

Original Research Article

REPLACEMENT OF FISH MEAL WITH BAMBARANUT WASTE
MEAL IN THE DIETS OF LARVAL AFRICAN CATFISH *CLARIAS*
GARIEPINUS BURCHELL (1822)

ABSTRACT

Background: High cost of fishmeal (FM) adversely affects [growth performance](#) of African catfish fingerlings. There is need for alternative [ingredients](#) from affordable and available [sources like plant proteins to](#) meet growing feed demands in the larviculture of African catfish. [Bambaranut waste meal \(BNWM\) is a proteinous, cheap and abundant, byproduct usually discarded or used to feed domestic chicken in Africa.](#)

Aims: To substitute fishmeal (FM) with bambaranut waste meal (BNWM) in five novel diet of larval African catfish *Clarias gariepinus* average weight $1.850 \pm 0.79\text{g}$ and examine their growth and nutritional performances.

Place and duration: The experiment was carried out at the Fisheries and Hybrobiology, research unit department of Zoology University of Nigeria Nsukka between Nov.29 and 30 of December.

Methodology: [We substituted BNWM:FM per diet as follows; feed 1, \(F1\), 94:0%; feed 2, \(F2\), 89:5 %; feed 3, \(F3\), 74:20 %; feed 4, \(F4\), 59:35%; and feed 5, \(F5\), 39:55%. Other ingredients were vitamin premix, vitamin C and palm oil. Catfish larvae were fed the experimental diets \(F1-F5\) for 30d.](#)

Results: African catfish larvae grew with optimal SGR of 8.2% day⁻¹ for those fed with 39BNWM:55FM, F5 and 7.2% day⁻¹ for those fed with 59BNWM:35FM, F4. The catfish fed with F1 94BNWM:0FM, and F2, 89BNWM:5FM, had lowest but similar SGR 5.0 and 5.3% day⁻¹ respectively. Food conversion ratio (FCR) were similar for larvae fed with F5, F4 and F3 (P>0.05). Similarly FCR were similar for larvae fed with F1 and F2 (P>0.05). The weight gains of the larvae were best and similar for those fed 39BNWM:55FM, F5 (5.0g) and F4 59BNWM:35FM, (4.5g), but better than those fed 74BNWM:20FM, F3 (3.5g). Those fed with F1 had least weight gain of (2.2g). The protein conversion ratio PCR was lowest and same for catfish fed with F5, (0.42 ± 0.6), F4, 0.4± 0.3 and F3 0.41± 0.2. More crude protein was required in diets to produce 1kg of fish among those fed with F1 94% BNWM (PCR 0.82 ± 0.5) and F2, 89 % BNWM (PCR 0.89 ± 0.3. Cost of feed increased with FM and fishmeal ratio was highest for F5.

Conclusions: The study shows that BNWM can supplement FM up to 59% in diets of African catfish. The lack of significant differences between FCR and SGR of F5 and F4 is important. It shows that BNWM which is discarded in mills is a valuable resource that holds profitable potential aquafeed production.

Key words: Specific growth rate, feed conversion ratio, bambaranut waste meal, fishmeal.

INTRODUCTION

African catfish is omnivorous and ~~in addition~~ possesses fast growth, hardiness and high fecundity and commands good market prices [1, 2]. Despite the boom in culturing African catfish, the production of fingerlings still remains a problem. Fingerling production in sub Saharan Africa is hampered by high cost of feed and cost of imported live feed like artemia. The cost of fishmeal is responsible for high cost of fish feed [3, 16]. Generally growth and intensification of aquaculture production also depends on development of sustainable protein source, to replace fish meal in aqua ~~feed~~ like plant protein [3, 4].

One of the major problems of culturing African catfish is the high cost of imported feed and lack of adequate and nutritious local fish feed due to cost of fish meal [5, 6]. Poor feed production impacts negatively on fingerling production which reduces number of fish seed used for restocking. The availability of fingerlings produced under controlled conditions, making use of natural as well as high protein diet is hampered in Africa by the cost of feed and artemia [2, 7].

Artemia is the most commonly used live feed for African catfish larvae but artemia is relatively costly in developing countries [8, 9]. The requirement for live feed for *C. gariepinus* appears to have a short duration. Species can be weaned unto dry feed at a relatively early stage [10, 31]. The inability of *C. gariepinus* to utilize dry feed effectively has been attributed to lack of functional stomach at start of exogenous feeding [10, 11, 12]. The age of the catfish larvae is determinant of its ability to utilize exogenous diets. However, [11] noted that in ontogeny *C. gariepinus*, the connection between the esophagus, the intestine and the anus opened at 144 hours post fertilization (h-PF).

