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Effects of Replacing Fish Meal with Grasshopper Meal in the Diet of *C. gariepinus* (Burchell, 1822) Fingerling

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ABSTRACT
Effects of replacing fish meal (FM) with grasshopper meal (GHM) in the diet of *C. gariepinus* was evaluated with the aim of utilizing grasshopper meal as an alternative dietary protein source to fish meal. Various fish meal replacement with grasshopper meal (0, 25, 50, 75 and 100%) were then added into the 40% the in the diet of *C. gariepinus* fingerlings in three replications. One hundred (100) *C. gariepinus* fingerlings with initial mean body weight of 4.64g and mean length of 7.37cm were assigned to five experimental diets. The diets were fed to the fingerlings for 56 days. Cost benefit analysis of replacing fish meal with grasshopper meal was also evaluated. The result shows that the growth indices decreased with an increase in the concentration of the grasshopper replacing fish meal. The highest final weight, daily weight gain, specific growth rate, survival rate, feed intake and protein efficiency ratio were higher in fish fed the control diet (0% grasshopper meal). The cost benefit analysis shows that fish fed 0% GHM recorded the highest benefit cost ratio of ₦4. 34, gross profit ₦952. 32, profit index ₦7. 98 and net profit of ₦732. 98. The results of this study have shown that Grasshopper meal has relatively high protein level but cannot be compared with fishmeal as in the diet of *Clarias gariepinus* fingerlings for optimal growth and feed utilization. However, 25 % grasshopper meal could be used to replace fish meal in a situation where fish meal could not be found and when the grasshopper is cheaper than the fishmeal.

Key words: Replacement, Fish meal, Grasshopper, Growth performance, *Clarias gariepinus*

INTRODUCTION

Protein is a major constituent of fish diet knowledge of protein requirement of fish is essential for the formulation of a well-balanced artificial diet for economical fish feeding. Protein requirement is linked to the general energy requirement of the fish at a given water temperature and the ability of the fish to gain weight at its inherent capacity. It is also related to size, age and environmental stress, such as stocking density, low dissolved oxygen supply and the presence of toxicants (Eyo, 2003).

Protein requirements for maximum growth for any species is a logical step in the development of a cost-effective feed for fish and entails determining the maximum amount required to produce maximum growth and not to be used for energy (Sang - Min and Tee - Jun, 2005). Thus, any substitution or addition of protein feed stuff in the diet of a fish which will not affect fish growth in a negative way will surely be welcome in aquaculture nutrition.

According to Gatlin (2010), meeting a fish minimum dietary requirement for protein or a balanced mixture of amino acids is critical for adequate growth and health. Fish utilize both plant and animal proteins, although animal protein is nutritionally better than plant protein and it has been observed that the fish require a higher percentage of protein in their diet than warm blooded animals (Lovell, 1984). In view of this, a fish farmer or a feed formulator has to bear in mind the protein requirement of fish for which they

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are formulating the feed. The major source of animal protein in nutritionally balance formulated feed of fish is a high-quality fish meal which is more expensive. Aquaculture is therefore constrained by the cost of fish meal according to Hoffman *et al.* (1997).

Unconventional dietary animal protein sources have been experimented as substitutes for fish meal with various levels of success. Sogbesan *et al.* (2006) investigated the use of the garden snail in supplementing fish meal in the diet of *Clarias gariepinus* and concluded that 25% of garden snail in the diet can be efficiently utilized. Also grasshoppers are found to invade most of the North-eastern and central states of Nigeria at a particular season of the year, causing great devastation of crops (Sharah, 2012). These grasshoppers are as rich as the fish meal in terms of its amino acid profile, Okoye (2003). Encourage by similarity in the quality of the amino acid profile of fish and grasshopper meal, this study intends to replace fish meal with a grasshopper meal to ascertain if these qualities of grasshopper amino acid profile can compare favourably in terms of growth performance and feed utilization by *Clarias gariepinus* as fish meal.

