FISH FEED DEVELOPMENT FOR SUSTAINABLE AQUACULTURE FISH PRODUCTION IN AFRICA

F.O.A. George and S.O. Otubusin

Paper prepared for presentation at the Farm Management Association of Nigria Conference, Ayetoro, Nigeria, September 4-6, 2007

FISH FEED DEVELOPMENT FOR SUSTAINABLE AQUACULTURE FISH PRODUCTION IN AFRICA

George, F.O.A. and Otubusin, S.O.

Department of Aquaculture and Fisheries Management University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State, Nigeria

ABSTRACT

Combinations of three commercial digestive enzyme supplements (protease, carbohydrase and phytase) were added at the rate of 50g/kg to Fish:Soybean (50:50) meal diets to evaluate their effects on the efficiency of soybean meal as a substitute for fishmeal in practical diets for *Clarias ganiepinus* juveniles (9.38 $\pm$ 0.04g) in a 30-day trial in in-door plastic tanks. Five diets were evaluated: T_1 (control, with fishmeal (i.e. 100:0 diet) as the sole protein source without enzyme); T_2 (fishmeal:soybean (50:50) without enzyme); T_3 (50:50 diet supplemented with protease and carbohydrase); T_4 (50:50 diet with phytase and carbohydrase) and T_5 (50:50 diet with protease and phytase). The fish were fed to satiation once daily at 9.00hrs. Results showed that all treatments supported the growth of *Clarias gariepinus,* as mean fish weight increased from 9.38 to 21.66g during the experimental period. No mortality was recorded under all the treatments during the experiment. Average daily growth (ADG) was highest (0.45g/fish/d) in fish fed diet T_3, followed by T_5 (0.43); T_1 (0.43); T_2 (0.41) and T_4 (0.33). Specific growth rate (SGR) was highest at 2.9% per day in T_5, followed by T_3, T_1, T_2 and T_4 with 2.88, 2.85, 2.79 and 2.43% per day respectively. Feed conversion ratio (FCR) was lowest in T_1 (1.09), followed by T_5 (1.12), T_3 (1.14), T_2 (1.16) and T_4 (1.24) respectively. Results confirmed that the use on supplementary digestive enzymes significantly improved the efficiency of soybean-based diets, suggesting that highly efficient fish diets could be produced using plant protein sources, thereby reducing the use of scarce and expensive fish-meal as protein source in fish feeds.

INTRODUCTION

Global appetite for fish has doubled in the last thirty years. According to FAO (2002), world fish consumption rose from about 45 million metric tones in 1973 to over 91 million metric tones in 1997. A look at fish consumption trend indicates that while per capita consumption of fish is increasing in the developing world, it is on the decrease in the developed world. This has been attributed to negative population growth rates in developed countries in contrast to the developing world, where population growth is on the increase, coupled with increasing fish consumption rates. In response to increased global preference for fish, fish production has increased drastically, though mostly through aquaculture. This is because beginning from the mid eighties, many important wild fish stocks became fully or over exploited (FAO 1998).

Africa produces only 1% of world aquaculture fish with Nigeria being the major producer, followed by Egypt, Uganda and Kenya (FAO, 2007). In Nigeria, the current annual demand for fish is about 1.5 million metric tonnes, against a production of about 0.5 million metric tonnes from both capture and culture. The gap in the demand/supply chain has always been filled through the importation of large quantities of frozen fish, which presently makes Nigeria the largest importer of frozen fish in Africa (Dada, 2004). In 1999, over two hundred thousand metric tones of fish was imported at a cost of over USD 267 million. This figure increased in 2002 to six hundred and eighty one thousand metric tonnes at a cost of over USD 375 million, a whooping

300% increase in quantity and 40% in value! It is obvious that this quantum of expenditure on fish importation cannot be sustained, thus a sustainable means of bridging the demand /supply gap for fish needs to be found.

Global fish production trend in the last few decades suggests that aquaculture has the potential to sustainably bridge fish demand and supply gap in Nigeria. According to Ita et. al (1985), Nigeria has a total surface area of over 12.5 million hectares. Over 1.75 million hectares of suitable sites have also been located for fish farming, however only 5,000 tonnes of fish are currently produced through aquaculture annually (Dada, 2004). According to FAO (1998) the major constraint to increased global aquaculture fish production is the rising cost and scarcity of the fish-meal, resulting from lower wild fish catches and fishmeal production. At present, about one third of the world's wild-caught fish is "reduced" to fishmeal and oil, mainly for aqua – feed production (Barlow and Pike, 2001). So far, aquaculture has consumed more fishmeal (as a major feed component) than the terrestrial livestock sector because poultry and livestock producers have increasingly switched to vegetable – based meals in place of fishmeal. However, full substitution of vegetable products for fishmeal and oil in aqua-feeds is not yet possible, particularly for carnivorous species, because many aquatic species exhibit lower growth rates and high mortalities when vegetable proteins replace fishmeal in their diets.