Complete eye differentiations took place 164 h-PF. Eye differentiation was concomitant with first feeding suggesting a key role of visual senses in feeding behavior [11].

Larviculture of African catfish therefore needs live food at least for the first four days of exogenous feeding after which they can be weaned to dry diets [9]. The dry feed must then be nutritious and acceptable to African catfish [13, 19]. The organoleptic qualities of the feeds must be enhanced through inclusion of ingredients like fishmeal to enhance acceptability.

The cost of fishmeal makes sourcing of alternative proteins imperative to sustain the increasing culture of African catfish [13, 14]. There had been many alternatives like Soybean meal [15], Palm fruit and bambaranut [16], groundnut cake [17], sesame seed meal [18], and cotton seed meal, [14]. Most of these analyses on alternative feeds ingredients were tested on fingerling stages of African catfish and not larval or post larval. There is paucity of articles on the effects of fishmeal supplementation on the growth and survival of larval African catfish example [17,12, 20].

High protein diet is very essential for growth and survival of early juveniles of *C. gariepinus*. Live feed like artemia and fish meal component of dry diets are both costly to the average fish farmer in Sub-Saharan Africa. There is need for the use of agro by products in fish feed production. This will reduce cost of production and enhance availability of feeds. Bambaranut waste meal (BNWM) is a byproduct of bambaranut flour production. Nigeria is a major producer of bambaranut which is also produced abundantly across the tropical world. Bambaranut is cheap, easily obtainable and the waste meal is either thrown away or sold at cheap prices. The protein content was reported to be about 24.14% [19,21] and carbohydrate content was estimated at 60% [20].

Bambaranut seed is also richer in essential dietary amino acids like lysine and methionine that is lacking in other known legumes. This paper examines the effects of addition of varying inclusion levels of bambaranut meal and fish meal in feeding *C. gariepinus* larvae.

MATERIALS AND METHODS

EXPERIMENTAL DESIGN AND SET UP

Complete randomized design (CRD) was used in this experiment. There were three replicate aquaria for each treatment feeds. Five treatment feed were made and feed 1 (F1) which had no fish meal was used as control. The fish per aquaria were used as observational units. This experiment was conducted in rectangular glass aquaria, length, 84cm, width, 40cm and depth 40cm. Aquaria were randomly arranged to receive similar treatment and be homogenous.

AQUARIUM AND WATER QUALITY MANAGEMENT:

Aquaria were washed and half filled with water and aerated for 24hrs before the introduction of fish. There was constant changing of water on a daily basis to remove uneaten food and to maintain hygiene. Rubber siphon was used in removal and introduction of the water. Water was supplied by University of Nigeria Nsukka water works. The supplied water was allowed to settle in a basin and exposed to the air for at least one hour. This was to make sure that harmful anions or cations like iron oxides that may be in are oxidized.

CLARIAS GARIEPINUS LARVAE: Larvae of *C. gariepinus* used for the experiments were obtained from African regional aquaculture center Aluu in Port Harcourt. The larvae were transported in oxygen bags and cold water bath, from Port Harcourt to our wet lab at Nsukka. The journey was done in the evening to avoid stress of hot weather. On arrival at Nsukka the larvae were allowed to rest for an hour and there was serial mixing of the aquaria water and water from oxygen bags. Approximately quarter liter of water from the aquaria was mixed with the oxygen bag water at intervals of 30min. Then the larvae were allowed to swim freely, on their own into the aquaria. The stocking density of the larvae was 15 larvae per aquaria.

WEIGHING AND MEASUREMENT OF LARVAE:

The larvae were collectively weighed and average weight was taken on a weekly basis. Weight measurements [of the catfish](#) were taken per treatment replicate. There were three replicate per treatment feed in this research. Weighing balance sensitive to 0.01g was used ~~in weighing. Length measurements were done using meter rule. The lengths were measured in millimeter. Length measurements were done per fish for the entire replicate tank. Length and~~ [Weighing of fish](#) were done in the morning hour from 06-07hours GMT.

FEED PREPARATION:

Bambaranut were obtained from the open market at Nsukka Enugu state milled and sieved. The initial endosperm was removed and the remaining used for feed production.

