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Dietary Effects of Spaghetti Waste as Maize Replacement in the Diet of Juvenile African Catfish, *Clarias gariepinus*

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Abstract: A 56-day experiment was conducted with *Clarias gariepinus* juvenile to evaluate the effects of replacing maize with Spaghetti Waste (SW). Four isonitrogenous experimental diets were formulated by substituting maize with spaghetti waste at different graded levels of 50, 75 and 100%, respectively with a control (100% maize). The experiment was run in triplicate and fish distributed into 21 plastic tanks. The fish were fed to satiation twice daily and water changed every two days to maintain good water quality. The weight of the fish was determined weekly by bulk weighing. The highest mean weight gain (106.40±4.59 g) and specific growth rate (2.96±0.07) were recorded in fish fed 100% SW, though no significant difference ($p>0.05$) was recorded between the control and other test diets. There was significant increase ($p<0.05$) in the feed intake with increased inclusion of the test ingredient. All the analysed blood parameters recorded significant difference ($p<0.05$) except in the white blood cell. The proximate composition of carcass recorded significant difference ($p<0.05$) for crude protein, while the ether extract and the dry matter were not significantly different ($p>0.05$). The highest crude protein (59.33±0.50) was however recorded in 75% SW inclusion. This study showed that maize can totally be replaced with spaghetti waste without any adverse effect on the growth and health status of *C. gariepinus*.

Key words: *C. gariepinus*, dietary effects, fish diet, maize, spaghetti waste

INTRODUCTION

In fish farming, nutrition is critical because feed represents about 70% of the production costs (Ayinla and Ajayi, 1996). To reduce the cost of available fish feeds, feedstuffs from agricultural and industrial by-products should be included in feed formulation. The extent of by-products inclusion in a feed ingredient depends on its relative cost to conventional feedstuff, safety to animal health and their alternative use.

Carbohydrates and fats supply energy to fish and these feedstuffs are available in large quantity at low prices. Carbohydrates which include starches and sugars are the most economical and inexpensive sources of energy for fish diets are included in fish diets to reduce feed costs and for their binding activity during feed processing.

Maize is the most utilized amongst cereals, as human food, animal feed, fodder crop and for industrial usage. Its grains, stalks, leave cobs, tassels and silks all have commercial value and as diets for many animals such as pigs, poultry birds, fish and cattle. Maize is a major carbohydrate source used in animal feed. However, its dual use in human and animal diets limits its availability and consequently increases its market price (Balogun and Fagbenro, 1995). Accordingly, research into other sources of carbohydrate to replace maize in the diet of fish for optimum performance becomes unavoidable.

Spaghetti is a long, thin and cylindrical pasta of Italian origin which looks like string when cooked (Wehmeier and Ashby, 2000). Its consumption had increased in Nigeria overtime due to its easy handling and preparation. On dry basis spaghetti contains 11-15% protein however; it is deficient in lysine and threonine and also a rich source of carbohydrate (Chillo *et al*., 2008).

Spaghetti by-product/waste include short-length and broken spaghetti which is rejected in quality control process. This product is abundant in some parts of the country (Nigeria) and is used by animal nutritionists and poultry farmers in broiler feed, because it is available at an economic price.

This study was conducted to evaluate the effects of replacing maize with spaghetti waste in the diet of African catfish (*Clarias gariepinus*) juveniles using growth, nutrient utilization, haematology and carcass assessments.

MATERIALS AND METHODS

A 56-day experiment was carried out at the Fish Nutrition Unit, Department of Marine Sciences, University of Lagos, Akoka, Nigeria.

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A total of one hundred and twenty (120) juvenile *Clarias gariepinus* (Mean weight, 16.50±0.01 g) was purchased from Fuard Farms at Cele-Egbe, Ikotun, Lagos. The fish were acclimatized for 2 weeks in plastic holding tanks (52.5×33.5×21.0 cm) and fed with 2 mm Coppens feed. Water was changed every two (2) days with de-chlorinated water from borehole to maintain good water quality as described by Aderolu and Akpabio (2009).

Procurement and processing of ingredients: Adequate quantity of various ingredients used for the experiment was purchased from Sabina Pad Nigeria limited, opposite Lagos State Abattoir, Oko-Oba, Agege, Lagos, before the commencement of the experiment to avoid fluctuation in ingredient composition. All the ingredients (spaghetti waste, maize, soybean, groundnut cake and fishmeal) were crushed and milled into very fine powder and stored in water proof cellophane for future use. The proximate composition of spaghetti waste, maize and the experimental diets was determined according to the Association of Analytical Chemists Method (AOAC, 2000).

Feed formulation and feeding regime: Four isonitrogenous diets were formulated; the control was without the test ingredient, while diets 1, 2 and 3 contained 50, 75 and 100% spaghetti waste, respectively. Fish were hand fed to satiation twice daily (10:00 and 16:00 h) for 8 weeks. The fish were bulk-weighed every week to determine the average weight gain.