This situation has raised concerns that demand for fishmeal and oil for the blossoming aquaculture sector will raise prices for these commodities; and place increasingly heavy pressure on wild fishers to produce fish for feeds. It becomes imperative then that technology is geared towards the provision of alternatives for fishmeal and oil in aqua-feeds. Through improved feed processing techniques and genetic selection, it has been possible to partially substitute protein-rich oil seed and grain by-product meals for fishmeal in aqua –feeds.

In addition, various methods, including heat treatment, fermentation, soaking e.t.c. have been used in soyabean processing, to reduce or remove anti-nutritional factors (Balogun and Ologhobo (1989) ; Beckman and Pfeffer (1989); Van den lngh et. al. (1991); Sadiku (1995); Solomon et. al. (1996). In recent times, supplementary digestive enzymes have been used extensively in animal nutrition to improve nutrient utilization, especially in proteins from plant source. In broiler and pig nutrition, the addition of supplementary digestive enzymes resulted in better feed utilization, faster growth and increased final weights (Sasserod,1992). In Atlantic salmon (*Salmo salar*), the addition of supplementary digestive enzymes improved growth and feed conversion efficiency (Carter et. al. 1994). Van Weerd et. al. (1999) observed positive effects of phytase treatment particularly on phosphorus digestibility and retention in the African catfish, *Clarias gariepinus* fed soybean meal – based diets.

The present study was conducted to evaluate growth responses, feed conversion and survival of *Clarias gariepinus* fed fish:soybean meal diets supplemented with *digestive enzyme* supplements. The African catfish, *Clarias gariepinus* is the major aquaculture fish species in Nigeria; also, there is little information on the use of supplementary digestive enzymes in soybean meal processing, especially in fish nutrition in Nigeria. The addition of supplementary digestive enzymes as a means of improving soybean quality is easy and more cost –effective, more so, in Africa where fish is in very high demand and the little fishmeal available rather are used in human nutrition.

METHODOLOGY

Twenty (20) juveniles of *Clarias gariepinus* (initial weight 8g ± .03g) each were kept in each tank of the laboratory experimental flow -through system comprising 12 plastic tanks with water capacity of 15l each (Figure 1) maintained at a water flow rate of 0.1l/min.). Fish were fed to satiation once daily on the reference diet (described in Table 1) for a period of two weeks to acclimatize experimental fish to the system. At the end of the acclimatization period, all fish were taken out of the system, pooled and weighed individually, then restocked in the experimental system at the rate of twelve (12) fish per tank. Experimental diets (Table 1) were then assigned randomly to tanks in replicates. Fish were fed once daily to satiation on the assigned experimental diets for a period of thirty days.

Table 1: Ingredients Composition (g/kg) of Experimental Diets.

Ingredients	* EXPERIMENTAL DIETS				
	Reference	Control	Procar	Carphy	Prophy
Fishmeal	450.0	225.0	225.0	225.0	225.0
Soyabean Meal	-	622.1	622.1	622.1	622.1
Maizemeal	480.0	82.9	82.9	82.9	82.9
Vit./Mineral Mix	10.0	10.0	10.0	10.0	10.0
Vegetable Oil	50.0	50.0	50.0	50.0	50.0
Corn Starch (Binder)	10.0	10.0	10.0	10.0	10.0
Enzyme (g/kg)	-	-	50.0	50.0	50.0

* Reference diet: Fishmeal, no enzyme

Control diet: Fishmeal: Soybean ; no enzyme

Procar: Fishmeal: soybean with protease and carbohydrase at 25g/kg each.

Carphy: Fishmeal: soybean with carbohydrase and phytase at 25g/kg each.

Prophy: Fishmeal: soybean with protease and phytase at 25g/kg each.

Data on weight gain, quantity of feed eaten and mortality were monitored and recorded on a weekly basis, together with water temperature, pH, and dissolved oxygen. Growth response and survival of fish were thereafter calculated as follows:

Initial mean weight, W_1 (g) = mean weight (g) of fish at the commencement of experiment (T_1).

Final mean weight, W_2 (g) =weight (g) of fish at the end of the experiment (T_2)

Average Daily Growth Rate, ADG (g/fish/d) = $\underline{W_2 - W_1}$

$$T_2 - T_1$$

$$\text{Specific Growth Rates, SGR (\%)} = \frac{\text{Loge } W_2 - \text{Loge } W_1 \times 100}{T_2 - T1}$$

$$\text{Feed Conversion Ratio} = \frac{\text{Quantity of Feed Consumed (g)}}{\text{Net Weight Gain (g)}}$$

$$\text{Survival (\%)} = \frac{100 \times \text{Initial Number of fish stocked} - \text{Mortality}}{\text{Initial Number of fish stocked.}}$$

Results were analysed for variance at 5% level of significance.