Feed composition was calculated using square method [22]. Specific weight of ingredients as shown in table 1 were measured and mixed with a Kenwood chef mixer for 30 minutes. In the process of mixing, 150mls of water was added to each of the feed type. Mixed dough was condition by pressure cooking for 35 min. Vitamin C and vitamin premixes were added and the dough was pulverized using 3mm Kenwood meat mincer. The pellets were dried at 40°C for 24 h in an oven and then refrigerated till needed. The proximate analyses of the diets and of BNWM were done according to methods in [30].

EXPERIMENTAL FEEDING OF LARVAE:

The feed was ground to powder and a little water was added to the feed to make a paste. This was due to the size of fry. Feeding was done at 5% of fish body weight. Larvae were fed twice daily in the mornings 08-09 hours and evenings, 17.00-1800 hours. Feeding was usually in the morning immediately after cleaning up the aquaria.

DATA ANALYSIS

~~One way ANOVA was used in calculating treatment and block effects and Fishers least Significant difference (FLSD_{0.05}) was used in separating treatment means. Analysis were done with Spss statistical package v.14.~~

FISH GROWTH AND NUTRITIONAL PARAMETERS

Specific Growth rate (SGR) was calculated as follows:

SGR % day⁻¹ = $100 * (\ln \text{ final weight (g)} - \text{ initial weight (g)}) * \text{Period in days}^{-1}$

Weight gain (g) (AWG) = Final body weight - Initial body weight * 3⁻¹

Feed conversion ratio (FCR) = $\frac{\text{Feed fed (g) (dry weight)}}{\text{Live weight gain (g)}}^{-1}$

Protein conversion ratio (PCR) = FCR*(Feed crude protein/100) [32]

Fishmeal ratio (FMR) = FCR*(%FM in diet/100) [32]

Percentage weight gain (% weight)

(PWC) = $\frac{\text{final body weight} - \text{initial body weight}}{\text{Initial body weight}}$

DATA ANALYSIS

One way ANOVA was used in calculating treatment and block effects and Fishers least

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RESULTS

A summary of the result of the experiment is presented in table 2..

Clarias gariepinus: The larvae of *C. gariepinus* readily accepted prepared feed. There

was no observed preference in larval acceptance of feed irrespective of treatment feed.

The catfish larvae were affected by temperature drop (Table 3) which was as a result of

the harmattan season. Low temperature resulted in late and reduced feeding and lower

growth rate. There was no case of mortality throughout the period of the experiment.

Water quality

The dissolved oxygen content of the water was $6.8 \pm 0.3 \text{ mg l}^{-1}$. Temperature records are recorded in Table 3, water exchange was regularly maintained to ensure good water quality. Aquaria were aerated regularly maintaining the dissolved oxygen level.

SPECIFIC GROWTH RATE (SGR):

The catfish larval SGR seemed to increase with increase in inclusion level of FM. However there was negative correlation between increasing percentage inclusion of BNWM and SGR of the fish (Fig. 1). The larvae fed with feed five (F5, 39BNWM:55FM) had the highest SGR of $8.2 \% \text{ day}^{-1}$ followed by those fed with feed four (F4, 59BNWM:35FM) with SGR of $7.2 \% \text{ day}^{-1}$. There was significant difference in the SGR of F5 and F4, ($P > 0.05$). FLSD_{0.05} 0.71. The SGR of larvae fed with F3, (74BNWM:20FM) was $6.0 \% \text{ day}^{-1}$, which was significantly different from those of F5 and F4 ($P < 0.05$). The lowest catfish SGRs $2.3 \% \text{ day}^{-1}$, was recorded for the larvae fed with feeds 1 (F1, 94BNWM:0FM), and feed 2 (F2, 89BNWM:5FM), $2.8 \% \text{ day}^{-1}$ respectively. There was however no significant difference ($P < 0.05$) in the SGR of F1 and F2 larvae. The SGR of the larvae are presented in table 2.

FEED CONVERSION RATIO (FCR):

The FCR of larval catfish did significantly reduce with increase in inclusion of FM. There was however a positive correlation between the feed conversion ratio and the percentage inclusion of BNWM (Fig.2). Catfish FCR increased with increasing BNWM inclusion from 1.1 ± 0.2 at F5 (39BNWM:55FM) to 4.6 ± 0.3 at F1 (94BNWM:0FM). The FCR of catfish fed with F5 were not significantly different from those fed with feed 4, F4, (59BNWM:35FM) (1.4 ± 0.6) $P < 0.05$. Feed 3 F3, (74BNWM:20FM) produced FCR that was similar to that of F5 and F4 but better than F1 (94BNWM:FM) and F2 (89BNWM:5FM) $P < 0.05$ (Table 2). The larval FCR seems to be affected more by high inclusion levels of BNWM than FM. The larval feed conversion ratios were also adversely affected by change in water temperature. By observation we noted during the experimental period that catfish larvae accepted less feed and therefore had lower feed intake during low temperature periods (early morning hours of week two) of experiment (Table 3). In week two of the experiment water temperature fell as low as $21 \pm 0.01^\circ$, due to harmattan period in Nsukka around December period of the experiment.