In order to sustain the high growth of the aquaculture industry, it is imperative to increase fish feed production, because fish feed accounts for 60-80% of the variable costs of production. The high cost and fluctuating price of fish meal as well as its uncertain availability have led to the need to identify alternative protein sources for fish feed. Therefore, in an attempt to attain a more economically sustainable and viable production, research, and interests have been directed towards the evaluation and use of unconventional protein sources of both plants (leguminous) and animal's origin.

The choice of *Clarias gariepinus* among other fish species was due to the fact that the fish species are found in nearly all fresh water bodies in Nigeria. They can be cultured in a small water bodies and also have the attribute of being good food converters (FAO/IFAD, 1987). The fish are also cultured due to their tolerance to low dissolved Oxygen, rapid growth rate, and acceptability of a wide variety of food items, hardy and disease resistant and respond to induce breeding (Adesulu, 2001). The fish is in high demand, highly priced and with high economic returns, either as fresh or smoked (Banyigyi *et al*., 2001). This study aimed at utilizing grasshopper meal as an alternative dietary protein source to replace fish meal in the diet of *Clarias gariepinus.*

MATERIALS AND METHODS

Study area

The experiment was conducted at the Teaching and Research Fish farm of the Modibbo Adama University of Technology (MAUTECH) Yola, Adamawa State. Adamawa State is located at latitude 9.14^0N, longitude 12.38^0E and an altitude of 185.9m. It has an average annual rainfall of about 759mm with maximum temperature of 39.7^0C. The rainy season runs from May through October, while the dry season commences November and ends in April. The driest months of the year are January and February when the relative humidity drops to 13% (Adebayo, 1999).

Preparation of grasshopper meal

Edible grasshoppers were purchased from the local market in Maiduguri irrespective of their sizes and species, the wings were removed, all appendages removed, sun-dried and grounded into powder using a milling machine. Proximate analysis of the grasshopper was performed using standard methods of AOAC (1995).

Experimental fish

One hundred (100) fingerlings of *Clarias gariepinus* (4.64g weight and mean length of 7.37cm) were obtained from a reputable hatchery in Yola- North local government area, Adamawa State. The fingerlings were acclimatized for 24 hours in a plastic bowl of 50 liters capacity before the commencement of the experiment. During the acclimatization, the fish were fed with grasshopper free 40 crude protein (CP) diet.'' Feed that were not consumed were syphoned daily.

Experimental diet

Forty percent (40%) crude protein diets (table 1) was formulated using toasted Fish meal (FM), Groundnut cake (GNC) toasted soy bean (SB) yellow maize (YM), bone meal (BM). They were grounded into powder separately. Palm oil was used as a source lipid. Methionine, lysine and table salt and vitamin premix were used as a source of amino acid, mineral and vitamins, respectively. All the ingredients were weighed and dry mixed and wet mixed thoroughly into a dough. The dough diet was pelletized using pelleting machine through 2.0mm dice and shade dried and packaged into a nylon bag until required.

Experimental design

The 40% crude protein experimental diet formulated, pelleted and again grounded into powder. Various concentrations of grasshopper meal (0, 25, 50, 75 and 100%) were then added into the 40% diet (table 1). The various grasshopper based dough were wet mixed and pelleted using mechanically operated pelleting machine through a 2mm die. The freshly prepared moist grasshopper based pellets were shade dried for several hours. The experimental diets were then allotted to the fingerlings stocked at 10 fish per a bowl (50 liters capacity filled with 30 liters of water) in triplicates. The diets containing five (5) different level of the grasshopper meal as replacement levels of fish meal were fed twice daily between 7:00am to 8:00am in the morning and 5:00pm to 6:00pm in the evening for 56 days. Sampling was done weekly to review to adjust the quantity to be administered.