RESULTS AND DISCUSSION

Results are summarized on Table 2. It has been demonstrated in poultry layers, broilers and pigs that supplementary digestive enzyme inclusion in practical diets enhances feed utilization efficiencies by improving energy performance and liberating bound nutrients, particularly phytate- bound minerals, for example, phosphorus. In vegetable proteins which oftentimes have anti-nutritional factors associated with them, e. g. soyabeans, supplementary digestive enzymes breakdown anti-nutritional factors, thereby, releasing nutrients hitherto unavailable to animals. Results of the present study confirm that the addition of supplementary digestive enzymes had positive effects on food conversion, and growth rates of *Clarias gariepinus* juveniles. Enzyme combination affected feed performance and it was observed that at the level of fishmeal: soybean inclusion (50:50) in this study, the enzyme combination mattered, as better results were obtained for rations containing protease (i .e. procar and prophy), the enzyme that catalyses protein breakdown and utilization. It seems that at this stage of *Clarias gariepinus* growth, protein content of diet is more critical than energy, more so as fish generally prefer protein as energy source when available.

CONCLUSIONS

Results in this trial confirm that cheaper vegetable proteins can be substituted for scarce and expensive animal protein sources like fishmeal. This will reduce fish feed costs and reduce expenditure on feeds which represent up to 50% of running expenses in commercial fish farming in Africa.

Table 2: Summary of Results

* EXPERIMENTAL DIETS

PARAMETERS	REFERENCE: T_1	CONTROL T_2	PROCAR T_3	CARPHY T_4	PROPHY T_5
Initial Mean weight(g)	9.34 (0.12)	9.45 (0.28)	9.38 (0.06)	9.38 (0.06)	9.38 (0.06)
Final Mean weight (g)	22.25^{b} (0.03)	21.79^{c} (0.03)	22.96^{a} (0.03)	19.04^{d} (0.01)	22.25^{b} (0.06)
ADG(g/fish/d)	0.43^{b} (0.03)	0.41^{b} (0.01)	0.45^{a} (0.03)	0.33^{c} (0.03)	0.43^{b} (0.03)
SGR (%/d)	2.85^{c} (0.16)	2.79^{d} (0.03)	2.88^{b} (0.06)	2.43^{e} (0.03)	2.90^{a} (0.03)
FCR	1.09^{e} (0.08)	1.16^{b} (0.02)	1.14^{c} (0.02)	1.27^{a} (0.03)	1.12^{d} (0.03)
SURVIVAL (%)	100	100	100	100	100

* Means on the same row with different superscript are significantly different ($P \geq 0.01$).

REFERENCES

FAO (1998). *The State Of World Fisheries and Aquaculture*. Rome.

FAO (2002). *Fisheries Report* No. 673. Rome.

FAO (2007). *State of World Fisheries and Aquaculture*. Rome.

Dada, B. F. “Contributions of fisheries to employment, national economy and food security in Nigeria”. *Fish Network*, Vol. 11: 1, pg. 1.

Ita, E.O.; Sado, E.K.; Balogun, J.K.; Pandogari, A. and Ibitoye, B. (1985). Inventory survey of Nigeria inland waters and their fisheries resources. 1. A preliminary checklist of inland water bodies in Nigeria. Kaini Lake Research Institute Technical Report Series, No. 14. KLRI, New Bussa, Nigeria.

Adekoya, B.B. (1999). *Ogun State Agriculture Development Project (ADP) Report*.

Aguiler-Manjarrez, J. and Nath, S.S. (1998). *A strategic reassessment of fish farming potential in Africa*. CIFA Technical Paper. No. 32, Rome, FAO. 170p.

Balow, S.m. and Pike, I.H. (2001). Sustainability of fishmeal and oil supply. Paper presented at the Scottish Norwegian Marine Fish farming conference, "Sustainable future for marine fish farming", held at the University of Stirling, Scotland, June 14-15, 2001.

Balogun, A.M. and Ologhobo, A.D. (1989). Growth performance and nutrient utilization of fingerlings of *Clarias gariepinus* fed raw and cooked soybean diets. *Aquaculture*, 76: 119-129.

Carter, C.G; Houlihan, D.F., Buchanan, B. and Mitchell, A.I. (1994). Growth and feed utilization efficiencies of sea water Atlantic salmon, *Salmo salar L.,* fed a diet containing supplementary enzyme. *Aquaculture and Fisheries Management*, 25: 37-46.

Sasserod, S. (1992). Novo Nordisk enzymes for the feed industry. Paper presented at the "Danish Days", 28th October, 1992, St. Petersburg.

Iyayi, E. (2003). Enzyme supplementation of feeds for improved quality and utilization. *The Guardian* Agrocare Section, Sunday 23rd March, pg.54.