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Growth Performance of African Mud Catfish, *Clarias gariepinus* (Siluriformes: Clariidae) Fed Tropical Banana Blossom, *Musa sapietum* (Zingiberales: Musaceae) Inclusion

Akinwumi Felix Olusegun and Abiodun Eniade
Department of Environmental Biology and Fisheries, Adekunle Ajasin University,
Akungba-Akoko, Ondo State, Nigeria

Abstract: One of the contemporary problems faced in aquaculture is the provision of adequate nutritive and cheap feed to reduce the cost of fish production. In this study, the efficacy of *Musa sapietum* Inflorescence (MSI) as an ingredient in the diet of the juveniles of African mud catfish, *Clarias gariepinus* was evaluated over a 90 days growth period. About 3 experimental diets were formulated at 0 (control), 10 and 15% inclusion levels of MSI. The nutrient composition of MSI, growth performance and survival rate of the juvenile fish, feed intake and water quality parameters were determined using standard procedures. The results showed that MSI had a moisture content of 94.90% in the DM fat represented 2.08% and crude protein 1.85 %. MSI was a good source of potassium (24755 ppm of DM), calcium (9804 ppm in DM), sodium (8824 ppm in DM) and magnesium (3529 ppm in DM) but low in phosphorous (106 ppm in DM). There were no statistical differences found ($p>0.05$) in the specific growth rate, feed conversion and protein efficiency ratio of the juvenile fish fed with the banana blossom inclusions in comparison to the control. The 15% flower meal inclusion resulted in the highest fish survival rate (70%) compared to 63.3% (10% inclusion) and 60% (control). There were no significant differences ($p>0.05$) in the feed intake by the fish raised with 10 and 15% inclusions of MSI (34 and 33%, respectively) in comparison to the control that yielded 33%. There were no significant differences in the mean water pollution rates by nitrite accumulation (0.000, 0.275 and 0.042 mg dL^{-1} in 15, 10 and 0% inclusions, respectively) and total dissolved solids (32, 35 and 33% in 15, 10 and 0% inclusions, respectively). The results obtained in this study indicated that *M. sapietum* flowers which are locally available in the rural areas and inexpensive have the potential to partially replace the expensive animal protein required in feed formulation and thus reduce cost in fish farming.

Key words: Aquaculture, banana, *Clarias gariepinus*, fish, feed, *Musa sapietum*

INTRODUCTION

Worldwide, fish has continued to provide nutritional and health benefits to mankind because fish products are low in fat and high in protein, vitamins, minerals and polyunsaturated fatty acids. Lamorde (1998), reported that protein and calorie malnutrition or shortage in ingested foods can impede health, working efficiency, productivity and overall economic progress. According to Alexandratos (1995), the ever increasing share of fish in animal protein intake and total protein supply implies that fish has become more and more important in people's diet. In the developing countries, fish is a highly acceptable food that supplies, as much as 40% of all animal protein (Edgerton and Assarsson, 1998). However, recent trends all over the world pointed to a decline in landing from capture fisheries which indicate that fish stocks have approached or even exceeded point of maximum sustainable yield (Ayoola, 2011). Similarly World Bank (2005), reported that capture fisheries are at the capacity of showing precipitous decline due to over fishing, habitat destruction and pollution. The challenge, therefore is to bridge the wide gap between fish demand and supply. Aquaculture remains the only viable alternative for increasing fish production in order to meet the protein demand of the people (Omitoyin, 2007). Making locally-produced fish more readily available for consumers will give them faster and fresher access to one of the healthiest sources of animal protein. However, supplying high-grade fish with strong nutritional content is a challenge for many farmers because quality fish requires quality fish feed which is unaffordable by many aquaculturists.

