



Growth performance of the African catfish, *Clarias gariepinus*, fed varying inclusion levels of *Leucaena leucocephala* leaf meal

^{1*}AMISAH, S; ¹OTENG, M. A; ²OFORI, J. K.

¹Department of Fisheries and Watershed Management, Kwame Nkrumah University of Science & Technology, Kumasi, Ghana; ²Water Research Institute, Council for Scientific and Industrial Research, Akosombo, Ghana

*Corresponding author: Amisah, S. email: steveamisahl@yahoo.co.uk

ABSTRACT: The efficacy of treated *Leucaena leucocephala* leaf meal as an ingredient in diet of the African catfish, *Clarias gariepinus*, of mean weight 40.18±0.51g was evaluated over a 90-day growth period. Four experimental diets were formulated at 0% (control), 10%, 20% and 30% inclusion levels of treated *Leucaena* leaf meal. Leaves were treated by soaking in water for 3 days and sun-drying for another 3 days. A control diet of fish meal with fish meal serving as the only protein source was formulated. All diets were isonitrogenous (30% protein). The 90-day feeding experiment was conducted in concrete tanks, each treatment having three replicates. Fish fed 20% *Leucaena* leaf meal recorded the best growth performance in body weight gain and Specific Growth Rate (SGR), although the best Feed Conversion Ratio (FCR) was recorded for fish fed on the control diet of 0% *Leucaena* meal. There were no significant differences between fish fed the control diet and the other experimental (P>0.05). The study demonstrated that *Leucaena leucocephala* leaf meal may be included in the diets of *Clarias gariepinus* at inclusion levels of up to 30% but it is efficacious and cost effective at 20% inclusion level. It is, therefore, recommended that *Leucaena leucocephala* leaf meal be used to partially to replace the expensive and imported fish meal. @JASEM

Fish farming continues to make substantial contributions to Ghana's animal protein requirements. On a global scale fish, crustaceans and molluscs production has increased from 3.9 percent of total production by weight in 1970 to 27.1 percent in 2000 and to 32.4 percent in 2004 (FAO, 2006). Ghana's contribution to these global figures remains, largely, insignificant and more needs to be done to bridge the yawning gap. The greatest limitation of fish farming in Ghana is the lack of suitable fish feeds. Most feeds are farm-based and commercial fish feed have to be imported, using the limited foreign exchange of the state. In Ghana, the most cultured species are Tilapia (*Oreochromis niloticus*) and the African catfish (*Clarias gariepinus*). The African catfish (*Clarias gariepinus*) is appreciated by consumers for the quality of its meat (Pruszyński, 2003) and is mostly smoked and used in soups. It is recognized by its long dorsal and anal fins, which give it a rather eel-like appearance. The catfish has a slender body, a flat bony head, and a broad, terminal mouth with four pairs of barbells. Its prominent barbells give it the image of cat-like whiskers. The fish is mostly cultured in earthen ponds. However, it can be cultured in other systems such as tanks and hapas. In the wild and riverine systems, the fish reproduces naturally but considerable effort is required to induce spawning under culture conditions. The African catfish is an excellent species for aquaculture as it is omnivorous, grows fast, and tolerates relatively poor water quality (Rad et. al., 2003).

A number of plants continue to be investigated for their potential in supplementing or even replacing fish meal. *Leucaena leucocephala* has been identified to hold the potential to make contributions to fish

nutrition with the possibility to reduce the total dependence of fish farming on fish meal in several locations in Ghana. *Leucaena leucocephala* is a leguminous, multipurpose tree and provides fuel wood, green manure, improves degraded lands and can be used as a cover crop. *Leucaena* leaf is known to contain about 22.7% crude protein (Atawodi et. al., 2008) and survives well on degraded soils which are low in nutrients. It has bipinnate leaves, lanceolate leaflets and has flat pods containing small seeds. The leaves and seeds contain the antinutritional factor mimosine (Francis et. al., 2001). Mimosine is known to inhibit the growth of animals, especially non-ruminants. *Leucaena leucocephala* is available in almost every geographical location in Ghana and grows fast. Its leaves are a good source of protein and needs to be examined in greater detail on its suitability for the African catfish, *Clarias gariepinus*. In Ghana, imported fishmeal, mainly from Israel and Brazil, is used in commercial production of catfish as the major source of protein. This has created a sustained dependence on these countries for the supply of fishmeal. The high cost of fishmeal makes commercial production of catfish capital intensive as it accounts for between 30 and 60 % of variable operating cost (Desilva and Anderson 1995). This has motivated the search for, local, cheap alternative sources of protein that aim to reduce production cost without compromising fish quality. These sources should hold the potential to supplement, replace or partly replace the imported fishmeal. Against this background, this study was conducted to:

