The use of soaked copra meal as a partial substitute for soybean meal in the diet of Nile tilapia (*Oreochromis niloticus*) fingerlings

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Abstract

A feeding trial was conducted in net hapas (fish enclosures constructed with fine mesh net) suspended in outdoor concrete tank to evaluate the nutritive value of soaked copra meal (a by-product of coconut oil industry) as a dietary protein supplement for soybean meal in practical diets for Nile tilapia (*Oreochromis niloticus*) fingerlings (mean initial weight, 7.26±0.23g). Four iso-nitrogenous (30% crude protein) and iso-energetic (16KJ/g) experimental diets were formulated in which soaked copra meal replaced soybean meal at four inclusion levels. The reference/control diet was tagged reference diet, while other diets were tagged TD1, TD2, TD3; at replacement levels of 0, 15, 30, and 45% soaked copra meal respectively. The diets were given at 3% wet body weight to triplicate groups of 10 fish for 70 days.

In terms of growth performance and nutrient utilization efficiencies, fish fed TD1 and TD2 performed measurably better than those fed reference diet, but were with values statistically similar (p>0.05). Apparent protein digestibility coefficients which ranged from 76.1% (reference diet) to 55.2% (TD3) and hepatosomatic indices with a range of 1.33% (reference diet) to 1.21% (TD3) decreased with increasing levels of soaked copra meal. There was however no significant difference (p>0.05) in the apparent protein digestibility and hepatosomatic indices values among the dietary treatments. The results showed that soaked copra meal can be incorporated in the diets of Nile tilapia, *Oreochromis niloticus*, fingerlings up to 30% without any deleterious effect on growth performance and nutrient utilization.

Key words: Experimental diets, fish, hepatosomatic index, iso-energetic, iso-nitrogenous, protein digestibility

Introduction

Traditionally, fishmeal and lately soybean meal are the major sources of protein in animal feeds. There is however limitation in the use of these feed ingredients as a result of their relevance in human nutrition coupled with decline in productivity. For instance, the productivity of soybean, which is inadequately grown in the tropics (Ng and Chen 2002) is on the decline (FAO 2001). It is being used in several human diets such as soy pap (*ogi*), soy milk and baby formula (IITA 1990). The resultant pressure has necessitated the need to evaluate cheaper ingredients which have little or no relevance for human nutrition in fish feed formulation.

Copra meal is often used as a protein source in the diets of fish (Kim et al 2001). Copra is obtained from the kernel of coconut fruit, which have been sun dried or dried using drying machines. The major producing countries are the Philippines and Indonesia, which account for about two-thirds of the world's total production of 2.0 million metric tons in 1997 (Swick 1999). The coconut production in Nigeria increased from 104,000 metric tons in 1986 to 151,000 metric tons in 1996 (Federal Ministry of Agriculture and Natural Resources 1997). However, the protein quality of copra is poor both in terms of its amino acid balance and digestibility (Swick 1999; Thorne et al 1990). It is deficient in important essential amino acids such as lysine, methionine, threonine and histidine but high in arginine, which is known to have antagonizing effect on lysine utilization (Swick 1999). Fortifying practical feeds in which copra meal is used with some essential amino acids such as lysine and methionine could solve the problem of arginine antagonism and also improve its protein quality. Copra meal also contains tannins as the major anti-nutritional factor (Mukhopadhyay and Ray 1999a) and high fiber (Swick 1999), which limits its utilization. It was envisaged that by reducing the level of tannin in copra meal, it could represent a cheap and valuable source of both energy and protein in the diet of tilapia.

Nile tilapia *(Oreochromis niloticus)* is the most predominantly cultured species among the cichlid family (Roderick 1997). It exhibits qualities that include fast growth, efficient use of feed and resistance to disease (Lovell 1989). Thus, the aim of this study was to evaluate the effects of soaked copra meal as a replacement for soybean meal on growth performance, nutrient utilization, digestibility and hepato-somatic index of Nile tilapia (*Oreochromis niloticus)* fingerlings.

Materials and methods

Experimental system and fish

The feeding trial was conducted in fish hapas (1x0.5x0.5)m suspended by bamboo poles in an outdoor concrete tank (5x3x1.5)m located at the experimental site of the Department of Aquaculture and Fisheries Management, University of Agriculture, Abeokuta, Nigeria. Fifteen hapas (1x0.5x0.5)m were suspended to ¾ of their volume using Kuralon twine tied to carefully arranged bamboo poles. The concrete tank was filled to 5/6 of its volume and was continually supplied with water to sustain optimal environment and to preclude primary productivity. The water was introduced in a splash for better aeration.

