Evaluation of pigeon pea (*Cajanus cajan*) as a substitute for soya bean meal in the diet of Nile tilapia (*Oreochromis niloticus*) fingerlings

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Abstract

Pigeon pea (*Cajanus cajan*) meal was substituted for soybean meal in the practical diets for Nile tilapia *Oreochromis niloticus* fingerlings. Six iso-nitrogenous diets (35% crude protein) were formulated in which heat-treated soybean meal was replaced at varying levels (0, 20, 40, 60, 80 and 100%) with protein from pressure-cooked and sun dried pigeon meal (23% crude protein). Nile tilapia fed 60% pigeon pea meal had significantly ($P < 0.01$) better growth response and nutrient utilisation. Growth was depressed in low pigeon pea fish and also in high (above 60%) pigeon pea diets. The poorest feed conversion ratio was observed from 100% pigeon pea fed fish.

Keywords: - Pigeon pea, protein, feed utilization, tilapia

Introduction

One major constraints to increased pond fish production in most developing world is the scarcity of cheap but balanced artificial fish diets. This problem is further compounded by the soaring cost as well as irregular supply of some important ingredients like fishmeal, hence the need for alternative available cheap fish feedstuffs of local sources.

Of all the plant protein feed ingredients, soybean (*Glycine max*) is considered to be the most nutritious and it is used as a major protein source in most fish diets (Lovell 1988). However, the cost of soybean meal keeps increasing due to the high demand both as food for humans as well as raw materials in livestock feed industry.

Several studies have been conducted to substitute fishmeal protein either wholly or partially with plant proteins in fish feeds (Carlos *et al* 1988, Balogun and Ologhobo 1989, Adeparusi, 1992; Webster *et al* 1995) while such that substituted the expensive soybean meal with some other less expensive plant

protein sources are few (Fasakin and Balogun, 1990).

Pigeon pea (*Cajanus cajan*) is a dicotyledonous flowering plant belonging to the family Leguminosae, originating from tropical Africa and introduced to India which now accounts for 90% of the world production (Purseglore, 1988). About 175 species abound in India while West Africa accounts for only one specie (Oyenuga, 1967; Purseglore 1988). The value of this legume is not much appreciated in the West African sub-region, because the pea requires a longer cooking time than the cowpea (*Vigna unguiculata*) (Oyenuga, 1967). Also due to the acid taste of the seed coat, the cooking water would have to be changed several times to make the final product palatable (Adeparusi 1992).

Although ground pigeon pea has been incorporated in fish feed replacing fish meal with favourable results. (Adeparusi 1992). However, the effects of pigeon pea protein as fish feed are yet to be exhaustively investigated in tropical fish feed. This pea is therefore being evaluated in this study as a replacement for

soybean protein in the diet of Nile tilapia (*Oreochromis niloticus*) which is one of the most cultured tilapia species in Nigeria.

Materials and Methods

Oreochromis niloticus fingerlings weighing $4.60\text{g} \pm 0.25$ were obtained from (Oluana Fish Breeding Centre, Ibadan, Oyo State, Nigeria). The fish were first starved for 72 hours and later acclimatized to assigned experimental diets for one week prior to the beginning of the actual feeding experiment. The experiment was conducted in 12 glass tanks (40 X 90 X 40 cm). The water for the experiment was held in an outdoor open tank for 72 hours to allow for escape of chlorine used in water treatment. The experimental fish were randomly stocked at 15 fish per tank and every treatment replicated.

Six iso-nitrogenous diets (35% crude protein) were formulated and prepared. Soyabean meal in the control diet was replaced with pressure cooked pigeon pea meal at 0%, 20%, 40%, 60%, 80% and 100% levels (Table I). The pigeon pea was purchased from a market in Abeokuta, Ogun State of Nigeria. The peas were sorted and soaked in hot water for about 45 minutes after which the husk (seed coat) was removed manually. The peeled peas were then cooked in an autoclave at 120°C for 15 minutes at the pressure of 15 psi (to remove the heat-labile anti-nutritional factors). The peas were allowed to cool and air dried to about 10% moisture content (FAO1987) and was ground in Fuji Mizuho mill, then incorporated into the diets at various levels.

