recorded was in the control diet and the lowest feed 122.27± 11.57g in treatment II, with inclusion level of 20% brewer's dried grain, in the experimental fish.

There was a significant difference (p<0.05) in the protein efficiency ratio among the treatments. The highest protein efficiency ratio was recorded at 1.48±0.003 in the control diet and lowest was recorded at 0.79±0.271 in 20% inclusion level of brewer's dried grain in the fish cultured.

There was a significant difference (p<0.05) in the total final weight among treatments. The highest total final weight was recorded at 142.39±3.47g in the control diet and lowest was recorded at 90.19±17.44g in the inclusion level of 20% brewer's dried grain in the cultured fish.

There was a significant difference (p<0.05) in the protein intake among the treatments. The highest protein intake was recorded at 60.05±0.86 in the control diet and lowest was recorded at 47.64±10.93 in 30% inclusion level of brewer's grain in the diet of *Clarias gariepinus.*

Percentage survival

The survival rate ranged from 83.33% – 90%.
There was no significant difference (p>0.05) in the percentage survival among the treatments. The highest percentage survival was recorded at 90.00% in 10% inclusion level and lowest percentage survival at 83.33% in 20% inclusion level of brewer's dried grain in the diet of *Clarias gariepinus.*

Net profit and cost-benefit ratio

The best net profit of ₦313.07 and cost-benefit ratio of 1.77 were recorded from fish fed 0% brewer's dried grain meal supplemented diet.

Fish carcass

The highest carbohydrate (CH_2O), moisture content and fibre were recorded for fish carcass in treatment I and the lowest C.H.O and moisture were recorded for fish carcass in treatment III, while the fish carcass in treatment IV had the lowest fibre. The highest energy, ash and protein were recorded for fish carcass in treatment III and the lowest was recorded in treatment I. The highest fat was recorded for fish carcass in treatment IV and lowest in treatment I.

Table 4: Growth parameters and nutrient utilization of *Clarias gariepinus* juveniles fed different brewer's dried grain level

Parameters	Treatment I	Treatment II	TeatmentIII	Treatment IV	Treatment V
Mean initial weight (g)	5.37±0.21[a]	5.23±0.07[a]	5.09±0.08 [a]	5.04±0.03 [a]	5.30±0.30 [a]
Mean final weight (g)	15.98±2.16[b]	12.99±2.04[ab]	10.98±1.95 [a]	11.74±2.34[b]	13.87±1.65[ab]
Mean weight gain (g)	9.69±2.11 [a]	7.76±2.09 [a]	5.40±1.94 [a]	7.73±2.72 [a]	8.57±1.38[a]
Total final weight (g)	142.39±3.47[b]	114.76±11.05[ab]	90.19±17.44 [a]	99.26±32.09 [a]	113.59±19.7[ab]
Specific growth rate (%/day)	0.56±0.05 [b]	0.47±0.08 [ab]	0.39±0.09 [a]	0.43±0.10 [ab]	0.49±0.03 [ab]
Feed conversion ratio	1.89±0.003 [a]	2.39±0.265 [a]	3.40±0.966 [a]	3.93±2.842 [a]	2.66±1.025 [a]
Gross feed conversion efficiency (%)	52.66±0.09 [a]	42.15±4.94 [a]	31.42±10.67 [a]	34.05±18.20 [a]	41.09±14.34 [a]
% Survival	90	90	83.33	83.33	83.33
Daily weight gain (g/day)	0.11±0.025 [a]	0.09±0.024 [a]	0.08±0.023 [a]	0.09±0.032 [a]	0.10±0.016 [a]
Relative growth rate	165.41±4.17[b]	119.48±20.69[ab]	77.02±34.15 [a]	96.65±62.54[ab]	16.09±48.21[ab]
Feed Intake (g)	168.47±2.44[b]	147.41±9.15 [ab]	122.27±11.57[a]	132.86±30.48[a]	146.63±3.86 [ab]
Protein efficiency ratio	1.48±0.003 [b]	1.11±0.131 [ab]	0.79±0.271 [a]	0.94±0.508 [ab]	1.08±0.380 [ab]
Protein intake	60.05±0.86 [b]	55.70±3.45 [ab]	48.12±4.55 [a]	47.63±10.93 [a]	55.35±1.46 [ab]

Table 5: Economic indices of the total *Clarias gariepinus* juveniles fed brewer's dried grain supplemented diet

Parameters	Diet I	Diet II	Diet III	Diet IV	Diet V
Cost of stocked juvenile (₦)	220	220	220	220	220
Cost of feeding (₦)	186.03	184.93	183.36	182.7	181.89
Value of fish (₦)	719.1	584.55	490.5	528.3	624.15
Profit index	3.87	3.16	2.68	2.89	3.43
Incident cost	21.22	19.19	23.83	24.77	25.27
Net profit (₦)	313.07	179.6	287.14	125.6	222.26
Benefit cost ratio	1.77	1.44	1.22	1.31	1.55
Total expenditure(₦)	406.03	404.93	403.36	402.70	401.89