Oreochromis niloticus fingerlings (7.26g±0.23) obtained from the production pond of a local fish farm were transferred to the site of the experiment and were acclimated for a period of 7 days in fish hapas.

Diet formulation and preparation

Copra meal was purchased as by-product from a local coconut industry in Nigeria and was subjected to treatment by soaking in water in a plastic bowl (40L) at room temperature (28-30^{o}C) for 16 hours according to Mukhopadhyay and Ray (1999a, b and c). The water was decanted and the soaked copra was sun dried for two days before use. All the other feed ingredients were milled using locally fabricated hammer mill and sieved through a 595µm sieve to remove chaff and to ensure homogenous size profile before being analyzed for proximate composition (table 1).

Table 1. Proximate composition of feed ingredients

	Crude protein, %	Ether extract, %	Crude fibre, %	Ash, %
Fish meal	67.7	4.10	1.31	14.8
Soybean meal	45.3	8.60	5.0	4.63
Groundnut cake	34.6	8.80	4.31	13.1
Copra meal	20.0	7.55	15.7	0.50
Corn meal	10.8	5.50	1.45	1.46

Four experimental diets were formulated to be iso-nitrogenous and iso-energetic containing (30% crude protein) and (16 KJ/g diet) respectively. The formulation was based on the proximate composition of the ingredients (table 1). There was a Reference diet with soybean meal as the main plant protein source. Others were coded TD1, TD2 and TD3 in which soaked copra meal progressively replaced soybean protein at 15%, 30% and 45% inclusion levels respectively. The diets were fortified with DL-Methionine (2%), Lysine (2%) and Vitamin/Mineral premixes (1.5%). The ingredients of each diet were thoroughly mixed in a bowl and pelletised in a mechanical pelletizer using 1% starch as binder (table 2).

Table 2. Gross composition (g/100g) and proximate composition (%) of the experimental diets

Ingredient	Reference diet , 0%	TD1, 15%	TD2, 30%	TD3, 45%
Fish meal	5	5	5	5
Groundnut cake	5	5	5	5
Soybean meal	47.3	45.1	42.4	38.4
Corn	35.3	28.4	21.9	13.9
Copra meal	-	6.96	16.2	26.7
Vegetable oil	3	3	2.9	2.9
Vit./Min. premix	1.5	1.5	1.5	1.5
Methionine	2.0	2.0	2.0	2.0
Lysine	2.0	2.0	2.0	2.0
Chromic oxide	1.0	1.0	1.0	1.0
Starch	1.0	1.0	1.0	1.0
Proximate composition, %n				
Moisture	8.55	10.14	9.22	9.65
Crude protein	30.0	29.9	29.9	30.2
Lipids	8.30	9.45	9.62	10.7
Crude fibre	8.65	10.5	11.1	11.7
Ash	6.52	5.08	7.70	6.57
Nitrogen Free Extract	38.0	34.7	32.4	31.3

**Supplied kg^{-1} diet, Vit.A, 4,000,000 i.u; Vit.D_3, 800,000 i.u; Tocopherols 4,000 i.u, Vit. K_3, 800mg; Folacin, 200mg; Thiamine, 600mg; Riboflavin, 1,800mg; Niacin, 2,000mg; Ca panthothenate, 2,000, Pyridoxine, 600mg; Cyanocolabamin, 4mg; Biotin, 8mg; Mn, 30,000mg; Zn, 20,000; Fe 8,000mg; Choline chloride, 80,000mg; Cu, 2,000mg, I, 480mg; Co, 80; Se, 40mg; BHT, 25,000mg; Anticaking agent, 6,000mg*

The moist pellets were sun dried for about six hours, packaged in tagged, air-tight polythene bags and stored in a dry place.

Experimental procedure

Nile Tilapia (*Oreochromis niloticus*) fingerlings were randomly distributed at a stocking rate of 10 fish per hapa. Each treatment was in triplicate. The experimental fish were fed with the formulated diet twice daily at 10.00h and 16.00h, six days a week at a feeding rate of 3% wet body weight per day for a 10-week experimental period. Fish were weighed weekly with a sensitive electronic balance (Mettler Toledo PB 602) and ration quantity was readjusted weekly. Mortality was monitored daily. Prior to the feeding trial, five fish were collected while at the end of the feeding trial 3-5 fish were selected from each hapa and sacrificed for proximate composition.

The level of tannin in raw and soaked copra was determined by the modified Prussian blue assay for total phenols according to Graham (1992). All analyses for proximate composition were determined according to the methods of AOAC (1990). Water temperature, dissolved oxygen and pH were monitored daily during the experiment. Temperature was monitored with a standardized mercury thermometer, dissolved oxygen concentration was determined using Jenway dissolved oxygen meter (9015), and pH was monitored with a Jenway automatic pH metre (Jenway, 3015) .Conductivity meter (WTW LF/91) was used in the determination of conductivity.