Table 1 Ingredient composition of test diets fed to *O. niloticus* fingerlings (g/Kg Diets)

Components	D I 0%	D II 20%	D III 40%	D IV 60%	D V 80%	D VI 100%
Soybean meal	416.7	333.3	250.00	156.5	75.7	0
Pigeon pea	0.00	137.9	275.8	398.5	501.6	594.2
Blood meal	57.1	64.9	73.1	89.0	103.7	101.7
Fish meal	138.9	138.9	138.9	138.9	138.9	138.9
Corn meal	298.8	236.5	173.7	128.6	91.6	66.7
Bone meal	25.0	25.0	25.0	25.0	25.0	25.0
Oyster shell	5.0	5.0	5.0	5.0	5.0	5.0
Vit. Premix	6.0	6.0	6.0	6.0	6.0	6.0
Palm Oil	50.0	50.0	50.0	50.0	50.0	50.0
Salt	2.5	2.5	2.5	2.5	2.5	2.5
Analysed Composition (% dry matter)						
Crude protein	34.70	34.65	35.00	35.10	34.75	34.98
Ether extract	8.61	6.98	6.00	5.98	8.63	7.00
Ash	8.50	8.32	8.60	9.90	7.95	7.40
Crude fibre	5.87	7.25	6.98	6.78	5.98	7.57
Moisture	5.80	6.00	5.96	5.55	5.68	6.00
NFE	35.52	36.80	37.46	36.69	37.01	37.05

The experimental fish were fed twice daily at 8.00 – 9.00 hrs and 16.00 – 17.00 hrs for 56 days at 3% body weight. Aeration was facilitated by the use of aerator pumps (Tecax 300). Stale water was drained out of the tanks every other day to maintain relatively uniform physico-chemical parameters and to prevent

fouling. Dissolved oxygen ranged from 6.8 to 8.2 mg/l. Control weighing of fish in each tank was carried out in batches every seven days and feed supply were adjusted to accommodate the increase in body weight of the fish. At the beginning of the experimental feeding trial, composite samples of ten whole fish and a

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random sample of five fish per tank at the end of 56-days experimental period were analysed for proximate composition. Nitrogen content was determined using AOAC (1990) methods and the factor of 6.25 was used to convert the nitrogen to protein. Fat, fibre, ash and moisture content of the diets and composite fish sample were analysed using AOAC (1990) methods.

Diet performance was evaluated on experimental fish according to Oliver Nova *et al.*, 1990 as follows:

(i) Weight gain (%) =

$$\frac{(\text{Final body weight} - \text{initial body weight})}{(\text{initial body weight})} \times 100$$

(ii) Specific Growth Rate (SGR%/day)

$$= 100 [\log_e \text{final body weight} - \log_e \text{initial body weight}] / \text{time (days)}$$

(iii) Feed conversion ratio (FCR) =

$$\frac{\text{Feed intake (g)}}{\text{Fish weight gain}}$$

(iv) Feed conversion efficiency (FCE) % =

$$\frac{\text{Weight gain}}{\text{Feed intake}} \times \frac{100}{1}$$

(v) Protein Efficiency Ratio (PER)

$$= \frac{\text{Fish weight gain}}{\text{Protein fed}}$$

(vi) Net protein utilization (NPU) =

$$(\text{Protein gain/protein fed}) \times 100$$

Statistical comparison of growth performance and protein utilization values was made by using analysis of variance (ANOVA) and correlation analysis system (SAS, 1988)

Results

Proximate analysis of experimental feed (Table 1) showed that there were not much variation within the nutrient values. Table 2 shows the range of values of the physico-chemical parameters in the experimental system. The temperature ranged from 26.30°C to 27.35°C, the pH ranged from 7.10 to 7.30 while the dissolved oxygen ranged from 6.80mg/l. to 8.20mg/l.

The mean growth response, feed performance and the carcass composition (before and after feeding) of Nile tilapia fed experimental diet is shown in Table 3.

Table 2 Range of values of physio-chemical parameters in the experimental system

Parameter	Range
Temperature (°C)	26.30 – 27.35
pH	7.10 – 7.30
Dissolved Oxygen (mg/l.)	6.80 – 8.20

Table 3 Effects of varying dietary cooked pigeon pea meal levels on the growth and nutrient utilization of *O. niloticus* in glass tanks for 56 days

DIET	I	II	III	IV	V	VI	SEM
	0%	20%	40%	60%	80%	100%	
Initial m. wt.(g)	4.50	4.90	4.55	4.75	4.50	4.10	0.25
Final m. wt.(g)	9.00	8.30	10.73	12.12	9.63	9.07	1.27
Mean. Wt. gain. (g)	4.50 ^{cd}	3.90 ^d	6.18 ^b	7.40 ^a	5.13 ^C	4.32 ^d	1.21
% wt. Gain	100 ^d	69.39 ^e	138.82 ^b	155.16 ^a	114.00 ^C	105.37 ^{cd}	27.17
Feed intake (g)	8.02 ^c	8.35 ^b	8.49 ^{ab}	9.87 ^a	8.67 ^a	8.32 ^b	0.59
Feed conversion ratio	1.78 ^{bc}	2.14 ^a	1.38 ^d	1.33 ^d	1.70 ^{Cd}	1.94 ^{ab}	0.29
Specific growth rate(% /day)	1.65 ^{cd}	1.40 ^d	2.04 ^{ab}	2.24 ^a	1.81 ^{bc}	1.55 ^d	0.29
Feed conversion efficiency (%)	56.18 ^b	48.23 ^c	72.95 ^a	75.30 ^a	59.00 ^b	51.98 ^c	10.15
Protein efficiency ratio	1.60 ^b	1.35 ^c	2.08 ^a	2.14 ^a	1.70 ^b	1.48 ^d	0.29
Net protein utilization	8.86 ^c	8.37 ^d	11.14 ^a	9.97 ^b	5.76 ^c	5.09 ^f	2.15

