EFFECT OF EXTRUDED PLANTAIN PEEL-BASED FISH FEED DIET ON GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF CATFISH (CLARIAS GARIEPINUS)

Oduntan O.B.[1], Oduntan A.O.[2] and Ogunmokun R.O. [1]

[1] Department of Aquaculture and Fisheries Management, University of Ibadan, Ibadan, Nigeria

[2] Product Development Programme, National Horticultural research Institute, Ibadan, Nigeria

femkem03@yahoo.co.uk, bosetunde12@yahoo.com, ogunmokunrotimi@gmail.com

ABSTRACT

The increasing cost of fish feed production has led to the need to search for alternative and non-conventional raw materials, including waste. Indiscriminate discarding of plantain peel has led to environmental challenges. A possible way to manage this waste could be to produce fish feed through extrusion cooking. Plantain peel flour produced by drying and grinding fresh peel obtained from a processing plant and was used to replace wheat bran at different levels (0, 5, 10, 15 and 20%) to produce a formulated balanced diet fish feed. The extruded feed was used daily at 5% body weight for eight weeks for the feeding trial. Growth performance parameters (Total Weight Gain (TWG) and Specific Growth Rate (SGR)) and nutrient use indices (Feed Conversion Ratio (FCR) and Feed Efficiency (FE)) were assessed. Data were analyzed using ANOVA at $\alpha_{0.05}$, for the sensitivity analysis. The formulated fish feed with 15% plantain peel showed the highest weight gain and best FCR. For the growth parameters, a significant variation of $p < 0.05$ was observed. Fish fed with 5% and 15%% plantain peel had the highest survival ratio. Significant variation was observed in the apparent digestibility of the control and experimental feed. Plantain peel could be used to formulate extruded fish feed to reduce production cost and environmental nuisance.

Keywords: fish feed, plantain peel, extrusion, mortality, growth.

1. INTRODUCTION

Aquaculture industries and those operating in the foodservice are increasingly looking for ways to make the production system more sustainable (Smith et al., 2010). These large corporate firms are not only looking at the way that fish are raised. They also have an increased interest in the production cost, hence how sustainable the feed ingredients really are and which changes can be made. By looking at the alternative feed sources, sustainability gains can be made that have a significant and long-term effect on parameters such as growth, feed conversion ratio and its efficiency amongst others. These efforts, geared towards reducing the production cost, will make fish farming attractive to both private and commercial investors and ultimately boost fish production. One of such is the utilization of plantain peel for catfish feed production (Lawal et al., 2014).

Plantain by-products from the plantain chips industry are considered to be waste, although they can be used as a feed ingredient. The peel is a cheap source of crude protein, crude fibre, phosphorous, unsaturated fatty acids and essential amino acids (Wolfe et al., 2003). An effective replacer of wheat bran in the fish diet added benefit that reduces feed costs (Ajasin et al., 2014). Replacing part of the wheat bran consumption by locally generated plantain peel products seems to be a promising way to reduce dependency on wheat products since most of the wheat were imported from overseas. Replacing wheat bran by plantain peel is worthwhile and a resource that will stay around for some time. A possible way of managing this waste could be in the production of fish feed through extrusion cooking.

Extrusion cooking has become one of the most popular technologies in food processing. It is a process by which moistened, expansible starchy and proteinous materials are plasticized and cooked in a tube by combination of moisture, pressure, temperature and mechanical shear (Singh et al., 2007). Extrusion cooking principles have been widely applied for the retention of nutrients, and adequate heat treatment against anti-nutritional factors and production of new products (Anuonye et al., 2009). In a study by Agbabiaka et al. (2013), there was a development to replace plantain peel with maize in pelletized fish feed, the technology has limitation in the availability of the nutrients and the quantity required to substitute for maize. Therefore, this study was aimed at evaluating the effect of extruded plantain peel aqua feed and its performance on the growth and digestibility by catfish (Clarias gariepinus).

2. MATERIALS AND METHODS

2.1 Sample preparation

Plantain peels was collected from processing unit of Product Development Programme, National Horticultural Research Institute (NIHORT), Jericho, Ibadan, Oyo State, Nigeria. The peel was dried at 60 ± 1^oC using a bed drier (Model Fexod D52, Nigeria) to about 10% moisture, milled to 0.2 mm particle size while the proximate analysis was determined using Association of Official Analytical Chemists (AOAC) methods (2005).