Haematological analysis: Blood samples of fish taken at random from each tank were collected in both syringe and heparinized bottles for haematological assay and taken to Bioassay Diagnostic Laboratory, Cele-Egbe, Ikotun, Lagos. Haemoglobin (Hb), Red Blood Cells (RBC), White Blood Cells (WBC) and Packed Cell Volume (PCV) were analyzed using the methods described by Joshi *et al.* (2002).

Carcass analysis: The proximate composition of fish carcass taken from each tank after the experiment was analyzed at the Department of Animal Science, University of Ibadan. The crude protein, ether extract and dry matter were determined using the AOAC (2000) methods.

Growth, nutrient utilization and economic parameters: Growth was estimated in terms of Mean Weight Gain (MWG), Relative Weight Gain (RWG) and Specific Growth Rate (SGR) according to Morais *et al.* (2001):

MWG = Mean final body weight (g)-Mean initial body weight (g)

$$RWG = \frac{\text{Average weight gain (g)}}{\text{No. of days (day)}}$$

$$SGR = \frac{\text{(LogeW1 (g) - LogeW2 (g)}}{\text{T2-T1 (day)}} \times 100$$

where, e is the natural logarithm, T_2-T_1 is experimental period, W_1 is initial weight and W_2 is final weight.

Nutrient utilization indices were expressed in terms of Feed Conversion Ratio (FCR) and Protein Efficiency Ratio (PER) as follow:

$$FCR = \frac{\text{Feed eaten in dry mass (g)}}{\text{Weight gain (g)}}$$

$$PER = \frac{\text{Mean weight gain}}{\text{Protein intake}}$$

Where:

$$\text{Protein intake} = \frac{\text{Total feed intake}}{\text{Protein content of feed}}$$

Statistical analysis: Data collected during the experimental period were subjected to analysis of variance (ANOVA) while Duncan's multiple range tests (Duncan, 1955) was used to determine difference in means.

RESULTS

The proximate composition of spaghetti waste and maize are presented in Table 1 while the gross composition of experimental diets is shown in Table 2.

Table 1: Proximate composition of spaghetti waste and maize

	Spaghetti	Maize
Dry matter	91.5	88.0
Crude protein	12.7	10.0
Ether extract	24.0	4.0
Crude fibre	2.0	2.0
Nitrogen free extract	80.5	84.0

Table 2: Gross composition of experimental diets containing graded levels of spaghetti waste as replacement for maize meal

	Experimental diets			
Ingredients (%)	CTR	Diet 1	Diet 2	Diet 3
Fish meal (72%)	27.00	27.00	27.00	27.00
Groundnut cake	15.13	15.13	15.13	15.13
Soybean meal	34.97	34.97	34.97	34.97
Maize	20.00	10.00	5.00	0.00
Spaghetti waste	0.00	10.00	15.00	20.00
Fish premix	0.50	0.50	0.50	0.50
Dicalcium sulphate	1.00	1.00	1.00	1.00
Palm oil	1.00	1.00	1.00	1.00
Vit. C	0.20	0.20	0.20	0.20
Salt	0.20	0.20	0.20	0.20
Calculated nutrients value of the feed				
Crude protein (%)	43.53	43.73	43.83	43.93
Lipids (%)	4.15	5.39	6.00	6.62
Energy-protein ratio (kcal g^{-1})	2803.4	2806.4	2807.9	2809.4

Table 3: Growth and nutrient utilization parameters of *C. gariepinus* fed graded levels of spaghetti waste as replacement for maize meal

Parameters	Control	Diet 1	Diet 2	Diet 3
Mean initial weight (g)	16.50±0.01	16.50±0.01	16.50±0.01	16.50±0. 01
Mean final weight (g)	103.63±2.63	105.31±2.99	106.40±4.59	109.44±3.40
Mean weight gain (g)	87.13±2.63	88.81±2.99	89.90±4.59	92.93±3.40
Average daily gain (g)	1.38±0.04	1.41±0.05	1.43±0.07	1.48±0.05
Specific growth rate	2.92±0.04	2.94±0.05	2.96±0.07	3.00±0.05
Voluntary feed intake	1.26±0.14	1.18±0.08	1.34±0.22	1.45±0.04
Feed intake	95.12±10.82^{ab}	91.30±9.71^{b}	102.46±15.09^{ab}	114.97±6.19^{a}
Feed conversion ratio	0.92±0.10	0.99±0.05	0.88±0.16	0.81±0.02
Protein efficiency ratio	2.15±0.24	2.29±0.12	2.05±0.37	1.88±0.04
Protein intake	40.90±4.65^{ab}	39.26±4.17^{b}	44.05±6.49^{ab}	49.44±2.66^{a}

Figures in each row with different superscript are significantly different ($p<0.05$) from each other

Table 4: Haematological Indices of *C. gariepinus* fed graded levels of spaghetti waste as replacement for maize meal