Analysed Composition of Fish Carcass (%dry matter)

Nutrient %	Initial	Final						SEM
		I 0%	II 20%	III 40%	IV 60%	V 80%	VI 100%	
Crude protein	62.10	65.20	65.20	66.20	65.60	64.10	3.88	1.27
Moisture	6.00	5.41	5.65	4.99	6.00	5.96	5.30	0.37
Ash	16.50	12.51	12.65	11.89	13.32	13.11	13.63	1.38
Fat	6.89	10.32	11.25	11.66	10.38	11.33	10.62	1.49

Values on the same row with same super fix are not significantly different ($P>0.01$)

SEM= Standard Error of the Mean.

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No mortality was recorded throughout the eight weeks experimental period. In almost all of the treatments, the fish fed readily and no feed was rejected. However, those fed diet containing 0% pigeon pea meal (Diet 1) exhibited a reduction in feed consumption rate. There was a good growth response in all the treatments, with the fish fed 60% pigeon pea meal (Diet 4) displaying the highest absolute growth in terms of body weight, weight gain (WG), feed conversion ratio (FCR) and specific growth rate (SGR) with values significantly better ($P < 0.01$) than fish fed other diets. Net protein utilization was highest in fish fed diet 3 (40% pigeon pea meal) and significantly better ($P < 0.01$) than other treatments while the lowest NPU was observed from fish fed diet 6 with a value of 5.09.

The carcasses composition (Table 3) showed a rising protein value from diet 1 and 2 (0% and 20% pigeon pea meal) to diet 3 (40% pigeon pea meal) and then coming down to the lowest value in diet 6 (100% pigeon meal). Moisture and ash content did not show a regular pattern or wide variation while the fat content was highest in diet 6 and lowest in diet 3.

Discussion

From this trial, it is apparent that pressure-cooked pigeon pea meal can replace all of soybean meal without any adverse effect and that replacement at 60% level gave the best performance of Nile tilapia (*O. niloticus*). The higher growth performance exhibited by fish fed higher inclusion level of pigeon pea meal (between 40% and 80% levels), (except for diet 2 which might be due to experimental error) might be due to the processing method of the pigeon pea used. Pigeon pea as well as other legumes like soybeans are known to contain anti-nutritional factors inhibiting the activities of protein digesting enzymes which can be removed by heat treatment (Faris and Singh, 1990).

Furthermore, the quality of these diets with rising pigeon pea content might have been increased by the increasing amount of animal protein (Fish meal and blood meal) (Table 1)

which might have covered up the effect of the limiting essential amino acids in pigeon pea meal which, according to Duke (1981) and Adeparusi (1992) are methionine, cystine and tryptophan. This is further buttressed by the argument of Coche (1990) that diets without fish meal are yet to be formulated. Also McDonald *et al.* 1987 opined that the best protein for animal is the one that has its amino acid profile nearest to that obtained in such animal body protein.

De la Penal *et al.* (1987) as cited by Adeparusi (1992) reported a significantly depressed growth ($P < 0.05$) and feed conversion efficiency when diets with 25% of protein contributed by pigeon pea or kidney bean meal were fed to milk fish (*Chanos chanos*). This could have resulted from the dry heat used in processing the meal in an oven for two hours at 110°C. Also the *O. niloticus* used in this study could have better utilized the pigeon pea due to a more effective processing method. It has been observed that hydrothermal treatment of Soybean is more effective than dry heating. For instance, Viola *et al.* (1983) observed that steam heating at 105°C for 60 minutes removed 95 – 100% of trypsin inhibitor (a factor which is also present in pigeon pea) while roasting at 232°C for 10 minutes removed 96% of trypsin inhibitor.

The increase in the NPU of fish from the control to 60% replacement level shows that the higher the replacement level of soyabean meal, the higher the biological value of the protein mixture. Thus replacing all the soyabean meal with pigeon pea meal in the diet of *O. niloticus* did not have adverse effect on growth and 60% replacement level produced the most balanced protein mixture for the growth and nutrient utilization of *O. niloticus*.

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