2.2 Feed formulation

Plantain peel flour was mixed with other feed ingredients at varying levels. Five nutritionally isocaloric ingredient feed blends were formulated to an isonitrogenous net target protein of 38% wet basin (wb), using four levels of plantain peel inclusion, namely 5, 10, 15 and 20%, while 0% level was used as control feed (Table 1).

Table 1: Gross Composition (g) of Experimental Diets

Feed ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Groundnut cake	16	16	18	20	22
Soymeal	23.7	23.7	21.7	19.7	17.7
Fishmeal	22	22	22	22	22
Wheat bran	25	20	15	10	5
Corn flour	5	5	5	5	5
Cassava flour	5	5	5	5	5
Plantain peel	0	5	10	15	20
DPC	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5
Lysine	0.1	0.1	0.1	0.1	0.1
Methionine	0.1	0.1	0.1	0.1	0.1
Vitamin C	0.1	0.1	0.1	0.1	0.1
Fish oil	1.5	1.5	1.5	1.5	1.5
Premix	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

The feed mash was extruded with a single screw extruder (Model Fexod S22C, Nigeria) and dried at 60 ± 1°C in a fluidized bed drier (Model Fexod D52, Nigeria) and packaged in a polyethene bag for further use.

2.3 Experimental fish and design

One hundred and fifty African catfish fingerlings, with an average weight of 2.5 g were collected from the Fish Farm, Department of Aquaculture and Fisheries Management, University of Ibadan. They were acclimated for seven days and fed with control diet. Subsequently, they were randomly assigned to the five-treatment diet at 30 fish per treatment in a plastic tank. Each treatment was replicated thrice in a randomized design having ten fish per replicate. The extruded feed was used for feeding trial at 5% body weight daily for eight weeks. The water was changed daily by siphoning.

2.4 Data collection and statistical analysis

The experimental fingerlings in each tank were weighed at the beginning of the experiment and weekly using a digital weighing balance (model Salter 1260SVDR, UK). Data on growth performance; Total Weight Gain (TWG), Total Growth Rate (TGR) and Specific Growth Rate (SGR), Feed Conversion Ratio (FCR), Feed Efficiency (FE) and nutrient utilization; Apparent Digestibility Coefficient (ADC) were collected using Morais et al (2001) methods. Data were analyzed using ANOVA at $\alpha_{0.05}$, while response surface methodology was employed for the sensitivity analysis using Design Expert 11.

3. RESULTS

The composition of the plantain peel used for the study shows the percentage of crude protein (5.38%), crude fiber (9.67%), crude fat (0.57%), moisture content (9.7%) and ash (4.0%). The result obtained revealed that plantain peel has higher content of crude fibre, ash, carbohydrate and appreciable amount of protein compared to wheat bran. Hence it was used to replace wheat bran in the fish feed diets. The study showed that fish fed 15% plantain peel inclusion had the highest TGR and SGR followed by the control (diet 1). Significant variation ($p<0.05$) in the TWG and SGR was observed among the diets (Table 2).

Table 2: Growth Performance Indices of Catfish fed the control and experimental feed

Response/Model	F-value	P-value	R^2	Std deviation
Total Weight gain	15.84	0.0006*	0.8407	0.64
Specific growth rate	16.82	0.0005*	0.8487	0.17
Feed conversion ratio	4.67	0.312	0.6087	0.25
Feed efficiency	3.70	0.0553	0.5522	4.57
Survival ratio	2.70	0.1082	0.4739	7.76

*- Significantly different

As depicted on Fig. 1, TGR decreased from 40.23 g of plantain peel-fed fish to 36.81 g (fed with 5% peel) and then increased until it reached its maximum at 41.06 g (fed with 15% peel). The same trend was observed for SGR (Fig. 2); maximum SGR was observed for fish fed 15% followed by the control. The FCR increased from 1.80 (without peel) to 2.07 (taken with 5% peel), followed by a decrease to 1.78 in a 15% fed plantain peel (Fig. 3). The FCR did not differ significantly at ($p>0.05$), but it was found that fish fed with 15% plantain peel consume enough feed and nutrient utilization than other diets, which increases weight gain. Similarly, FE of the control and experimental feed were not significantly different ($p>0.05$), however, 15% plantain peel had highest FE (Fig. 4). The survival ratio of the control and experimental feed were not significantly different ($p>0.05$). Highest survival ratio of 100% was observed at 20 % plantain peel inclusion, while 15% had the least of 80% survival ratio (Fig. 5).