WEIGHT GAIN:

From the initial average weight of $1.85 \pm 0.79\text{g}$ the catfish had optimal weight gain of $5.00 \pm 0.4\text{g}$ when fed with diets F5 (39BNWM:55FM). The AWG was reduced to 4.54 ± 0.2 when the amount of BNWM in the diet was increased to 59BNWM:35FM) Feed 4. There was however no significant difference between the AWG of catfish fed

with F5 and those fed F4 ($P<0.05$). Further percentage increment of BNWM in the catfish diet to 74BNWM:20FM, (F3) significantly reduced AWG to $3.53 \pm 0.3g$. There was significant difference ($P<0.05$) in the AWG of F3, F4 and F5. Increasing inclusion of the BNM from 74% (F3) to 89% (89BNWM:5FM) (F2) and 94% (94BNWM:0FM) (F1) led to further reduction in weight gain of the larval catfish from 3.53g (F3), to 2.83g (F2) and 2.23g (F1). There was no significant difference in the AWG of F2 fed catfish and those on F1 ($P<0.05$) (Table 2). We noted a negative correlation between the percentage inclusion of BNWM and AWG of the fish (Fig. 3).

PROTEIN CONVERSION RATIO (PCR)

The protein conversion ratio (PCR) measures the amount of protein needed to produce a unit or kg of the fish. Results shows that for the catfish fed with F5, 39% BNWM (39BNWM:55FM), 0.42Kg of the crude protein will be needed in the diet to produce 1Kg of the fish flesh. There was no significant differences in the PCR of the catfish fed with 39% BNWM (39BNWM:55FM) F5, 59% BNWM (59BNWM:35FM) F4, and 74% BNWM (74BNWM:20FM) ($P>0.05$). Conversely there was significant difference between the PCR of feed F1 94% BNWM (94BNWM:0FM), 89% BNWM (89BNWM:5FM) and F5, F4 and F3 ($P<0.05$).

FISHMEAL RATIO (FMR)

Fishmeal ratio measures the quantity of fishmeal in diet needed to produce 1kg of the fish. There was steady increase in FMR with increasing FM inclusion. However $0.61 \pm 0.6\text{kg}$ of FM will be needed to produce 1kg of fish fed with feed 5, 39% BNWM (39BNWM:55FM). The catfish fed with F4 59% BNWM (59BNWM:35FM) would require $0.49 \pm 0.5 \text{ kg}$ to produce 1kg of the fish, which was significantly lower than F5 ($P<0.05$). The FMR increased with increasing inclusion of FM. The catfish fed with 74% BNWM (74BNWM:20FM) F3, required almost half of the FMR of F5 0.32kg to produce 1kg of the fish (table 2). Feed 2 89% BNWM had the lowest FMR $0.23 \pm 0.3\text{kg}$.

~~LENGTH GAIN:~~

~~The length gain of catfish seems to increase with increase in FM inclusion. However the length gain of catfish fed with F5 (2.46mm), F4 (2.28mm) and F3 (1.89mm), were similar but not significantly different ($P<0.05$). There was no significant difference in the LG of catfish fed with F3 and F2. ($P<0.05$, $\text{FLSD}_{0.05}$, 0.71). The lowest LG were measured for feed 1 LG 1.38mm and feed 2 LG 1.23mm respectively. There was however no significant difference in the ALG of feed 1 and 2 ($P<0.05$) $\text{FLSD}_{0.05}$ 0.71, (table 2).~~

~~PERCENTAGE WEIGHT GAIN:~~

~~The percentage weight gain of the catfish increased with increasing inclusion of FM as tabulated in table 3. The PWC of the catfish was 178.08% for the catfish fed with F5, but this was not significantly different from PWC of those fed with F4 (161.8%) ($P>0.05$) Table 2. The lowest percentage gains were calculated for feed 1, PWC, 89.06 and feed 2 PWC, 96.75. However there was no significant difference in the PWC of catfish fed with F1 (89.06%) and F2 (96.75%), ($P>0.05$, $\text{FSLD}_{0.05}$ 18.63).~~