(a) Determine the optimum inclusion level of *Leucaena* leaf meal in formulated diets of *Clarias gariepinus* and

(b) Examine the growth performance of *Clarias gariepinus* fed varying inclusion levels of *Leucaena leucocephala* leaf meal.

MATERIALS AND METHODS

Study location

The study was conducted at the Aquaculture Research Development Centre (ARDEC) of the Water Research Institute of the Council for Scientific and Industrial Research (CSIR) at Akosombo in the Eastern region of Ghana between January and April 2008.

Sources of ingredients and diets preparation

Fishmeal, maize, wheat bran, and groundnut husk, were obtained locally from the market while *Leucaena* leaves were freshly plucked from their branches on the compound of Water Research Institute, Akosombo. The long, leaf stalks were removed by hand. *Leucaena* leaves were soaked in

water for 3 days and afterwards sun dried for another 3 days. All ingredients were ground into powdery form using a corn mill. The milled *Leucaena* leaves were then sieved with a mosquito net to separate the fine powder from the remaining fibre. The proximate chemical composition of feed ingredients were estimated by the methods described by the (AOAC, 1984), to determine the crude protein content.

Four isonitrogenous diets containing different levels of *Leucaena* Leaf meal (0, 10, 20 and 30%) were prepared (Table 1). The experimental diets with crude protein levels of 30% were formulated using the trial and error method. The ingredients were then thoroughly mixed together by hand. Warm water was added to the premixed ingredients and homogenized to a dough-like paste. The diets were then pelletised using a 2-mm pellet press. The diets were sun-dried for 4 days and stored in airtight containers throughout the experimental period.

Table 1: Composition of experimental diets (%dry matter basis) with varying inclusion levels of *Leucaena leucocephala* leaf meals (LLM)

Ingredients	%Crude Protein	0% LLM (Diet 1) (Control)	10% LLM (Diet 2)	20% LLM (Diet 3)	30% LLM (Diet 4)
¹ Fishmeal	65.00	30	25	20	15
Leucaena leaf meal	23.54	0	10	20	30
White Maize	8.49	20	20	20	20
Wheat Bran	16.76	30	30	30	30
Groundnut husk	13.58	15	15	15	15

Price per 40 kg Fish meal = 36- 40 USD; *Leucaena* leaves were obtained at no cost

¹Seapak®

Experimental procedure

The experiments were carried out in rectangular concrete tanks of 2.5m x 0.7m x 0.58m with water volume maintained at 0.17 m level. A total of 16 concrete tanks were used. A total of 240 African catfish, *Clarias gariepinus*, juveniles with an average weight of 40.18± 0.51g were randomly allotted at the rate of 10 juveniles per tank into each of the 16 experimental concrete tanks, each tank having 2 other replicates. The fishes were allowed to acclimatise 14 days prior to the start of the experiment. Feeds were formulated from *Leucaena leucocephala* leaves to test their efficacy on the growth performance of the catfish. The experimental diets varied with increasing levels of *Leucaena* leaf meal, 0%, 10%, 20%, and 30% with decreasing levels of fish meal. Most ingredients of standard catfish feed formulas can be substituted for, but whenever fish meal has been left out of catfish diets, poorer growth and food conversion have resulted (Stickney (1974). For this reason, feed were formulated with inclusions of varying quantities of fish meal combined and *Leucaena* leaf meal. The emphasis in this intervention is to formulate protein diets that can

substitute or reduce the quantities of expensive fishmeal in formulated diets without compromising growth performance of the fish.