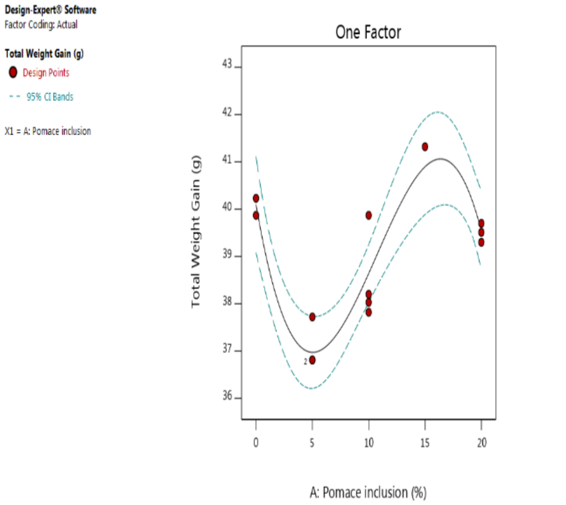

Figure 1: Total weight gain of fish fed control and experimental feed

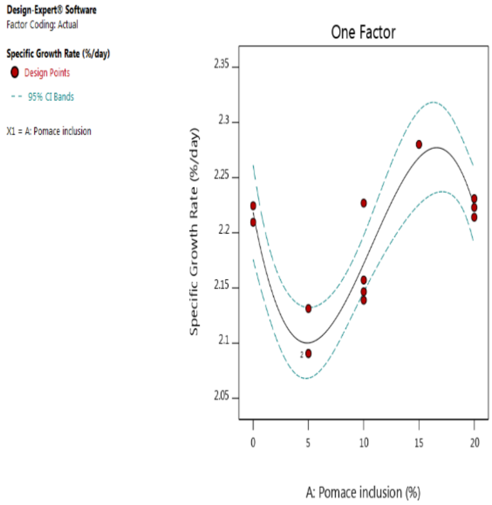

Figure 2: Specific growth rate of fish fed control and experimental feed

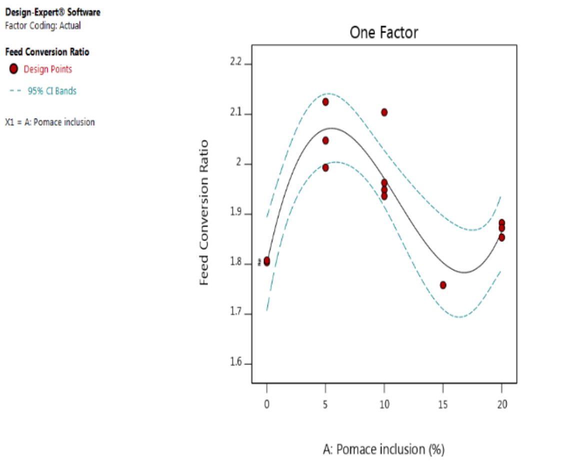

Figure 3:Feed Conversion ratio of control and experimental feed

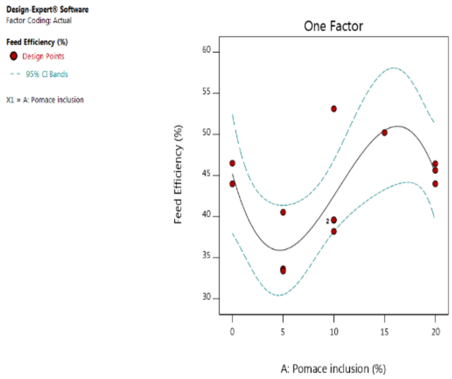

Figure 4: Feed efficiency of control and experimental feed

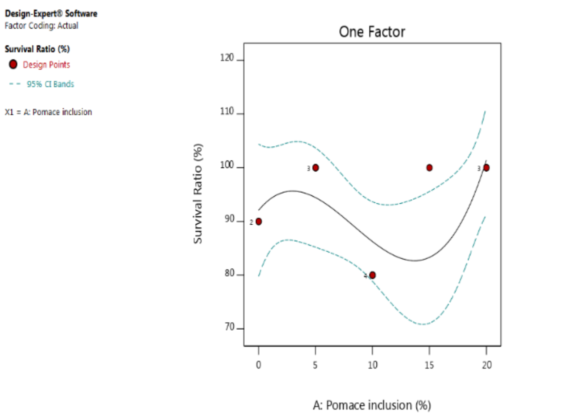

Figure 5:Survival ratio of fish fed control and

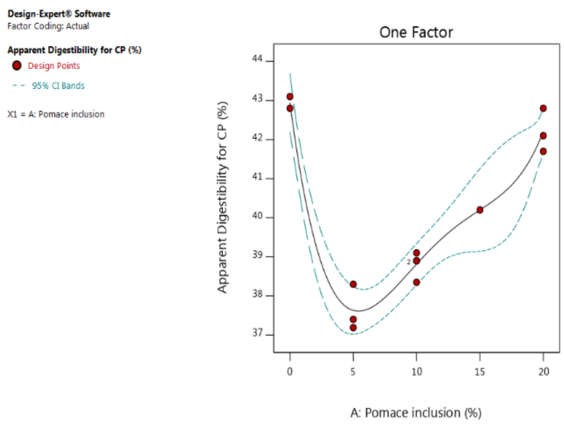

Figure 6: Apparent digestibility of fish fed

experimental feed	**control and experimental feed**

Significant variation was observed in the apparent digestibility of the control and experimental diet (Table 3). Apparent digestibility of protein decreased from 42.8% to 37.2% (Fig. 6).

Table 3: Digestibility parameters of control and experimental diets

ADC	% replacement					R^2	P-value
	0	5	10	15	20		
Protein	42.8	41	40.2	37.2	38.9	0.9595	< 0.0001
Fat	7.92	7.81	7.65	7.22	7.51	0.9573	< 0.0001
Digestible Energy (KJ/g)	20.4	11.8	12.30	10.6	16.17	0.9962	< 0.0001

4. DISCUSSION

The observation of the weight gain phenomenon with the plantain peel inclusion in the diets were in agreement of the findings of Agbabiaka et al. (2013) of increased weight gain in peel supplemented for maize in pelletized catfish feed. The decrease in weight gain from control up to 10% plantain peel inclusion could be a result of high fibre level which accumulates to increase cell wall materials and non-soluble polysaccharides, which invariably limit the rate of digestion and