TEMPERATURE

The diurnal temperature variations in the experiment were measured with minimum and maximum thermometer inserted into the aquaria. There were notable temperature fluctuations during the second and third week of the experiment. Catfish was adversely affected in the second and part of third week of experiment. The lowest temperature range measured was 21°-23°C in week 2 and 22°-25°C recorded in week 3 of the experiment (Table 3). The highest temperature ranges were 25°C-29°C for week 1 and 26°C -28°C for the 4th week of the experiment. Temperature fluctuation affected fish welfare and feeding period of the catfish larvae. During the low temperature fluctuations of second and third week larvae were not accepting feed during early morning hours 08hr, as they were doing in previous week. Feeding rate was reduced with reduction in temperature.

DISCUSSION

Larval African catfish growth rate was affected more by increasing inclusion levels of the BNWM than FM. Although the catfish grew with good SGR there was negative correlation noted between SGR and percentage inclusion of BNWM. This could be due to several factors like reduced amino and fatty acid. Reduction in dietary Lc-3 PUFA had been noted in aqua diets where FM was substituted with plant proteins. Serious reduced growth rate may be the case if fish oil or other essential oil are not included in diet formulation. However these experimental diets contained palm oil has some linoleic acid and also linolenic acid (NRC 1993). Fish generally needs some linolenic acid in their diets [30]. African catfish is known to naturally feed on palm fruits. [17,20] Bambaranut

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[waste meal is not an oil source and needs fortification with oil due to its low oil content \(Table 1\).](#)

Although the combination of F5 (55FM:39BNWM) seems optimal in terms of SGR (8.2% day⁻¹), the SGR of catfish fed with F4, (59BNWM:35FM) (7.2% day⁻¹) was comparably close with 1% day⁻¹ tradeoff. [Growth reduction was not up to 5% when BNWM was increased from 39% to 59%, but was about 10% at 74% BNWM inclusion F3.](#) The performance of the catfish fed with F4 suggests that African catfish larvae may not need up to 55% FM in their diets. More so there were no significant differences in the weight gains and length gains of the catfish irrespective of whether they were fed with F5, F4 or F3.

The increase in FCR of the catfish larvae fed with higher than 39% BNWM inclusion levels suggests effects of [reduced amino acids from FM. It could as well be due to higher amount of Anti nutritional factors like phytic acid. Proximate analyses in this research showed that BNWM Has Phytic acid content of 0.84 kg⁻¹. Increasing BNWM increased](#) carbohydrate content of the ingredient. However there was no significant difference in the FCR of catfish fed F5, F4 and F3. This seems to also show that the catfish larvae utilized the BNWM efficiently well. African catfish is known to utilize carbohydrates in feeds [1, 22]. Bambaranut meal has 50% carbohydrates [19] and 30 % neutral sugar majorly glucose and galactose [22].

Although the catfish utilize BNWM effectively it was evident that inclusion level more than 74% reduced growth rate considerably. The poor performances of the fish fed with F2 and F1 were evident that BNWM should not be used alone in the diets of larval African catfish. Complete substitution of FM with BNWM reduced larval growth rate

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from 8.2% day⁻¹ of F5, to 5% day⁻¹ of F1. The inclusion of 5% FM in F2 could not significantly increase growth rate. This suggests that catfish larvae assimilated more nutrients from BNWM due to its higher inclusion level than FM. This was earlier reported by [13] for first feeding African catfish fed with diets substituting FM with BNM and corn meal. Although BNM contained essential amino acids like methionine and cystine, complete substitution of FM causes lack of other amino acids which could have been supplied by FM. Evidently, poor growth of fish fed with F1 and F2 could be as result of the poor amino acid profile of the diets. The poor growth could also be as result of some anti nutritional factors like phytic acid. According to the proximate analysis of BNWM in this research there are about 0.84 g kg⁻¹ of phytic acid in BNWM.. Nevertheless, poor array of essential amino in diets could lead to proteins catabolic processes and hence poor growth. Amino acids had been noted to be catabolic substrate in first feeding fish larvae [25].

The result of this experiment is in line with [2], who noted high SGR and weight gain in *C. gariepinus* fish fed 50 % FM diets It is also in line with earlier works of [24,25] who found 50% inclusion of fish meal optimal in fish feed of swim up fry's of channel catfish.