Table 1: Composition of the experiment

Ingredients (%)	**Grasshopper replacement levels (%)**				
	0	**25**	**50**	**75**	**100**
Fish meal	25.00	18.75	12.50	6.25	0.00
Grasshopper meal	0.00	6.25	12.50	18.75	25.00
Soybean meal	23.54	24.30	27.75	28.50	27.85
Ground nut cage meal	22.61	23.85	22.10	23.35	25.50
Yellow maize meal	21.70	19.70	18.00	16.00	14.50
Vitamin Premix	0.50	0.50	0.50	0.50	0.50
Bone meal	2.00	2.00	2.00	2.00	2.00
Binder	2.00	2.00	2.00	2.00	2.00
Palm oil	2.00	2.00	2.00	2.00	2.00
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20	0.20
NCl	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated crude protein	39.9808	39.9964	39.9840	39.9993	39.8092

At the end of the 56 days rearing, the final weight (g), final length (cm), total consumed (g) were recorded. The following growth indices were estimated using the following formula:

i. Mean weight gain = final weight – initial weight ÷ number of fish

ii. Specific growth rate (SGR) = log of final weight –log of initial weight ÷ time of culture (days) x 100

iii. Relative Growth Gate (RGR) = final weigh – initial weight ÷ initial weight x 100
iv. Survival (%) = Number of fish harvested ÷ number of fish stocked
v. Condition factor a (K1) = L^3÷W x 100, where L = standard length and live fish weight
vi. Feed Conversion Rate (FCR) = feed intake ÷ weight gain
vii. Feed Intake = total quantity of feed consumed by the fishes throughout the feeding trial
viii. Protein Intake = Feed intake × % CP in diet
ix. Protein efficiency ratio = mean weight gain ÷mean protein intake

Water quality parameters

The water quality parameters were monitored weekly, temperature using mercury in glass thermometer, ammonia using an ammonia meter, Dissolved Oxygen and pH using (Model: 102)

Statistical analysis

All data obtained from the experiment were subjected to one-way analysis of variance (ANOVA). Means between the treatments were determined using LSD at 5% (p≤0. 05) confidence level.

RESULTS

Proximate composition of grasshopper meal

The crude protein of the grasshopper was 57.6%, while crude lipid, crude fiber, crude ash and moisture were of 7.24, of 10.54, 13.6%, and 5.32respectively. Nitrogen free extract and gross energy were 5.7% and 416.64 (Kcal/g).

Table 2 shows the proximate composition of the experimental diets containing various grasshopper meal (GHM) replacing fish meal. Crude protein (CP) of the control diet (0% GHM) to diet with 100% GHM ranged from 39.90 - 40.60%. The CP was higher diet with 25% fish meal replacement level, followed by the control diet (0%) fish meal replacement with GHM. No significant variation (p>0.05) was observed in the CP values among the entire treatment. The lowest CP level was observed in diet with 50 and 755 GHM levels. Crude lipid of 0% GHM to 100% GHM ranged from 9.70 - 13.20%, Crude fiber of 0 % GHM to 100% GHM ranged from 1.90 - 3.40%, while ash content of 0% GHM to 100 % GHM ranged from 6.90 - 8.60%. The NFE of 0 % GHM to 100% GHM also ranged between 28.70 to 35.20%, Moisture content of Diet 1 to the Diet 5 ranged from 5.30 - 7.10% respectively.