Data collection and statistical analysis

Growth parameters were calculated according to Castell and Tiews (1980). Digestibility coefficients was determined using the acid digestion method (Furukawa and Tsukahara 1966) and calculated as follows:Total digestibility (%)=100-[100(%Cr_2O_3 in food/% Cr_2O_3 in faeces)]. Apparent protein digestibility (%) =100 – [(100(%Cr_20_3 in diet x % protein in feaces)/(%Cr_20_3 in feaces x % protein in diet). The Hepatosomatic index of fish at the end of experiment was computed as: Hepatosomatic index (H.S.I) = 100(liver weight/body weight). The data describing growth performance and feed utilization were analyzed statistically using one-way Analysis of variance (ANOVA) and the differences among means were tested for significance ($P<0.05$) using SPSS statistical package.

Results

Soaking at room temperature for a sixteen-hour period reduced the tannin content of raw copra meal from 2.50% to 0.86%. The proximate composition of diets is presented in Table 2. There was a progressive increase in the dietary lipid and crude fibre contents as copra meal increased in the diets while the moisture and ash content followed no definite order. The crude protein values were identical (29.9-30.2%) in all the dietary treatments.

The growth performance, nutrient utilization, apparent protein digestibility and hepatosomatic index of *Oreochromis niloticus* fingerlings fed with the experimental diets are presented in Table 3.

Table 3. Growth performance, feed utilization, nutrient digestibility, survival and carcass composition of *Oreochromis niloticus* fingerlings fed various levels of treated copra meal

Parameters		**Reference diet, 0%**	**TD1, 15%**	**TD2, 30%**	**TD3, 45%**	**±SEM***
Average initial weight, g/fish		7.30^a	7.59^a	7.17^a	7.43^a	0.23
Average final weight g/fish		13.1^a	13.1^a	13.0^a	11.6^a	0.42
Weight gain, g/fish		5.77^a	5.47^a	5.80^a	4.17^b	0.32
Weight gain, mg/day		77.6^a	78.1^a	82.8^a	59.5^b	4.56
Percentage weight gain, %		79.0^a	82.7^a	81.1^a	56.4^b	4.72
Specific growth rate, %/day		0.85^a	0.86^a	0.84^a	0.64^b	0.04
Food conversion ratio		2.37^b	2.36^b	2.48^b	3.15^a	0.14
Food efficiency, %		42.2^a	42.4^a	40.3^a	31.7^b	0.02
Protein efficiency ratio		1.13^a	1.16^a	1.16^a	0.89^a	0.06
Apparent protein digestibility, %		76.1^a	72.2^a	69.0^a	55.2^b	3.19
Hepatosomatic index, %		1.33^a	1.28^a	1.23^a	1.21^a	0.08
Survival, %		83.3^a	86.7^a	83.3^a	76.7^a	3.36
Carcass analysis, %	*Initial*					
Moisture	9.55	9.33^a	9.24^a	8.96^a	9.05^a	0.07
Crude protein	56.4	63.3^a	65.3^a	64.7^a	62.9^a	2.46
Lipids	6. 20	8.25^b	9.00^b	9.75^a	10.2^a	0.73
Ash	9.19	7.83^a	7.50^a	8.50^a	8.83^a	0.77

*Mean of triplicate data in each row with similar superscript are not significantly different (p>0.05) *Standard error of pooled means*

Growth performance was generally poor. There were no significant differences (p>0.05) in mean weight gain among all the dietary treatments except in fish fed DT3. Although fish fed TD2 (30% copra meal) had the highest value of 5.80g, while reference diet had a value of 5.77g. Food conversion ratio was also lowest in fish fed TD1 but not significantly different (p<0.05). Similar trends were observed in protein efficiency ratio. Total and apparent digestibility decreased as copra meal increased in diets. There was no significant difference (p>0.05) in total and apparent digestibility values in fish fed reference diet, TD1 and TD2. Fish survival ranged between 70.0 and 86.7% (Table 3). There was no significant difference (p>0.05) among treatments.

Carcass proximate composition of the experimental fish is presented in Table 3 The moisture content of the fish fed the experimental diets were similar and not significantly different (p>0.05). Crude protein content of fish fed experimental diets increased progressively as copra meal decreased with fish fed reference diet recording the highest but their was no significant difference (p>0.05) among the dietary treatments. Lipid level was lowest in fish fed the reference diet and it differed significantly (p<0.05) from those fed with TD2 and TD3 while ash content ranged from 7.50% in fish fed TD2 to 8.83% in those fed with TD3 but there was no significant difference (p>0.05).