The advantages offered by the use of imported floating pelleted feeds are constrained by high costs and therefore, unaffordable to the majority of the small scale

Corresponding Author: Akinwumi Felix Olusegun, Department of Environmental Biology and Fisheries, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria

fish farmers, particularly in the developing countries. One of the reasons, for the high prices of fish feeds in tropical aquaculture ventures is the contained fishmeal. A relatively large percentage of animal protein (usually fish meal) needs to be incorporated into fish diets (De Silva, 1989; Huguenin, 1997; Bureau *et al*., 1999). Otubusin (2001) and Agbebi *et al*. (2009), reported that fish meal is the greatest source of protein required for artificial feed production in animal husbandry (especially, livestock and fish). Fish are known to require a high proportion of protein in their diet because they metabolize protein as an energy source.

*Clarias gariepinus*is generally considered to be one of the most important tropical freshwater fish species for aquaculture because of its high fecundity rate, acceptance of a wide range of natural and artificial foods, fast growth, tolerance to high stocking density and environmental extremes (Bruton, 1988; Dada and Wonah, 2003). A number of plants have been investigated for their potentials in supplementing or even replacing fish meal. *Leucaena leucocephala* leaf was tested on *C. gariepinus* juveniles and it was found efficacious and cost-effective at 20% inclusion level in partially replacing fish meal in fish diet (Amisah *et al*., 2009). The agricultural, medical and economic importance of *Musa sapietum* is well documented. Sharrock and Frison (1998), ranked banana as the fourth most important food crop in developing countries after rice, wheat and maize. It is a food crop commonly grown in towns and villages in Nigeria. Wickramarachchi and Ranamukhaarachchi (2005), reported that it has a tremendous nutritional value and can be consumed as food additive, as a curry, boiled or deep fried salad with rice and wheat bread. The efficacy of the various parts of the plant as antiulcerogenic, antihelminthic, hypoglycaemic and organic fertilizer has been widely demonstrated (Chanda *et al*., 2006; Yang *et al*., 2003; Pari and Umamaheswari, 2000; Prasad *et al*., 1993).

However, scanty information is available on the use of *M. sapietum*as an ingredient in fish feeds, hence this study. The major objective of the study was to evaluate the potential of *M. sapietum*, as a major inclusion in the feed of the most widely cultured catfish in Nigeria, *C. gariepinus*. The feed acceptability and growth response of *C. gariepinus* juveniles to different inclusion levels of the plant's inflorescence and the quality of the culturing water were investigated. The specific focus is to provide protein diets that can substitute or reduce the quantity of expensive fishmeal in formulated diets without compromising growth performance of the fish.

MATERIALS AND METHODS

Sources of ingredients and diets preparation: Fishmeal, soyabean meal, groundnut cake, yellow maize, wheat offal, vegetable oil, mineral premix, vitamin C, salt and binder were obtained from a local market while *M. sapietum* Inflorescence (MSI) were freshly collected from their stalks at the campus of Adekunle Ajasin University, Akungba-Akoko, Nigeria. The banana bracts were removed by hand, rinsed and soaked in boiled water (100°C) for 20 min to ensure softness. The required gram was measured out and blended using the electronic blending machine (SAISHO model: S-248). After blending, the fibre was sieved using a plastic sieve (0.2 mm) and the filtrate was retrieved. The proximate compositions of feed ingredients were estimated by the methods described by the AOAC (2000).

About 3 diets containing different levels of MSI (0, 10 and 15%) were prepared (Table 1). The experimental diets with crude protein levels of 29.9, 22.9 and 19.4%, respectively were formulated using the trial and error method. The ingredients were thoroughly mixed manually, warm water (43.3°C) was added to the premixed ingredients and homogenized with hand to a dough-like paste. The diets were then pelletized using a 2 mm pellet press (new improved Jumbo mincer, 700/800 series, Ohaus corporation, NJ, USA). The diets were sun-dried for 2 days and stored in airtight containers throughout the experimental period.

