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Partial Replacement of Soybean Cake with *Amaranthus spinosus* Leaf Meal in the Diet of Nile Tilapia (*Oreochromis niloticus*)

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Abstract. The study, designed to assess the potentials of oven dried *Amaranthus spinosus* leaf meal as partial replacement for soybean cake in the diet of Nile Tilapia, revealed no significant difference ($P>0.05$) in feed and protein intake. Fish fed on *Amaranthus spinosus* leaf meal diets had significant ($P<0.05$) higher survival percentage, while that on soybean cake meal (control diet) recorded significant ($P<0.05$) better weight gain, average daily rate of growth, efficient feed and protein utilization as well as average final weight.

Keywords: *Amaranthus spinosus* leaf meal, soybean cake, Nile tilapia, feed efficiency ratio, protein efficiency ratio

Introduction

Over the years oil seed cakes have been evaluated as fish feed ingredients. With advanced processing techniques their nutritive values have been enhanced to such an extent that they are now considered as conventional ingredients in aquaculture. However, the increasingly scarce supply of conventional plant protein sources and concomitant rise in prices have made it necessary to seek a cost effective replacement to supply dietary protein in aquaculture feed. Thus, research studies into cheaper alternative plant protein sources for development of low cost feeds for small scale farmers has become an utmost priority in developing countries like Nigeria, in order to maximize profit (Fashina-Bombata *et al.*, 2005; Akegbejo-Samsons and Ojini, 2004; Fasakin and Balogun, 1998). This is necessary because a greater percentage of fish supply comes from small-scale peasants and rural farmers (Omotoso and Fagbenro, 2005; FAO, 2002; Ogbe *et al.*, 2001).

Amarathus is an annual plant distributed world wide in both humid and warm regions and is now widely cultivated in most tropical areas (Steentoft, 1988; Tindall, 1983). *Amarathus spinosus* are usually short-lived annuals, with potential for self and cross pollination. They are widely available, especially during the rainy season, and widely dispersed by wind, growing almost on every soil, thus regarded as weed. Presence of thistles on the stem limit their consumption by man; however, the leaves are high in pro-vitamins (A and C), minerals (iron, calcium and potassium) and proteins, with lysine constituting as much as 5.9% of the proteins which is equal to that in soybean and more than that in some of the best maize strains (Steetoft, 1988; Tindall, 1983). Nile tilapia (*Oreochromis niloticus*) is one of the most cultured tilapia species in Nigeria; it is planktivore or herbivore. In view of the above, this study was conducted to assess the utilization of oven dried *Amaranthus spinosus* leaves as partial replacement for soybean cake in the diet of *Oreochromis niloticus* fingerlings, with the aim of widening the choice of available plant protein sources.

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Materials and Methods

Materials and feed preparation. *A. spinosus* leaves were collected from Lagos State University, Ojo Campus, Lagos, Nigeria. The leaves were oven dried at 60 °C until constant weight was obtained. The leaves were later ground with electrical food blender. Four experimental diets were prepared, containing approximately 32% crude protein. Diet I contained 0% Amaranthus leaves or 100% soybean cake (SBC) protein and served as the control. Diets 2, 3, and 4 contained varying levels of the leaves at 25, 50 and 75% of SBC protein, respectively. The percentage composition of the diets is presented in Table 1.

Experimental fish management. A total of 96 fingerlings of *Oreochromis niloticus* were purchased from Habib Farm at Agric-complex near Volkwagen Nigeria Limited, Badagry Expressway, Lagos. The fish were fed on commercial diet for 2 weeks to allow for acclimatization. They were randomly distributed to four treatments in three replicates, each making 8 fish to each replicate and 24 fish to a treatment in a randomized complete block design. The fish were managed for 56 days in the laboratory in plastic bowls with capacity for 80 litres of water. Partial replacement of water was made daily before feeding. Feeding was done twice daily between 9.00-10.00 h and 16.00 - 17.00 h.

Parameters measured. Fish weight was taken fortnightly. Quantity of feed consumed was recorded from which protein intake, average daily growth (ADG), feed conversion ratio (FCR) and protein efficiency ratio (PER) were calculated according to the established method of Adron *et al.* (1976). Mortality was recorded from which survival percentage was calculated.

Chemical and statistical analyses. Test ingredients were analyzed for proximate composition using the methods of AOAC (1990). Data generated were analyzed using analysis of variance as described for complete randomized design (Steel and Torrie, 1980). Significant differences were determined by using Duncan's multiple range test (Duncan, 1955).

Results and Discussion

The results of the nutrient composition of the test feedstuffs are presented in Table 1 and those of performance characteristics in Table 3. SBC had higher content of crude protein and ether extract while *A. spinosus* leaves had higher content of dry matter carbohydrates (crude fibre and nitrogen free extract) and ash. Performance characteristic results showed no significant difference ($P>0.05$) in total feed and protein intake. Fish on control diet (SBC 100% protein) had significantly ($P< 0.05$) best values in average final weight, weight gain, average daily rate of growth, feed conversion and protein efficiency ratios. However, they had significantly ($P<0.05$) lowest survival percentage (41.67%) whereas the fish on 75% *A. spinosus* leaves had the best survival percentage of 79.17%. There was no significant ($P>0.05$) difference in all of the parameters measured among fish on the leaf diets except for fish on 50% of the leaves which had significantly ($P< 0.05$) best FCR while PER was not significantly ($P>0.05$) different from values recorded for fish on other *A. spinosus* leaf diets.