Table 2: Proximate compositions of the experimental diets

Parameters (%)	Grasshopper replacement level (%)				
	0	25	50	75	100
Moisture Content	6.50±1.10^a	5.30±1.00^a	5.60±0.50^a	6.40±1.00^a	7.10±1.00^a
Crude Protein	40.30±1.00^a	40.60±1.00^a	39.90±1.00^a	39.90±1.00^a	40.20±1.00^a
Crude Ash	8.00±1.00^a	7.20±1.00^a	6.90±1.00^a	8.60±1.00^a	7.10±1.00^a
Crude Lipid	13.10±1.00^a	13.20±1.00^a	9.70±1.00^a	11.70±1.00^a	12.50±1.00^a
Crude Fibre	3.40±1.00^a	3.30±1.00^a	3.20±1.00^a	2.90±1.00^a	1.90±1.00^a
NFE (%)	28.70±1.00^a	30.40±1.00^a	35.20±1.00^b	30.50±1.00^a	29.90±1.10^a
GE Kcal/g	468.91±1.00^b	478.53±1.00^c	461.28±1.00^a	460.85±1.00^a	467.62±1.00^b
DE Kcal/g	319.41±1.00^a	325.02±1.00^a	256.22±49.00^a	310.67±1.00^a	316.70±1.00^a

Values with the same superscripts across the row are not significantly different (p > 0.05)
Key: NFE = Nitrogen free extract, GE = gross energy, DE = Digestible energy

Table 3 shows the growth parameters and feed utilization of *Clarias gariepinus* fed grasshopper meal as a substitute for fish meal. There was a decrease in growth indices of the fingerlings with the increase in the fish meal replacement with grasshopper levels. Fish fed with control diet (0 % fish replacement level) has significance ($p<0.05$) higher (21.08±1.23) final weight compared to the entire treatment. The lowest (10.44±1.11g) final weight was observed in *C. gariepinus* fingerlings fed with 100% grasshopper meal. There was a significant difference ($p>0.05$) between the final weight of fish fed 100% grasshopper compared to the rest of the fish replacement levels.

The mean daily weight gain was also higher (16.50±1.17) in the control diet, followed by those fed 25% grasshopper replacement level. No significant variation ($p>0.05$) was observed between the weight gains of fish fed 100% grasshopper compared to those fed 25% grasshopper replacement level. The mean weight gain was significantly ($p<0.05$) lower ($6.03±0.97^{d}$) in fingerlings fed 100% grasshopper.

Specific and relative growth rates were observed for higher (1.19± 0.0%/day and 359.99±20.83, respectively) in the fish fed 0 % grasshopper. There was no significant difference ($p>0.05$) between the SGR values of the fish fed control diet compared with those fed with 25% grasshopper replacement level. However, there was a significant difference ($p>0.05$) between the relative growth values of fingerling fed 0% grasshopper compared to those fed 25% grasshopper. The lowest specific and relative growth rates (0.67±0.06 and 135.90±17.40, respectively, were recorded in fish fed 100% grasshopper and were statistically ($p<0.05$) from the entire treatments.

The highest (93.00) survival rate of 93% was recorded in fish fed 0 % grasshopper followed by those fed 25% grasshopper replacement, while the lowest survival was observed fish feed 100 % grasshopper replacement of fish meal. Fish treated with 75% grasshoppers feed had the highest (1.38±.0.20) condition while the lowest condition factor value was in fish fed 100% grasshopper meal. The condition factor values of fish fed 0% grasshopper meal was significantly ($p>0.05$) different from the entire treatments.

Table 3: Mean growth and feed utilization of *C. gariepinus* fed various replacements of fish meal with Grasshopper meal