Experimental procedure: The experiments were carried out in 9 plastic tanks (50L each) with water volume maintained at 2/3 level of the tank. A total of 90 African catfish, *C. gariepinus* juveniles with an average weight of 9.5±0.5 g were randomly allotted at the rate of 10 juveniles per tank. Each experimental unit was having 2 other replicates. The fish were allowed to acclimatize 14 days prior to the start of the experiment. Feeds were formulated, as experimental diets with increasing level of

Table 1: Percentage composition of experimental diets

	Diet		
Ingredients	A (control, 0% MSI inclusion)	B (10% MSI inclusion)	C (15% MSI inclusion)
Fishmeal	25	15	10
Soyabean meal	20	20	20
GNC	20	20	20
Yellow maize	10	10	10
Wheat offal	15	15	15
Vegetable oil	1	1	1
Mineral premix	1	1	1
Vitamin C	1	1	1
Salt	1	1	1
Binder	6	6	6
MSI extract	0	10	15
Total	100	100	100

the inclusions ofMSI at 0, 10 and 15%. The fish were fed twice daily (morning and evening) at 7% body weight throughout the experiment. The ration was adjusted every 2 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 day. The water in the tank was also changed with pre-conditioned pipe-borne water from the well twice in a week.

Fish growth and feed acceptability: Data on fish growth characteristics were recorded every 2 weeks while the feed acceptability was taken on a daily basis from the left over. The total weight of the fish was measured using a manual scale of model scout pro Spu402, the standard length was determined using a measuring ruler. The experimental tank was inspected daily to remove dead fish. Daily Weight Gain (DWG), Relative Weight Gain (RWG), Fish Weight Gain (FWG), Period Efficiency Ratio (PER), Feed Conversion Ratio (FCR), Survival Rate (SR), Specific Growth Rate (SGR), Gross Food Conversion Efficiency (GFCE), Protein Intakes (PI), Protein Efficiency Ratio (PER) and Mortality (M) were determined as follows:

$$\text{Daily Weight Gain}\left[\text{DWG}\left(\text{g day}^{-1}\right)\right]=\frac{(\text{Wf}-\text{Wi})\text{g}}{\text{Culture period}(\text{days})}$$

$$\text{Relative Weight Gain}\left[\text{RWG}(\%)\right]=\frac{(\text{Wf}-\text{Wi})\times 100}{\text{Wf}}$$

Where:
Wf = Final average weight at end of experiment
Wi = Initial average weight at beginning of experiment

$$\text{Fish Weight Gain}\left[\text{FWG}(\text{g})\right]=\text{Final weight of fish}-\text{Initial weight of fish}$$

$$\text{Period Efficiency Ratio}(\text{PER})=\frac{\text{Fish weight gain}(\text{g})}{\text{Protein intake}(\text{g})}$$

$$\text{Feed Conversion Ratio}(\text{FCR})=\frac{\text{Weight of feed given}(\text{g})}{\text{Fish weight gain}(\text{g})}$$

$$\text{Survival Rate}\left[\text{SR}(\%)\right]=\frac{\text{No. of fish that survived}}{\text{No. of fish stocked}}\times 100$$

$$\text{Specific Growth Rate}\left[\text{SGR}(\%/\text{day})\right]=\frac{\left[\text{Ln(Wf)}-\text{Ln(Wi)}\right]}{\text{Culture period}(\text{days})}\times 100$$

$$\text{Gross Food Conversion Efficiency}\left[\text{GFCE}(\%)\right]=\frac{1}{\text{FCR}}\times 100$$

$$\text{Protein Intake}(\text{PI})=\text{Weight of feed supplied}\times\text{Crude protein}(\%)$$

$$\text{Protein Efficiency Ratio}(\text{PER})=\frac{\text{Increase in the weight of fish produced}}{\%\text{ crude protein of feed}(\text{g})}$$

$$\text{Mortality}\left[\text{M}(\%)\right]=\frac{(\text{N}_\text{O}\text{-N}_\text{t})}{\text{N}_\text{O}}\times 100$$

Where:
N_O = Number of fish at the start of the experiment
N_t = Number of fish at the end of the experiment

Water quality: The temperature, dissolved oxygen, total dissolved solids and pH of the rearing water were measured weekly using the multi-parameter water analysis probe meter (HANNA). Nitrite (NO_2^-) was measured twice weekly with the aid of nitrate-nitrite test strips (Waterworks TM R 0512A-NN, Rockhill, Sc. USA).