It may not be economical to produce 55% FM diet in sub- Sahara Africa due to the cost. The fed cost 0.26USD kg⁻¹for F5 will be costly for fish farmers especially in the sub-Saharan Africa. The cost of production of feed F3, 74% BNWM and F4, 59% BNWM diet feed 4 was cheaper than F5. The difference could attract farmers patronage. and could provide alternative to F5. The growth and nutritional effects of F3 is also in line with earlier work of [26], who found 20% fishmeal inclusion with soybean producing

optimal weight gain in catfish. [Results on the FMR shows that the PCR was based on the fish meal production when it is in high inclusion. Translation of the high FMR could less attractive in terms of profit especially in developing nations. A look at the cost of F5 and F4 \(Table 4\) shows that about 0.06USD is saved per kg diet produced. This could be of some economic importance in producing fish feed industrially.](#)

The results on temperature effects highlights' importance of temperature in African catfish larviculture. Since the replicates tanks were randomly distributed the effects was similar for all treatment. However, low temperature ranges of the aquarium water in week 2, of the experiment were $21 \pm 0.01^{\circ}\text{C}$ to $23 \pm 0.01^{\circ}\text{C}$ (due to the harmattan season). Low temperature ranges $<23^{\circ}\text{C}$ reduces growth rate of African catfish. Optimal temperature range for raising of African catfish larvae is 30°C [27]. Catfish larvae that were reared entirely at 22°C showed more size variation than those on higher temperatures. Size variation results from differential feed intake as a result of the low temperature regime. The increase in rearing temperature from week 3 to 4 of the experiment however increased growth rate. This is in line with [10], who noted that temperature is most important abiotic variable affecting growth and early juvenile of siluroides, [and also \[20\] who noted similar temperature effects on hybrids of *C.gariepinus* and *H. bidorsalis*](#). For most siluroide species the optimal culture temperature range for larvae and early juveniles was 26°C - 30°C [10].

Conclusions

BNWM can supplement up to 59% FM in diets of larval African catfish. The lack of significant differences between FCR and SGR of catfish fed with F5 and F4

shows BNWM supported catfish high growth rate even at almost 50% reduction in amount of fishmeal. BNWM which is discarded in mills is a valuable resource that holds profitable potential aquafeed production. BNWM is a plausible alternative to FM in larval diets but should not be used alone. [The cost of production and protein conversion ratio and fish meal ratio favors production of F4 and F3 diets more than F5.](#) [The results on phytic acid content and low lipid level of the BNWM shows that BNWM should not be used all alone.](#) ~~is could be of serious financial implications in feed production especially in sub Saharan Africa and Asia. However more researches are needed on the effects of possible anti nutritional contents of BNWM.~~ More researches are also needed on the adults or grow out stages to elucidate its effects on the grow out stage and brooder

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Table 1. Composition and proximate composition of experimental diets Varying in FM and BNWM, used in feeding larval African catfish for 30d.

Ingredient	Feed 1	Feed 2	Feed 3	Feed 4	Feed 5
Fishmeal	0	5	20	35	55
Bambaranut meal	94	89	74	59	39
Vit &Min premix	3.8	3.8	3.8	3.8	3.8
Vit. C	0.2	0.2	0.2	0.2	0.2
Palm oil	2	2	2	2	2
Total	100	100	100	100	100

<u>Proximate analyses</u>					525
<u>Crude Protein</u>	<u>17.9</u>	<u>19.9</u>	<u>26.1</u>	<u>31.5</u>	526
<u>Crude fat</u>	<u>4.0</u>	<u>4.3</u>	<u>6.1</u>	<u>6.3</u>	527
<u>Crude fiber</u>	<u>7.0</u>	<u>6.9</u>	<u>6.2</u>	<u>6.4</u>	528
<u>Moisture</u>	<u>10.2</u>	<u>10.5</u>	<u>11</u>	<u>10.1</u>	529
<u>Ash</u>	<u>4</u>	<u>4</u>	<u>4.7</u>	<u>4.3</u>	530
					531
					532

Proximate analyses of bambaranut waste meal BNWM.