Fish feeding and culture

The fishes were fed twice daily, between 8.00-9.00am and 15.00-16.00pm at 2% body weight throughout the experiment. The ration was adjusted every two weeks when new mean weights of fish for the various experimental units were determined. Left-over feed and faeces in each tank were siphoned out each week. The water in the tanks was also changed with pre-conditioned pipe-borne water every week.

Data collection and analysis

Data on fish growth characteristics were recorded every two weeks. The weight of individual fish was determined with an electronic scale of model KERN 572, the Standard Length was determined with a measuring board. The experimental tanks were inspected daily to remove dead fish, if any. Fish weight gain, feed conversion ratio, specific growth rate and mortality were determined as follows. The

initial and fortnightly mean weights per treatment were computed as follows:

(i) Weight gain = Final weight of fish - Initial weight of fish

(ii) Specific growth rate (SGR) was calculated as:

$$\text{SGR (\% per day)} = \frac{(\text{Log}_e W_2 - \text{Log}_e W_1)}{T_2 - T_1} \times 100 \quad (1)$$

Where:

W₂ = Weight of fish at time T₂ (final)

W₁ = Weight of fish at time T₁ (initial)

(iii) Feed conversion ratio (FCR). This was calculated from the relationship of feed intake and wet weight gain.

$$\text{FCR} = \frac{\text{Total feed consumed by fish (g)}}{\text{Weight gain by fish (g)}} \quad (2)$$

(iv) Mortality (M) was calculated as: (3)

$$M = \frac{(N_0 - N_t) \times 100 \%}{N_0}$$

Where:

N₀ = Number at the start of the experiment

N_t = Number at the end of the experiment

(v) Condition factor (K) was calculated as:

$$K = \frac{W \times 100}{L^3} \quad (4)$$

Where: W = Weight of fish

L = Standard length of fish

Water quality

Water quality parameters were measured during each sampling. Temperature and dissolved oxygen were measured *in situ*, with a WTM, OxiCal – SL portable electronic probe. The water pH was also measured with Sontex model SP-701 pH meter. Ammonia and

nitrite were also measured with the aid of a Visible Spectrophotometer after it had been treated with Nessler's reagent.

Statistical analysis

Data was subjected to one-way analysis of variance (ANOVA) followed by the Tukey's multiple comparison test for the means at a significance level (P<0.05).

The statistical package used for the analysis was the GraphPad InStat tm. The results are presented as mean ± SE (standard error)

RESULTS

The growth performances of *Clarias gariepinus* in response to difference inclusion levels of *Leucaena leucocephala* meals are presented in the sections that follow:

Growth performance

Growth performance of the African catfish, *Clarias gariepinus*, fed varying quantities of feed containing *Leucaena leucocephala* leaf meal (LLM) over a 90-day period is presented (Table 2). Fish fed with LLM at 20% inclusion level gave the best growth performance which was marginally better than those fed on fish meal without the leaf meal (0% LLM). On the other hand fish fed 30% LLM (Diet 4) resulted in the slowest growth performance (Table 2). There were no significant differences (P>0.05) in the initial body weight (IBW), final body weight (FBW), mean weight gain, Feed Conversion Ratio (FCR), Specific Growth Rate (SGR), mortality, initial condition factor and final condition factor (Table 2). The highest weight gain and SGR were found in fish fed Diet 3 (20% LLM). The highest and least FCR was recorded in fish fed on Diet 4 (30 % LLM) and Diet 1 (0% LLM) respectively. The least weight gain and SGR were observed in fish fed Diet 2 (10% LLM).

Table 2: Growth performance of juvenile African catfish, *Clarias gariepinus* fed with *Leucaena leucocephala* diets for 90 days.