Statistical analysis: Data obtained were subjected to Analysis of Variance (ANOVA) and where differences existed at 0.05 significance level, the treatment means were separated using duncan multiple range test. The results are presented, as mean±SE (Standard Error) for condition factor and as mean±standard deviation for water quality parameters.

RESULTS AND DISCUSSION

The composition of formulated feeds used for the experiment is shown in Table 1. The feeds included fishmeal, soyabean meal, Ground Nut Cake (GNC), yellow maize, wheat offal, vegetable oil, mineral premix, vitamin C, salt, binder (starch) and MSI. The proximate composition of the feeds is shown in Table 2 while the proximate and mineral compositions of the banana inflorescence are shown in Table 3. The results in Table 3 indicate that MSI contained very high moisture content (94.90), fat content (2.08) crude protein (1.85) and is a good source of minerals, such as Potassium, Calcium, Sodium and Magnesium. The values in Table 4 show that there were increases in the bi-weekly average weights of the fish in the decreasing order 0, 15 and 10% but there were no

Table 2: Proximate composition of feeds (%)

MSI inclusion	Moisture	Fat	Ash	Crude protein	Crude fibre	Carbohydrate
0% (control)	10.18	10.89	2.97	39.38	2.18	34.40
10%	12.15	7.77	9.80	42.26	2.38	25.64
15%	11.90	11.65	8.00	45.57	2.09	20.79

significant differences ($p>0.05$) in the means of the condition factors of the juveniles of *C. gariepinus* fed with the inclusion levels of *M. sapietum* flower meal in comparison to the control. The data obtained in this study showed that the Daily Weight Gain (DWG), Relative Weight Gain (RWG) and Fish Weight Gain (FWG) were highest at 0% inclusion and lowest at 10% inclusion (Table 5). The results in Table 5, also indicate that the Food Conversion Ratio (FCR) was highest in 15% inclusion and decreasingly in 10 and 0% levels. Similarly, the survival rate of the fish was highest in 15% MSI inclusion (70%), decreasingly 63.3 and 60% in 10 and 0% inclusion levels, respectively. The percentage feed acceptability of juveniles of African catfish, *C. gariepinus* fed varying quantities of feed containing *M. sapietum* flower meal over a 90 days period is presented in Fig. 1. The highest percentage feed acceptability (34%) was demonstrated in fish fed 10% inclusion while the fish fed 0 and 15% inflorescence inclusions both had 33% feed acceptability.

The culturing water at the different inclusions of *M. sapietum* exhibited significant differences ($p<0.05$) in dissolved oxygen, pH, temperature, nitrite and total dissolved solids (Table 6). The mean water pollution rates by nitrite accumulation (0.000 and 0.275 mg dL^{-1} in 15 and 10% inclusions, respectively) were not statistically different from the control (0.042 mg dL^{-1} in 0% inclusion) (Fig. 2). Similarly, there were no significant differences in the mean water pollution rates by total dissolved solids (32, 35 and 33% in 15, 10 and 0% inclusions, respectively) (Fig. 3).