Table 1. Percentage composition of experimental diets

	Replacement level of SBC protein (%)			
Ingredients	0	25	50	75
Maize	40.00	38.38	30.17	25.34
Soybean cake	25.00	18.75	12.50	6.21
A. spinosus leaves	0.00	8.87	18.33	27.41
Wheat meal	7.00	8.00	11.00	13.00
Fish offal	25.00	25.00	25.00	25.00
Salt	0.50	0.50	0.50	0.50
Vitamin mineral premix	1.50	1.50	1.50	1.50
Bone meal	1.00	1.00	1.00	1.00
Calculated CP	32.11	32.06	31.91	31.87
Calculated CF	1.39	1.75	2.16	2.53

SBC = soybean cake; CP = crude protein; CF = crude fibre

Table 2. Proximate composition of test ingredients (%)*

Parameters	*A. spinosus* leaves	Soybean cake
Dry matter	22.55	91.85
Crude protein	30.01	45.34
Crude fibre	7.97	5.56
Ether extract	3.39	4.07
Ash	13.65	9.14
Nitrogen free extract	44.98	27.74

* = results represent average of three analyses

Generally no particular trend was observed in the performance of fish on *A. spinosus* leaf diets. However, the reduced performance of Tilapia, fed on the leaf diets, did not appear to be due to the palatability problem, because the amount of feed consumed by fish on the leaf diets were not significantly different from 100% SBC or control diet, thus suggesting the acceptability of the diets to the fish. Likewise, the comparison of the protein content and intake of these diets by the fish does not indicate differences (32.11% for the control and 31.87% for 75% replacement) (Table 1) of sufficient magnitude to indicate insufficient intake to meet the requirement of Tilapia (Otubusin, 2000; Ishak and Hassanen, 1987); it is likely that antinutritional factors were involved in it. *A. spinosus* leaves are implicated to contain alkaloids, phenols, saponins and oxalates (Bressani, 1994; Tindall, 1983) which inhibit protein and other nutrient digestion. This may decrease digestibility of these nutrients and subsequent utilization for tissue synthesis and growth.

A. spinosus leaves were included in the diet based on the premise that its combination with SBC might be complementary. This is based on the assumption that the protein sparing action of carbohydrate (which is the principal nutrient of *A. spinosus* leaves) might be utilized in enhancing overall nutrient utilization, thus reducing feed cost (Hertrampf and Piedad-Pascual, 2000; Wee, 1991; Hepher, 1979; Adron *et al.*, 1976), while also utilizing the significant symbiotic gut flora, for which herbivorous fish are noted, to assist digestion (Caulton, 1982; Trewavas, 1982). Since the results obtained in this study do not appear to suggest palatability, acceptability and intake of nutrients as problem, the actual availability of the nutrients may be the issue. Therefore, there is need to enhance the availability of *A. spinosus* leaf nutrients. *A. spinosus* leaves used in this study were only oven dried. Better or other processing methods such as pressure cooking may be necessary to inactivate these anti-nutritional factors (Ezeagu, 2005;

Table 3. Performance characteristics of *Oreochromis niloticus* fed on soybean partially substituted with *A. spinosus* leaves

	Replacement of SBC protein (%)				
Parameters	0	25	50	75	± SEM
Total feed intake (g)	142.46	142.30	132.52	137.45	24.90
Weight gain (g)	10.63a	4.27b	4.80b	4.17b	0.22
Average daily rate of growth	0.19a	0.08b	0.09b	0.07b	0.02
Feed conversion ratio	13.60c	33.59a	27.80b	33.81a	4.02
Protein intake	45.74	45.62	42.29	43.81	7.80
Protein efficiency ratio	0.23a	0.09b	0.11b	0.10b	0.03
Average final weight (g)	32.93a	26.55b	25.05b	26.37b	1.50
Survival percentage	41.67c	62.50b	45.83c	79.17a	7.42

* = means in the same row having the same alphabet are not significantly (P > 0.05) different; SEM = standard error of means

Elemo *et al.,* 1998). However, of importance is the improvement seen over the earlier studies wherein growth losses were reported in fishes fed on plant materials (Okeyo, 1987; Legner and Murray, 1981). The improvement might be due to the fact that some part of the feed nutrients were provided by animal protein (fish meal) which is noted for its good nutritive value. This may have had a complementary effect on nutrient utilization. Thus, it is suggested that the degree of utilization of nutrient is determined by various feed components; the more is the materials of better digestion and utilization, the better is the performance. The results obtained in the study also seem to support earlier work reported on the superiority of SBC nutrients over other plant proteins (except for the low survival recorded in this study). The low survival observed in fish fed on SBC may be the result of the high availability of its nutrients. Soybean is known to have high bioavalability, particularly of protein; this factor, along with lack of aeration and water exchange, may have encouraged accumulation of end products of metabolism in the water which may have altered the water quality negatively. While anti-nutritional factor may have reduced digestion and accumulation of the by-products of metabolism in case of *A. spinosus* leaf diets, consequently high survival was recorded in fish fed on 75% replaced diet.

Conclusion

The results obtained in this study further confirm the superiority of SBC nutrients over other plant proteins (and in this case *A. spinosus* leaf) and the need for aeration and continuous maintenance of water quality parameters when SBC is used in Tilapia diets to boost survival.

Palatability or acceptability of *A. spinosus* leaf nutrients may not be the limitation to its utilization, rather the anti-nutritional factors associated with it. There might be need for other processing methods to inactivate the anti-nutritional factors. It is hoped, it will improve its utilization, thus widen the availability and choice of feedstuffs to fish farmers, particularly to the peasants and rural farmers which dominate fish industry in Nigeria.

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