Parameters	Diet 1 0% LLM	Diet 2 10% LLM	Diet 3 20% LLM	Diet 4 30% LLM
IBW ¹ (g)	39.05±0.55 ^a	40.35±1.05 ^a	40.36±0.95 ^a	41.00±0.60 ^a
FBW ² (g)	47.95±0.23 ^a	46.87±1.62 ^a	50.20±0.29 ^a	48.43±1.25 ^a
WG ³ (g)	8.59±0.50 ^a	6.68±0.73 ^a	9.85±1.24 ^a	7.43±1.25 ^a
FCR ⁴ (gg ⁻¹)	4.95±0.23 ^a	6.27±0.13 ^a	5.13±0.83 ^a	6.39±1.12 ^a
SGR ⁵	0.28±0.01 ^a	0.22±0.02 ^a	0.31±0.04 ^a	0.24±0.6
MOR ⁶	0±0.00 ^a	0±0.00 ^a	0±0.00 ^a	0±0.00 ^a
Initial condition factor (K)	0.95±0.01 ^a	0.98±0.07 ^a	0.97±0.10 ^a	0.88±0.06 ^a
Final condition factor (K)	0.90±0.01 ^a	0.93±0.05 ^a	0.92±0.10 ^a	0.88±0.05 ^a

^{a, b, c, d} mean values in the same row with different superscript are significantly different (P < 0.05)

¹ Initial body weight

² Final body weight

³ Weight gain

⁴ Feed conversion ratio

⁵ Specific growth rate

⁶ Mortality

Water quality measurements

Water temperatures and pH remained fairly stable in all the treatments (Table 3)

There was no mortality throughout the experimental period but a single case of cannibalism was observed in fish fed the control diet (0% LLM) after the initial sampling.

Table 3: Water quality fluctuations in experimental tanks containing the African catfish, *Clarias gariepinus*

Treatments	Temperature (°C)	D O (mg/l)	pH (range)	NH ₃ -N (mg/l)	NH ₂ -N (mg/l)
0% LLM	27.1	2.4	7.12 – 7.56	0.34	0.038
10% LLM	27.2	3.9	7.15 – 8.36	0.22	0.038
20% LLM	27.3	1.7	6.98 – 7.43	0.66	0.042
30% LLM	27.3	2.1	7.06 – 7.62	0.32	0.038

DISCUSSIONS

Shortage in world production of fish meal, the conventional protein feed source, coupled with increased demand for fish meal in feeds for livestock and poultry is likely to reduce the dependence on fish meal as a single protein source in aqua-feeds. Throughout the world the efficiency of various alternative protein sources as partial or complete dietary replacements for fish meal has been evaluated in fish diets (Wee and Wang, 1987; Abdel-Fattah and El-Sayed, 1999; Ali *et. al.*, 2003). On the other hand there is little or no work on alternative protein sources for fish feed in developing countries such as Ghana. The West Africa sub-region and several developing countries continue to rely on imported fish meal. Ghana has recently started a feed mill, GAFCO, which produces some feeds for livestock but the lack of an extruder means they cannot

produce feeds that can float in the water and most farmers depend largely on imported feeds.

The use of leaf meal as a possible fish meal substitute to reduce the cost of fish feed is receiving increasing attention by fish nutritionists around the world (Bairagi *et. al.*, 2004). It is, however, important that the selected protein sources do not conflict with human food security interests. The use of *Leucaena leucocephala* leaves do not conflict with human food security issues and this study has demonstrated that the leaves have the potential to partly replace fish meal and considerably reduce expenditure on fish meal, without compromising growth performances of the African catfish

When alternative food sources such as plant protein are used in fish diets, one of the common problems encountered is the acceptability of the feed by fish, and this frequently relates to the palatability of the