The efficiency of some alternative protein sources, as partial or complete dietary replacements for fish meal has

Table 3: Proximate and mineral compositions of boiled *Musa sapietum* inflorescence

Proximate	Percentage
Moisture	94.90
Ash	0.49
Fat	2.08
Crude fibre	0.38
Crude protein	1.85
Nitrogen free extract	0.03
Mineral (ppm)	
Ca^{2+}	9804.00
Mg^{2+}	3529.00
Na^{2+}	8824.00
K^{+}	24755.00
P^{+}	106.00

Table 4: Bi-weekly mean average weight (g) and condition factor of *Clarias gariepinus*

	Weight (week)						
Diet	0	2	4	6	8	10	12
0% (control)	10	15.1	20.3	26.6	39.1	48.0	60.1
10% MSI	10	13.8	17.5	20.6	26.3	32.4	42.9
15% MSI	10	14.7	18.4	24.0	29.8	36.0	44.3

	Condition factor		
Diet	Mean±SE	ANOVA (p = 0.05)	Homogeinity of variance (p = 0.05)
0% (control)	$0.76±0.03^a$		
10% MSI	$0.83±0.13^a$		
15% MSI	$0.75±0.04^a$	0.75 ($p>0.05$)	0.10 ($p>0.05$)

Means with different superscripts are significantly different at p = 0.05

Table 5: Growth and nutrient parameters of *Clarias gariepinus* juveniles fed different inclusion levels of *Musa sapietum* flower meal

	Inclusion (%)		
Parameters	0	10	15
Daily weight gain (g day^{-1})	0.56000	0.37000	0.38000
Relative weight gain (%)	83.36000	76.69000	77.43000
Fish weight gain (g)	50.10000	32.90000	34.30000
Protein intake (g)	140090.41000	124362.73000	160834.76000
Period efficiency ratio	0.00036	0.00026	0.00021
Feed conversion ratio	2.05000	2.70000	3.04000
Survival rate (%)	60.00000	63.30000	70.00000
Specific growth rate (%/day)	2.00000	1.62000	1.66000
Gross food conversion efficiency (%)	1.41000	1.12000	0.97000
Protein efficiency ratio	1.27000	0.78000	0.75000
Mortality (%)	40.00000	36.70000	30.00000

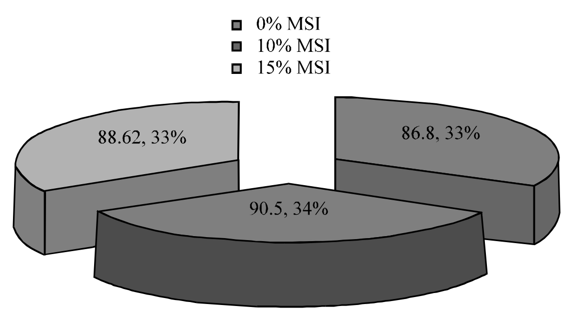

Fig. 1: Percentage feed acceptability by juveniles of *Clarias gariepinus* fed three inclusion levels of *Musa sapientum*

Table 6: Water quality parameters of culture tanks for juveniles of *Clarias gariepinus* fed *Musa sapietum* inflorescence

	Mean±SD				Homogeneity
Parameters	0% MSI	10% MSI	15% MSI	ANOVA (p = 0.05)	of variance (p = 0.05)
Dissolved Oxygen (mg dL^{-1})	$0.41±0.49^a$	$0.37±0.43^a$	$0.36±0.44^a$	0.94	0.82
pH	$5.05±3.06^a$	$5.03±3.05^a$	$5.01±3.03^a$	0.99	0.99
Temperature (°C)	$18.34±11.07^a$	$18.30±11.04^a$	$18.21±10.9^a$	1.00	1.00
NO_2^- (mg dL^{-1})	$0.41±1.42^a$	$0.27±0.95^a$	$0.00±0.00^a$	0.58	0.08
Total dissolved solids (%)	$121.25±79.94^b$	$112.33±75.71^b$	$113.08±78.5^b$	0.95	0.97