Hepatosomatic index (table 3) decreased as copra meal increased in diets with fish fed reference diet recording the highest value of 1.33% and fish fed TD3 recording the lowest value of 1.21%. No significant difference (p>0.05) existed in hepatosomatic indices among treatments.

Mean values of temperature, dissolved oxygen and pH measured biweekly throughout the experimental period ranged between 26.45 and 26.79^{0}C, 7.45 and 8.22 and 6.40 and 6.85 mg/l respectively.

Discussion

The present study demonstrates that soaked copra meal could be used to partially replace soybean meal in pelleted feed for *Oreochromis niloticus*. Replacing soybean meal with as high as 30% soaked copra meal into the diet of *Oreochromis niloticus* will not compromise growth performance and feed utilization efficiency. However, partial supplementation at 45% inclusion level of treated copra meal resulted in reduced growth. Similar trends were also observed in the fish performance in terms of percentage weight gain, specific growth rate, food conversion ratio and food efficiency ratio. The results of the present study are in agreement with the works of Mukhopadhyay and Ray (1999a and b). The authors fed treated copra meal and sesame seed meal to *Labeo rohita* and recommended an inclusion level of 30% and 40% respectively. They also observed that plant-derived proteins such as linseed meal and sesame seed meal could replace fish meal at levels as high as 50% when fortified with amino acids (Mukhopadhyay and Ray 1999c, 2001). Also, Obasa et al (2003) observed that preasure cooked pigeon pea could replace 60% of soybean meal in the diet of *Oreochromis niloticus*. They also recorded an improved growth performance in fish fed diets where soybean meal was replaced over that fed control or reference diet. They argued that *Oreochromis niloticus* probably utilized the pigeon pea better due to the processing method which probably increased its nutritional quality.

Though oilseeds and their by-products usually constitute a major source of dietary protein in fish feeds for warm water species (Akiyama 1991; Lim and Dominiy 1989;Tacon 1993), their incorporation at high inclusion levels could be limited by a number of factors which include the presence of anti-nutritional factors like tannins, (flavonoid polyphenolic compound). These form complexes with protein thereby reducing the digestibility and consequently biological availability of this nutrient (Mole and Waterman 1987). In addition, they possess poor amino acid profile and high crude fibre content (Tacon and Jackson 1985) which could be removed or reduced by processing. Mukhopadhyay and Ray (1999a) reported that soaking at room temperature for a 16-hour period reduced the levels of tannins in raw copra meal from 2.4% to as low as 0.9%. Most probably, in the present study, the fish thrived on soaked copra as much as soybean at 30% inclusion level as a result of reduction in tannin content in the treated copra meal.

The results also showed low and progressive decrease in apparent protein digestibility coefficients with increase in copra meal. This is in agreement with similar studies where soaked copra was fed to *Labeo rohita* (Mukhopadhyay and Ray 1999a). The observation in the latter study however showed higher apparent protein digestibility values than the results of the present study. This may probably be due to the fact that *L. rohita* had a capacity to utilize plant-derived proteins better (Jobling 1994) and *Clarias isheriensis* (Fagbenro 1990) since these species have cellulase activity in their guts. It could also be the result of slight increase in the crude fibre contents of the test diets, as a result of increasing soaked copra meal. High crude fibre, generally associated with plant-derived proteins is known to depress apparent protein digestibility coefficients (Olivera-Novoa et al 2002).

There was a slight decrease in apparent protein digestibility coefficients when compared with similar studies on the use of plant-based proteins in the diet of *Oreochromis niloticus*. For instance, Siddhuraju and Becker (2003) and Hossain et al (2003) evaluated the nutritional value of mucuna seed and sesbania endosperm in the diet of *Oreochromis niloticus* and recorded better fish performance in terms of mean weight gain, specific growth rate, food conversion ratio and food efficiency ratio than in the present study. This could result from the presence of reasonable levels of fishmeal and lower inclusion levels of these plant-based proteins in their experimental diets. It is generally known that fishmeal is the best source of protein in fish feeds (Tacon 1993).

The carcass lipid content of fish fed the test diets was higher than the group fed the reference diet and was inversely proportional to the moisture content. This could be due to the higher lipid content of copra meal.

Conclusions

- The present study demonstrated that the incorporation of soaked copra meal can be as high as 30% in the diets of *Oreochromis niloticus*.

- The relevance of this is the probable reduction in cost of fish feed, as copra meal, can be obtained locally as a by-product of coconut oil industry.

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