diet (Rodriguez et. al., 1996). In the present investigation, all the experimental diets were accepted by *Clarias gariepinus juveniles*, indicating that the levels of incorporation of *Leucaena* leaf meal did not affect the palatability of the diets. This might be attributed to the processing technique which involved soaking and drying techniques that might have reduced the antinutrient in *Leucaena* leaf meal, thereby increasing its palatability in *Clarias gariepinus*. This observation corroborates the works of Siddhuraju and Becker (2003), Francis et. al., (2001) and Fagbenro (1999). These workers reported that reduction in antinutrient by different processing techniques resulted in better palatability and growth in fish. Wee and Wang (1987), reported that soaked *Leucaena leucocephala* leaf meal gave a significantly better growth response than sundried or commercial leaf meal in the diets of Nile Tilapia, possibly due to a destruction of the mimosine content by the processing technique. The potential of a feedstuff such as leaf meal in fish diets can be evaluated mainly on the basis of its proximate chemical composition, particularly the, crude protein content. The proximate composition of *Leucaena* leaf meal in the present investigation revealed that the crude protein content was 23.54%. This value was higher than the values reported by some earlier researchers such as Bairagi et. al. (2004) and Atawodi et. al. (2008). The difference might be attributed to differences environmental conditions such as soil types, provenances, harvesting time and processing methods. Although the nutritional quality of *Leucaena* leaf meal as determined by *Clarias gariepinus* body weight gain, specific growth rate and feed conversion ratio was higher in fish fed on Diet 3 (20% leaf meal), no significant ($P > 0.05$) differences were observed in other experimental diets. Available information on tilapia revealed that Ipil-Ipil, *Leucaena leucocephala* leaf meal in the diets of *Oreochromis niloticus* at 12.5% inclusion did not affect growth, however, at high levels of inclusion, 25% or more, the growth of *O. niloticus* was adversely affected. In the present investigation, inclusion of *Leucaena* leaf meal at level as high as 20% did not reduce the growth rate but rather gave the best weight gain in *Clarias gariepinus* juveniles. Various workers on Tilapine fishes have shown that leaf meal protein at low levels of inclusion (less than 50%) in fish diets were able to support growth (Ritcher et. al., 2003; . Santiago et. al., 1988; Afuang et. al., 2003). The growth performances of the fish (Table 2) agree with those of the earlier workers (Ritcher et. al., 2003). No mortalities occurred throughout the period and, therefore, the meal did not have any deleterious effects on the fish. Although body weight increases were generally low (Table 2) the Condition Factors were not significantly different

for all the treatments. The slow weight gains might be attributed also to the fact that fish were fed exclusively on the formulated feeds with no vitamin supplements and no access to natural feed as may be found in pond or riverine conditions. The African catfish is omnivorous and feeds from a wide array of organisms under natural conditions.

Conclusions: The leaves of *Leucaena leucocephala* have the potential to make considerable contributions to growth of the Africa catfish. It also has the potential to partially replace fish meal in a feeding regime and, thereby, reduce feed cost to the fish farmer, whose most important production cost comes from feed. This study has demonstrated that, in general, *Leucaena* leaf meal could be included up to 30% level in *Clarias gariepinus* diets without any negative effects on the growth. However, study the best inclusion level was found in the diet containing the 20% *Leucaena* leaf meal. *Leucaena* leaves are locally available in the tropics and can be obtained throughout the year. The cost of 40 kg of imported fish meal ranges between 36-40 USD, whilst it cost little or nothing to collect *Leucaena* leaves from the wild. It is, therefore, more economical to partly replace fishmeal with LLM at the 20% inclusion level without reduction in growth. Experiments with the same feed formulations under natural earthen pond conditions and in re-circulating systems are recommended for future study to elucidate growth performances under natural conditions. It is also recommended that smaller catfish fingerlings, of about 25g be used in other feeding trial to elucidate response on early growth and the length class sizes that would best respond to growth of the *Leucaena leucocephala* leaf meal.

Acknowledgements: We are grateful to the Water Research Institute of the Council for Scientific and Industrial Research for providing the facilities for this work. References for various sources are gratefully acknowledged.

REFERENCES

- Abdel-Fattah, M. and El-Sayed, M. 1999. Alternative dietary protein sources for farmed tilapia. *Oreochromis sp.* Aquaculture 179, 149-106
- Afuang, W., Siddhuraju, P. and K. Becker. 2003. Comparative nutritional evaluation of raw, methanol extract residues and methanol extract of Moringa (*Moringa oleifera* Lam.) leaves on growth performance and feed utilization in Nile Tilapia. (*Oreochromis niloticus* L.). Aquaculture Res., 34: 1147-1159.