Growth Parameters	**Grasshopper replacement levels (%)**				
	DI	**DII**	**DIII**	**DIV**	**DV**
IW (g)	$4.58±0.06^{a}$	$4.78±0.73^{a}$	$5.01±0.32^{a}$	$4.44±0.22^{a}$	$4.41±0.15^{a}$
FW (g)	$21.08±1.23^{a}$	$17.82±2.47^{b}$	$15.93±2.63^{c}$	$13.05±2.25^{d}$	$10.44±1.11^{e}$
MWG	$16.50±1.17^{a}$	$13.04±1.17^{ab}$	$10.92±2.31^{b}$	$8.61±2.03^{c}$	$6.03±0.97^{d}$
IL (cm)	$7.35±0.15^{b}$	$7.10±0.40^{b}$	$7.80±0.40^{a}$	$7.40±0.20^{b}$	$7.20±0.10^{b}$
FL	$11.52±0.33^{a}$	$12.13±0.63^{a}$	$10.95±1.05^{b}$	$10.55±0.35^{b}$	$10.30±0.20^{c}$
LG (cm)	4.17	5.03	3.15	3.15	3.10
SGR (g/day)	$1.19±0.04^{a}$	$1.02±0.01^{a}$	$0.89±0.80^{b}$	$0.83±0.10^{c}$	$0.67±0.06^{d}$
RGR (%)	$359.99±20.83^{a}$	$273.63±5.39^{b}$	$215.90±32.32.^{c}$	$192.13±36.20^{d}$	$135.90±17.40^{e}$
SR (%)	93.00	92.00	90.00	90.00	87.00
K(1)	$1.16±0.06^{a}$	$1.33±0.02^{a}$	$1.07±0.10^{a}$	$1.11±0.15^{a}$	$1.18±0.01^{a}$
K(2)	$1.38±0.20^{a}$	$1.00±0.20^{c}$	$1.22±0.15^{b}$	$1.23±0.21^{b}$	$0.93±0.05^{c}$
FCR	$3.79±1.05^{a}$	$4.15±0.23^{a}$	$4.19±0.48^{a}$	$4.58±0.15^{b}$	$4.87±0.55^{b}$
FI	$304.75±82.16^{a}$	$296.17±47.81^{a}$	$292.19±51.11^{a}$	$218.47±29.89^{c}$	$245.86±26.03^{b}$
PI	$122.81±33.11^{a}$	$120±19.42^{a}$	$116.59±20.40^{a}$	$87.17±11.19^{c}$	$98.75±10.56^{b}$
PER	$0.71±0.20^{a}$	$0.60±0.04^{a}$	$0.61±0.10^{a}$	$0.55±0.03^{a}$	$0.52±0.06^{a}$

Value with the same superscript along row are not significantly different ($p>0.05$)

Key: FW = Final weight, MGW = mean weigh gain, IL = initial length, FL = Final length, LG = length gain, SR = survival rate, K1 and 2 condition factors, FCR = feed conversion ratio, FI= feed intake, PI = protein intake, PER = Protein efficiency ratio.

Feed intake, protein intake and protein efficiency ratio were higher (304.75±82.16, 122.81±33.11 and 0.71±0.20, respectively) in fish fed 0% grasshopper meal diet. No significant variation (p>0.05) was observed between the FI, PI and PER values of fish fed 0% grasshopper diet compared those recorded in fish fed containing 25 and 50% grasshopper replacing fish meal. Similarly, there were no significant differences (p>0.05) among the FI, PI and PER values of fish fed 50, 75 and 100% grasshopper diet. Fish feed 100 % grasshopper had the highest (4.87) FCR, while the lowest (3.79) value was recorded in the control diet. There were significant differences (p<0.05) between the FCR value in fish feed

Table 4: Cost - benefit analysis of replacing fish meal with grasshopper meal in the diet of *C. gariepinus*

Parameters	**Fish meal replacement level with Grasshopper (%)**				
	DI	**DII**	**DIII**	**DIV**	**DV**
Cost of feeding (₦)	119.34	110.39	102.60	72.59	77.11
Cost of fingerlings (₦)	100	100	100	100	100
Cost of feed/kg (₦)	391.61	372.73	351.16	332.28	313.63
Investment cost (₦)	219.34	210.39	202.60	172.59	177.11
Gross profit (₦)	952.32	668.79	711.88	381.88	589.16
Net Profit (₦)	732.98	458.40	509.28	209.29	412.05
Profit index (PI)	7.98	6.06	6.94	5.26	7.64
Benefit-Cost ratio	4.34	3.18	3.51	2.21	3.33