Table 6: Proximate composition of experimental diet

Parameters	**Dietary Treatments (%)**				
	0%	**10%**	**20%**	**30%**	**40%**
Crude protein	35.64±0.02^{a}	37.78±0.01^{c}	39.35±0.02^{d}	35.85±0.01^{b}	37.75±0.01^{c}
Crude fat	6.94±0.01^{b}	6.83±0.01^{a}	7.23±0.01^{e}	7.07±0.01^{c}	7.14±0.01^{d}
Crude fiber	3.04±0.01^{b}	3.15±0.01^{c}	2.98±0.01^{a}	2.89±0.01^{a}	3.05±0.01^{a}
Moisture content	9.97±0.01^{a}	10.03±0.01^{b}	10.22±0.01^{c}	10.34±0.01^{d}	10.43±0.01^{e}
C.H.O	40.18±0.02^{a}	37.57±0.01^{c}	35.16±0.06^{a}	38.89±0.03^{d}	36.97±0.01^{b}
Energy value kcal/kg	3657.5±0.00^{a}	3651±0.00^{a}	3631.50^{a}	3626.5±0.00^{a}	3626.5±0.00^{a}
Crude Ash	4.23±0.01^{a}	4.64±0.01^{b}	4.67±0.007^{e}	4.96±0.01^{d}	5.06±0.014^{c}

Table 7: Carcass composition of *Clarias gariepinus* after the end of the experiment

Treatment	I	II	III	IV	V
%Crude Protein	61.54	71.585	71.72	71.485	71.665
%Crude Fat	7.34	7.46	7.56	7.7	7.57
%Crude Ash	2.05	2.085	2.115	2.065	2.055
%Crude Fiber	0.001	0.0008	0.0006	0.0005	0.0007
%Moisture	72.82	72.26	72.15	72.19	72.26
%CHO	1.25	0.61	0.33	0.55	0.46
Energy Value	1375.70	1403.95	1410.85	1410.10	1406.20

Discussion

The physio-chemical conditions of the experimental fish are within the limit tolerable by African catfish and are within the limit stated by Olurin *et al*. (2006). There was no significant difference (p>0.05) in the dissolved oxygen, temperature and pH of the water qualities. There was no significant difference (P<0.05) in the mean weight gain of the fish fed with the diets containing brewery waste at various inclusion levels and the diet without a brewery waste. This indicates that inclusion of brewery waste in the diet of fish will result in weight gain of fish, this supports the findings of Zerai *et al.,* (2008) who reported that weight gain did not differ significantly (P >0.05) with up to 50% replacement of brewery waste in tilapia diet. Swain and Barbuddhe (2008) reported that brewery waste protein can replace 20% soya protein in the diet of chickens without causing significant differences in the growth and feed intake.

Although the highest specific growth rate of fish fed with a diet containing no brewer's waste in the experiment was recorded, there was a significant difference (p<0.05) in the specific growth rate, relative growth rate and feed intake among the treatments. The highest feed intake was recorded in fish fed with a diet containing no brewer waste.

Considering the mean weight gain during the feeding period and cost of feed consumed, the result indicated that cost per kg of weight gain is least for treatment V. Therefore, it will be advantageous to use brewer's waste instead of maize whenever the price of maize is high and brewer's waste is available. Also, there was a significant difference ($p<0.05$) in the total final weight among the treatments.

The highest total final weight of fish fed with a diet containing no brewer waste in the experiment was the best. This is due to the fact that the diet containing no brewer waste was consumed more due to the palatability of maize, this enhances feed intake thereby resulting in the fish recording the highest final weight.

In addition, brewing and distilling removed only the starch and sugars from the grain which consisted of some portions that were not fermented during the fermentation process, such as protein, fat, insoluble carbohydrates, vitamins and minerals. They also contained appreciable amounts of yeast formed during fermentation (Negusse, 2009). Moreover, the nutritional value of these by-products was influenced by the original materials, such as grains used and the different processes (Beker, 1985).

In the current study, it was observed that feed intake and utilization were affected by the proportion of brewer's waste that replaced maize and fish performed well even at the highest level of replacement (40%). Similar to this result, Zeral *et al*. (2008) indicated that feed intake and utilization were depressed at high levels of brewer's waste supplementation. The cost of production and the benefits positively favoured all treatments since the values computed are greater than 1.0 which showed an increase in the fish value above the amount invested. It showed that more monetary profit is gained when 40% of brewer's dried grain meal is used in the diet of *C. gariepinus*.

Recommendations

The study has established that agro-industrial by-products can replace maize in the ration of *Clarias gariepiuus*, it has been determined that brewer's waste can reasonably replace maize even at 40% level without significant variation in performance. Further, the partial replacement of maize by brewer's waste at 40% was found economical. Hence, brewer's waste should be used whenever it is available as an additional feed in feed mixing or as a sole supplementary feed to roughage feed for fish.

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