- Ali, A., Al-Asgah, NA., Al-Ogaily, SM. and Ali, S. 2003. Effect of feeding different levels of Alfalfa Meal on the growth performance and body composition of Nile Tilapia (*Oreochromis niloticus*). Asian Fisheries Science 16, 59-67 Asian Fisheries Society, Manila, Philippines
- AOAC. 1984. Official Methods for Analysis (14th edition). Association of Official Analytical Chemists. Arlington VA. USA.
- Atawodi, SE., Mari, D., Atawodi, JC. and Yahaya, Y. 2008. Assessment of *Leucaena leucocephala* leaves as feed supplement in laying hens. *African Journal of Biotechnology* Vol.7(3),pp.317-321. AcademicJournals Internet:<http://www.academicjournals.org/AJB> (Accessed: 29-02-08)
- Bairagi, A., Sarkar Ghosh, KS, and Ray, AK., 2004. Evaluation of the nutritive value of *Leucaena leucocephala* leaf meal, inoculated with fish intestinal bacteria *Bacillus subtilis* and *Bacillus circulans* in formulated diets for rohu, *Labeo rohita* (Hamilton) fingerlings. *Aquaculture Research*, 35, 436-446
- De Silva, SS and Anderson, TA..1995. *Fish Nutrition in Aquaculture*. Ghapman and Hall. London. 319pp
- Fagbenro, OA., 1999. Comparative evaluation of heatprocessed winged bean (*Psophocarpus tetragonolobus*) meals as partial replacement for fishmeal in diets for African catfish (*Clarias gariepinus*). *Aquaculture*, 170, 297-305.
- FAO. 2006. *The State of World Fisheries and Aquaculture*. FAO Fisheries Technical Paper. No. 500. Rome, Italy. Internet: <http://www.fao.org/docrep/fa0>. (Accessed: 30-02-2008)
- Francis G., Makkar, HPS and K. Becker. (2001). Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. *Aquaculture* 199,197-227
- Pruszyński, T. 2003. Effects of feeding on ammonium excretion and growth of the African catfish (*Clarias gariepinus*) fry. *Czech J. Anim. Sci.*, 48 (3): 106–112
- Rad, F., Kurt, GI. and Bozaoulu, AS. 2003 Effects of spatially localized and dispersed patterns of feed distribution on the growth, size dispersion and feed conversion ratio of the African Catfish (*Clarias gariepinus*). *Turk J Vet Anim Sci* 28, 851-856
- Ritcher, N., Siddhuraju, A. and Becker, K. 2003. Evaluation of nutritional quality of moringa (*Moringa oleifera* Lam.) leaves as alternative protein source for Tilapia (*Oreochromis niloticus* L.). *Aquaculture*, 217, 599-611.
- Rodriguez, SM., Olvera, NMA. and Carmona, O. C. 1996. Nutritional value of animal by product meal in practical diets for Nile Tilapia, *Oreochromis niloticus* (L) fry. *Aquaculture Res.*, 27: 67-73.
- Santiago, CB., Aldaba, MB. Laron, MA. and Reyes, OS. 1988. Reproductive performances and growth of Nile Tilapia (*Oreochromis niloticus*) brood stock fed diets containing *Leucaena leucocephala* leaf meal. *Aquaculture*, 70: 53-61.
- Siddhuraju, P. and Becker, K. 2003. Comparative nutritional evaluation of differentially processed mucuna seeds (*Mucuna pruriens* (L.) DC var. utilis (Wall ex Wight) Baker ex Burck, on growth performance, feed utilization and body composition in Nile Tilapia (*Oreochromis niloticus* L.), *Aquaculture*, 34: 487-500.
- Stickney, RR. 1974. Principles of Warm Water Aquaculture. pp 166-221. Southern cooperative series publication. Tokyo
- Wee, K.L. and Shun-Sen Wang. 1987. Nutritive value *Leucaena leaf* meal in pelleted feed for Nile tilapia. Division of Agricultural and Food Engineering, Asian Institute of Technology, Bangkok, Thailand. *Aquaculture* 62, 97-108