DISCUSSION

The optimum aim of every Aquacultural investor is to make profit at the end of the culture cycle. The results of proximate analysis showed that grasshopper meal used in this study had a nutrition value comparable to that of fishmeal. The 57.60% crude protein value agreed with finding of Mlcek *et al*. (2014) who reported 57.3% crude in grasshopper meal. However, the crude protein level of grasshopper reported in this study varied with the findings of Tao-Sun *et al*. (2010) who reported the crude protein of four species of grasshopper to range between 62.4–67.2% of the Tibetan land, China, and that of Olaleye (2015) who recorded 64.51% crude protein of grasshopper in Nigeria. However, the crude level of GHM recorded in this study was higher than the 35.76% reported for grasshopper in Nigeria by Ojewole *et al*. (2005), Banjo *et al*. (2006), Omotoso (2006), Sogbesan and (Ugwumba, 2008). Nakagaki *et al*. (1987) reported 62% CP for house cricket (*Acheta domestica*). Olaleye (2015) documented 64.51% CP for cricked, 61.50% CP was reported by Alegbeleye *et al*. (2011). The differences in the crude protein of the grasshopper meal according to Apandi *et al*. (1974) could be due to the season, geographic location and method of harvesting, processing and storage.

The crude lipid was 7.24% and is good as it is being used as a component of encasement of feed nutrient meant for fish to prevent loss of water soluble nutrients such as proteins and amino acids because of its insoluble property in water. The crude fiber content of 10.54% was high due to the fact that grasshopper has an exoskeleton made of chitin Okoye and Nnaji (2004). The Nitrogen free extract was 5.70%, which is the smallest amount of carbohydrates that can be digested easily because of its solubility Falayi (2009). The dry matter of grasshopper meal is very high, 94.7% with low moisture content of 5.32%. This implies quick drying of feed compared to dry matter of fishmeal, 90.0% and moisture content of 10% according to Eyo (2001).

The best growth indices recorded in fish fed the control diet this study differs with findings of Olaleye (2015), who reported best growth indices in fish fed on 20% fish meal and 10% GHM. The current study demonstrates that grasshopper meal as a dietary protein source that could supplement the increasingly expensive fishmeal in the diets of *C. gariepinus* fingerlings have shown low potentials of utilization. It shows that the replacement of fish meal in the diet of *C. gariepinus* fingerling with a grasshopper meal at a lower level of 25% could be incorporated without a deleterious effect on growth and nutrient utilization. This is in accordance with the findings of Alegbeleye *et al*. (2011) even though the control diet (100%) fishmeal gave the highest growth and feed utilization performance. These might be attributed to good odour, colour and stability of the feed in water in line. The negative effects of growth indices with an increase in the GHM replacing fish could be due to the presence of chitin in grasshopper. A Similar scenario was also observed when arthropods were fed to fish and livestock (Wang *et al*., 2005 and 2006; Olsen *et al*., 2006; Sogbesan and Ugwumba, 2008). The reduced growth performance in the group fed 75% GHM and 100% GHM could also be due to low amino acid availability; these diets contained lower lysine and lower methionine, respectively, than those required by of *C. gariepinus* (Alegbeleye *et al*., 2011). High survival levels (87 - 93%) indicated that the diets were harmless and low mortality was thought to be the consequence of handling stress and ammonia content in the culture water.

The water quality parameters recorded were within the optimum range of water quality parameters for *C. gariepinus* culture, values reported (Omotayo *et al*., 2006). The cost benefit analysis shows that fish fed 0% (control diet) recorded the highest (₦4.34) benefit cost ratio, gross profit (₦952.32), profit index (₦7.98) and net profit of ₦732.98 when compared to various grasshopper meal replacement levels.

Conclusion

The results of this study have shown that Grasshopper meal has relatively high protein level, not comparable to that of fishmeal, especially when used in the diet of *Clarias gariepinus* fingerlings for optimal growth and feed utilization. However, 25 % grasshopper meal could be used to replace fish meal in a situation where fish meal could not be found and when the grasshopper is cheaper than the fish meal.

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