nutrient absorption (Aderolu and Oyedokun, 2009). The increase at 15% could be due to optimum energy to protein ratios of the feed which encourages more feed intake and growth of the fish (Lemos et al., 2014) and also the presence of amylase and cellulase in catfish which were responsible for the breakdown of cell wall material in plantain peels couple with the grinding effects of the vomerine teeth, characteristics of Clariid catfishes which exposes the cell wall surface area to digestion (Agbabiaka et al., 2013). The observed cubic replica for the feed utilization (Fig. 3) indicated a high FCR at 5 and 20% peel inclusion which could probably due to poor palatability of the feed. This was substantiated by Lawal et al. (2014) that the presence of anti-nutritional factors which include hydrogen cyanide, saponins, oxalate and phytate in plantain and banana peel affects palatability. The digestibility parameters of the catfish established a high regression values (R^2) between 0.95-0.99 indicating that the peel inclusion level make a change in digestion of the feed. Although the inclusion levels of plantain peel agreed with the digestibility of the protein, the extrusion cooking method applied for the processing of the diet could contribute the high digestibility coefficient values obtained. The ADC of the control diet was significantly ($p<0.05$) higher than other treatments (Table 3). The decreased crude protein digestibility of the diets established in this study was slightly different. This may be due to presence of enzyme inhibitors in the diet and the protein chemically unavailable (Oujifard et al., 2012).