<u>Crude protein</u>	<u>21.92</u>
<u>Lipid</u>	<u>7.16</u>
<u>Crude fiber</u>	<u>3.78</u>
<u>Dry matter</u>	<u>90.76</u>
<u>Moisture</u>	<u>9.24</u>
<u>Ash</u>	<u>4.54</u>
<u>Phytate</u>	<u>0.84</u>

Vit. A,4800, 000 I.U.D,vit. D, 800,000 I.U,vit.E, 12,000 I.U.D, vit. E, 12,000 I.U.D, vit. K,0.80g, vit. B1,0.04g, vit. B2, 1.20g, vit. B12, 8.0g, vit.C, 100g, Folic acid, 0.80g, Biotin, 0.06g, Choline Chloride,80.0g, manganese,10.0g, Iron, 50.0g, Copper, 10.0g, Iodine, 0.30g, Cobalt, 0.3g,Selenium 0.4g

Table 2

Average weight gain (g),(AWG), Specific growth rate % day⁻¹(SGR),Feed conversion ratio (FCR), Protein conversion ratio (PCR) and Fishmeal ratio (FMR) of African catfish fries average weight 1.85 ± 0.79 g fed with diets varying BNWM and FM for 30d

<u>FEED</u>	<u>AWG</u>	<u>SGR</u>	<u>FCR</u>	<u>PCR</u>	<u>FMR</u>
<u>F 1 (94:0)</u>	<u>2.23 ± 0.5^c</u>	<u>5.0 ± 0.4^d</u>	<u>4.6 ± 0.3^b</u>	<u>0.82 ± 0.5^b</u>	<u>0.00 ± 0.4^d</u>
<u>F 2 (89:5)</u>	<u>2.83±0.1^{bc}</u>	<u>5.3 ±0.5^d</u>	<u>4.5 ± 0.1^b</u>	<u>0.89 ± 0.3^b</u>	<u>0.23 ± 0.3^c</u>
<u>F3 (74:20)</u>	<u>3.53± 0.3^b</u>	<u>6.0 ± 0.3^c</u>	<u>1.6 ± 0.6^a</u>	<u>0.41 ± 0.2^a</u>	<u>0.32 ± 0.1^b</u>
<u>F4 (59:35)</u>	<u>4.54 ± 0.2^a</u>	<u>7.2 ± 0.2^b</u>	<u>1.4 ± 0.3^a</u>	<u>0.43 ± 0.3^a</u>	<u>0.49 ± 0.5^b</u>
<u>F5 (39:55)</u>	<u>5.00 ± 0.4^a</u>	<u>8.2 ± 0.5^a</u>	<u>1.1 ± 0.2^a</u>	<u>0.42 ± 0.6^a</u>	<u>0.61 ± 0.6^a</u>
<u>FLSD_{0.05}</u>	<u>0.77</u>	<u>0.71</u>	<u>1.87</u>	<u>0.30</u>	<u>0.09</u>

Table 3

Average weekly water temperature variations during harmattan season of catfish culture .Catfish were fed FM /BNWM diets for 30d.

	<u>Period</u>	<u>F1</u>	<u>F2</u>	<u>F3</u>	<u>F4</u>	<u>F5</u>
<u>Week 1</u>	<u>Morning</u>	<u>25 ± 0.2</u>	<u>25 ± 0.5</u>	<u>24 ± 0.4</u>	<u>26 ± 0.1</u>	<u>29 ± 0.4</u>
	<u>Afternoon</u>	<u>27 ± 0.6</u>	<u>27 ± 0.7</u>	<u>29 ± 0.4</u>	<u>29 ± 0.4</u>	<u>31 ± 0.6</u>

<u>Week 2</u>	<u>Morning</u>	<u>23 ± 0.8</u>	<u>21 ± 0.4</u>	<u>22 ± 0.9</u>	<u>23 ± 0.5</u>	<u>23 ± 0.3</u>
	<u>Afternoon</u>	<u>22 ± 0.6</u>	<u>22 ± 0.9</u>	<u>24 ± 0.5</u>	<u>23 ± 0.2</u>	<u>24 ± 0.6</u>
<u>Week 3</u>	<u>Morning</u>	<u>22 ± 0.5</u>	<u>23 ± 0.7</u>	<u>23 ± 0.6</u>	<u>24 ± 0.1</u>	<u>25 ± 0.8</u>
	<u>Afternoon</u>	<u>22 ± 0.8</u>	<u>22 ± 0.6</u>	<u>23 ± 0.4</u>	<u>23 ± 0.4</u>	<u>24 ± 0.6</u>
<u>Week 4</u>	<u>Morning</u>	<u>26 ± 0.3</u>	<u>26 ± 0.3</u>	<u>25 ± 0.6</u>	<u>27 ± 0.6</u>	<u>28 ± 0.5</u>
<u>-</u>	<u>Afternoon</u>	<u>28 ± 0.6</u>	<u>28 ± 0.4</u>	<u>30 ± 0.7</u>	<u>31 ± 0.3</u>	<u>32 ± 0.7</u>