	Experimental diets			
Parameters	CTR	Diet 1	Diet 2	Diet 3
PCV (%)	34.00±1.1^{c}	36.50±1.10^{ab}	37.50±1.2^{a}	35.50±1.15^{b}
Hb	10.95±0.32^{c}	11.80±0.25^{ab}	12.00±0.35^{a}	11.45±0.28^{b}
RBC	7.40±0.40^{c}	8.50±0.35^{a}	8.65±0.45^{a}	8.05±0.40^{b}
WBC	11000±1500	11500±1000	10000±1100	12500±1800

Values in each row with different superscript are significantly different ($p<0.05$) from each other

Table 5: Carcass composition of *C. gariepinus* fed diet containing spaghetti waste

	Experimental diets			
Parameters	CTR	Diet 1	Diet 2	Diet 3
Crude protein	56.32±0.40^{b}	54.74±0.10^{c}	59.33±0.50^{a}	58.89±0.30^{a}
Ether extract	16.02±0.45	14.70±0.29	15.87±0.42	15.63±0.35
Dry matter	11.55±0.60	10.96±0.75	10.90±0.82	11.95±0.55

Values in each row with different superscript are significantly different ($p<0.05$) from each other

The result of the growth and nutrient utilization parameters showed the fish readiness to accept the test ingredient (Table 3). The Mean Weight Gain (MWG) was observed to increase with increased inclusion level of the test ingredient, though, no significant difference ($p>0.05$) was recorded amongst the test diets. However, all the test diets recorded better MWG than the control. The highest MWG (92.93±3.40 g) was recorded by fish fed 100% spaghetti waste inclusion level, followed by fish on 75% inclusion (89.90±4.59 g), while fish on the control diet recorded the least value (87.13±2.63). The result of the average daily weight gain and the specific growth rate followed similar pattern to the MWG. There was significant increase ($p<0.05$) in the feed intake of the fish. Though, the feed intake of fish on 50% inclusion level dropped against the control diet, while no significant difference ($p>0.05$) was reported between the control and 75% inclusion level. However, the fish fed 100% Spaghetti Waste (SW) inclusion level consumed more feed than any other group. There was significant difference ($p<0.05$) in all the haematological parameters tested, except for whiteblood cell (Table 4). The Packed cell Volume (PCV) of the test diets increased significantly, fish on the control diet had the least PCV (34.00%) and fish on 75% inclusion level had the highest (37.00%). Similar trend was observed in Haemoglobin (Hb) and Red Blood Cell (RBC). The highest White Blood Cell (WBC) value (12500) was recorded by fish on 100% SW inclusion level while 75% SW inclusion level recorded the least value (10000). The spaghetti waste inclusions significantly improve the crude protein of the fish carcass at 75 and 100% inclusion levels (Table 5). The highest crude protein value was recorded in fish fed 75% SW, while there was no significant difference ($p>0.05$) in the dry matter and ether extract.

DISCUSSION

The nutritional quality of spaghetti meal as determined by growth indices observed in this study showed the adequacy of the diets at meeting the nutritional requirements of the fish. This is evident as a result of improved weight gain in all the experimental fish during the feeding period. The reason for this could be due to processing conditions of spaghetti which was reported by Booth *et al.* (2001) to have great impact on starch digestibility. Ghazi *et al.* (2002) reported that improved digestibility could be as a result of the inactivation of the anti-nutritional factors which interfere with the digestive process. Considering the weight gain observed with increased inclusion of the test ingredient, palatability will not be a problem in replacing maize with spaghetti waste. This result was corroborated by Glencross *et al.* (2007), who reported that, level of feed intake is a test for palatability. Non-significant difference recorded in the growth and nutrient utilization of fish fed graded levels of spaghetti waste is similar to the findings of Olurin *et al.* (2006) who fed graded levels of cassava meal to African catfish. Aderolu *et al.* (2009) also had similar result when they replaced maize meal with sorghum meal in the diet of *C. gariepinus*. However, contrary result was observed by Burel *et al.* (2000), who reported that the digestibility of starch decreases at different inclusion levels, when they tested digestibility of extruded peas, extruded lupin and rapeseed meal in rainbow trout and turbot.

Blood parameters are considered patho-physiological indicators and help fish biologists to interpret physiological responses to stress imposed by the environment (Akinrotimi *et al.,* 2007). Haematological characteristics of most fish have been studied with the aim of establishing normal value range and any deviation from it may indicate a disturbance in the physiological process (Rainza-paiva *et al.*, 2000). The values obtained in this experiment for both the PCV and Hb were within the normal ranges recommended for *C. gariepinus* by Adedeji *et al.* (2009) who reported PCV values (37.25±2.12 and 31.17±1.47) and Hb values (10.10±0.214 and 8.40±3.94) for cultured and wild fish, respectively. The result of the haematological parameters indicates the healthy status of the fish that were used in this study. From this, it could be concluded that the replacement of maize meal with spaghetti waste up to 100% inclusion level would not have any adverse effect on the wellbeing of *C. gariepinus*.

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