Means with different superscripts are significantly different at p = 0.05

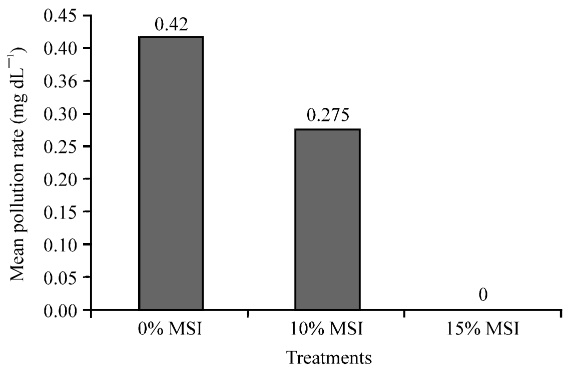

Fig. 2: Mean water pollution rate by nitrite accumulation in the treatments

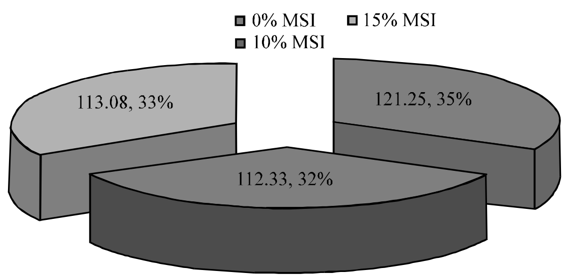

Fig. 3: Mean water pollution rate by accumulation of dissolved solids in the treatments

been evaluated in fish diets (Wee and Wang, 1987; El-Sayed, 1999; Ali *et al*., 2003). Amisah *et al*. (2009), demonstrated that the leaf meal of *Leucanea leucocephala* was efficacious and cost effective at 20% inclusion level in partially replacing the expensive fish meal. Bichi and Ahmad (2010), suggested that the optimum requirement of cassava leaves in the formulation of practical diets for the improved growth of *C. gariepinus* was 66.7%. Information on the use of *M. sapietum* flower meal as alternative protein source for fish feed is very scanty. However, Perera (2011) and Sheng *et al.* (2010), reported that banana blossom is not only nutritious and delicious when prepared but that it is a very rich source of other minerals, such as copper, iron and antioxidants.

The potential of a feed stuff in fish diets can be evaluated mainly on the basis of its proximate chemical composition, particularly, the crude protein content. In this study, the proximate composition of *M. sapietum* flower showed that the crude protein content (1.85/100 g) was higher than the value (1.1±0.01%) reported in the same flower by Akaninwor and Arachie (2002) and Sheng *et al*. (2010) for the flowers of *M. paradisiaca* (1.62/100 g) but lower to the value for *M. baxijiao* flowers (2.07/100 g). However, the discrepancies in proximate values might be attributed to the processing methods and interspecies differences.

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-Serna *et al*., 1996). However in this study, >80% of each of the MSI included diets was accepted by the fish and there were no statistical differences in the percentage feed acceptability ($p>0.05$) compared to the control. The high level of the acceptance of *M. sapietum* flower meal by the fish could be an indication of the palatability of the diets. This might be attributed to the processing technique which involved steam-heating which might have reduced the anti-nutrients in *M. sapietum* flower meal, thereby increasing its palatability in the fish. This observation is in agreement with the findings of Siddhuraju and Becker (2003), Francis *et al*. (2001) and Fagbenro (1999) who reported that the reduction in the anti-nutrients by different processing techniques resulted in better palatability and growth in fish.

Although, the highest weight gains were recorded in fish fed without MSI inclusion, there were no significant differences in the growth parameters of the fish juveniles exposed to the banana flower inclusions when compared to the control. The mean water pollution rate by nitrite accumulation and total dissolved solids were highest in the fish fed completely with fish meal (0%) mainly because of the protein loading rate and probably due to the accumulation of the leftover food in the reservoirs.

CONCLUSION

The results obtained in this study showed that the flower of *M. sapietum* has the potential to make considerable contributions to the growth of the African mud catfish, *C. gariepinus*. It can also combat the problem of water pollution usually encountered in animal protein sourced fish meal, thus helpful in pond water management. In addition, the utilization of MSI in fish diets could reduce the nuisance created by wastes of banana flowers and thereby enhance environmental waste management. Intensified experiments under natural earthen pond conditions and in re-circulating systems are recommended for future study to elucidate growth performances under varying conditions.

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