Table 4

Cost of producing experimental diets kg⁻¹ used in feeding larval catfish

<u>Feed</u>	<u>Cost USD</u>	<u>Cost Nigeria Naira</u>
<u>F1</u>	<u>0.12 USD</u>	<u>20.90^d</u>
<u>F2</u>	<u>0.13 USD</u>	<u>23.15^d</u>
<u>F3</u>	<u>0.17 USD</u>	<u>29.90^c</u>
<u>F4</u>	<u>0.21 USD</u>	<u>36.65^b</u>
<u>F5</u>	<u>0.26 USD</u>	<u>45.65^a</u>

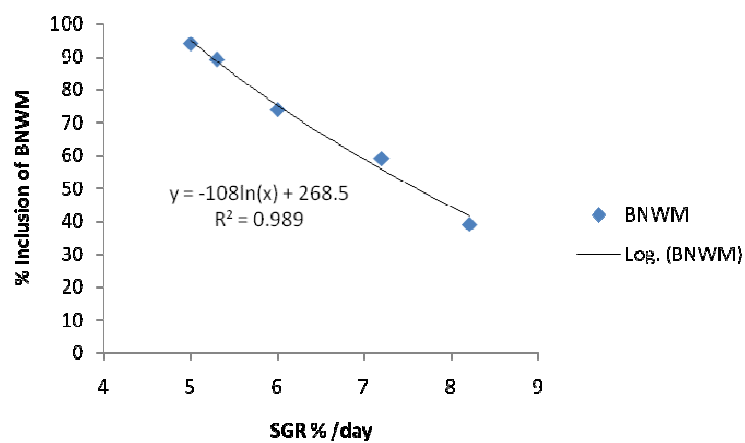


Fig. 1
Relationship of percentage inclusion of bambaranut waste meal with specific growth rate of African catfish fry fed with diets varying in inclusion of BNWM and fishmeal (FM) for 30d.

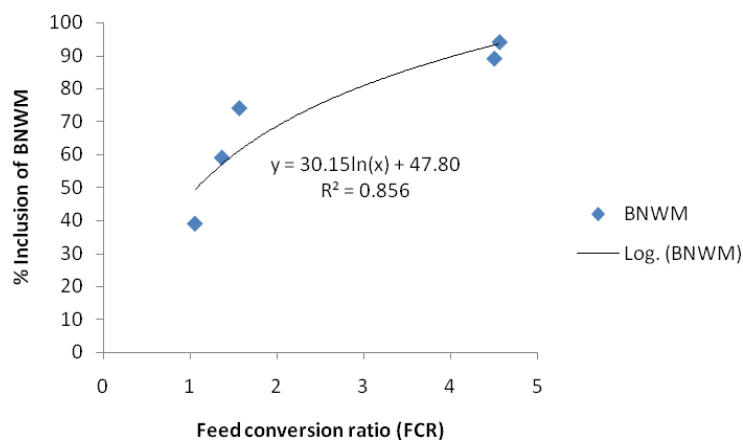


Fig 2.
Relationships between percentage inclusion of bambaranut waste meal (BNWM)
and feed conversion ratio (FCR) of African catfish fed with diets varying in
inclusion of BNWM and Fishmeal for 30d.

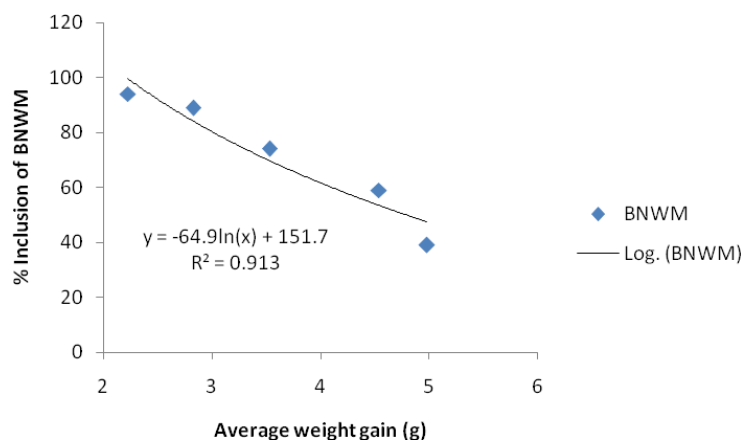


Fig. 3.
Relationship of percentage inclusion of bambaranut waste meal (BNWM) with
average weight gain of African catfish fry, fed with diets varying in inclusion levels
of BNWM and fishmeal (FM) for 30d.