5. CONCLUSION

Plantain peel was successfully used to replace wheat bran in extruded fish feed. The best growth rates were achieved with a 15% inclusion of plantain peel, while the use of nutrients was also noticeable. It can be concluded that plantain peel could be used to formulate extruded fish feed for optimum growth, to reduce production cost and its environmental nuisance.

References

Anuonye, J. C., Onuh, J. O., Evansegwim, E. and Adeyemo, S. O. (2010) 'Nutrient and antinutrient composition of extruded acha/soybean blends', Journal of Food Processing and Preservation, 34, pp. 680–691. *doi*.org/10.1111/*j*.1745-4549.2009.00425.x.

Ajasin, F. O., Omole, A. J., Oluokun, J. A., Obi, O. O. and Owosibo A. (2004) 'Performance characteristics of weaned rabbits fed plantain peel as replacement maize', World Journal of Zoology, 1, (1) pp. 30-32. doi:10.22161/ijaers/3.10.26.

Aderolu, A. Z. and Oyedokun, G. (2009) 'Comparative utilization of biodegraded and undegraded rice husk in Clarias gariepinus diet', African Journal of Biotechnlogy, 8(7), pp. 1358-1362. doi:

10.3923/jfas.2008.312.319.

Agbabiaka, L. A., Okoeie, K. C., Ezeafulukwe, C. F. (2013) 'Plantain peels as dietary supplement in practical diets for African catfish (Clarias gariepinus burchell 1822) fingerlings', Agriculture and Biology Journal of North America, 4(2), pp. 155 – 159. doi:10.5251/abjna.2013.4.2.155.159.

AOAC (2005) 'Association of Official Analytical Chemists', Official Methods of Analysis, 18th edn (edited by W. Horwitz and G.W. Latimer) Gathersburg, MD, USA: AOAC International.

Lawal, M. O., Aderolu, A. Z., Dosunmu, F. R. Aarode, O. O. (2014) 'Dietary effects of ripe and unripe Banana peels on the growth and economy of production of juvenile catfish (Clarias gariepinus Burchell, 1822)', Journal of Fisheries Sciences.com, 8(3), pp. 220 -227. doi:10.3153/jfscom.201428.

Lemos, M. V. A., Arantes, T. Q., Sonto, C. N., Martins, P. G. P., Araujo, J. G., Guimaraes, I. G. (2014) 'Effects of digestible protein to energy ratios on growth and carcass chemical composition of Siamese fighting fish', Betta splendens, 38(1), pp. 76-84. doi: org/10.1590/S1413-70542014000100009.

Morais, S. G., Bell, J. G., Robertson, D. A., Roy, W. J., Morris, P. C. (2001) 'Protein/Lipids ratios in extruded diets for Atlantic (Gadus morhua L.) effects on growth, feed utilization, muscle composition and liver histology', Aquaculture, 203, (1-2) pp. 101 – 119. doi: 10.1016/S0044-8486(01) 00618-4.

Oujifard, A., Seyfabadi, J., Kenari, A. A., Rezaei, M. (2012) 'Fish meal replacement with rice protein concentrate in a practical diet for the Pacific white shrimp, Litopenaeus vannamei Boone, 1931', Aquaculture International, 20, pp. 117 – 129. doi: 10.1007/s10499-011-9446-8.

Wolfe, K., Wu, X., and Liu, R. H. (2003) 'Antioxidant activity of apple peels', Journal of Agricultural and Food Chemistry, 51, pp. 609-614. doi**:** 10.1021/jf020782a.

Singh, S., Gamlath, S., Wakeling, L. (2007). Nutritional aspects of food extrusion: A review. International Journal of Food Science and Technology. 42(8): 916 – 929. doi:10.1111/j.1365-2621.2006.01309.x.

Smith, M. D., Roheim, C. A., Crowder, L. B., Halpern, B. S., Turnipseed, M., Anderson, J. L., Asche, F., Bourillón, L., Guttormsen, A. G., Kahn, A., Liguori, L. A., McNevin, A., O'Connor, M., Squires, D., Tyedemers, P., Brownstein, C., Carden, K., Klinger, D. H., Sagarin, R. and Selkoe, K. A. (2010). "Sustainability and Global Seafood." Science, 327, pp. 784–786. doi: 10.1126/science.1185345.