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# EFFECTS OF FISH MEAL REPLACEMENT BY MAGGOT MEAL IN DIETS OF *CLARIAS GARIEPINUS* FINGERLING (BURCHELL, 1822).

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## ABSTRACT

The effects of fish meal replacement by maggot meal in diets of Clarias gariepinus fingerling fed different levels of maggot meal were investigated. Four (4) experimental diets were formulated to contain 0%, 25%, 50%, and 75% of maggot meal and were designated as T1 (0% inclusion), T2 (25% inclusion), T3 (50% inclusion) and T4 (75% inclusion) in a completely randomized design. Twelve (12) net hapa 1m×1m×1.2m were suspended in a polythene collapsible pond with the aid of Kuralon twine tied to iron pegs. The polythene collapsible pond was filled to the brim with borehole water. Each treatment had three replicates, with 10 fish accommodated in each hapa (mean initial body weight (10.86±0.03 g) per fish. Water temperature and other water quality parameters were monitored for 120 days. The results for growth and feed utilization revealed that the best experimental diet was the 75% inclusion level, as it gave the best weight gain (170.53g), specific growth rate (1.02%days), feed conversion ratio (1.48) and protein efficiency ratio (194.60), compared with the other diets. Cost-benefit analysis showed that fish fed 75% maggot meal has the best economic return, net profit (1377₦) and profit index (4.17) compared to other treatments. This result indicated that a 75% maggot meal diet of Clarias gariepinus fingerlings as a replacement for fish meal improves the nutritive value for fish, hence can serve as an alternative ingredient and replacement for fish meal in fish feed production.

**Keywords: Maggot meal, Fish meal, *Clarias gariepinus*, feed conversion ratio**

## INTRODUCTION

The global decline in capture fisheries over decades has necessitated the expansion and intensification of aquaculture to meet rising demand for fish as a critical protein source. With wild fisheries operating at or beyond sustainable limits (FAO, 2022), aquaculture now accounts for over 52% of global fish production, driven by population growth and dietary shifts (World Bank, 2023). In Nigeria, for instance, current fish production stands at

Approximately 1.2 million metric tonnes, leaving a deficit of nearly 2 million metric tonnes to meet national demand (FAO, 2021). To bridge this gap, sustainable aquaculture practices are essential, particularly through optimizing fish feed—a key determinant of productivity and profitability (Akinrotimi et al., 2020; Ogunji et al., 2021).High-quality feed is vital for enhancing fish growth, nutrient absorption, and overall health. However, reliance on imported fishmeal, a primary protein source in aquafeeds, raises costs and supply-chain vulnerabilities (Tacon and Metian, 2021). This has spurred research into locally sourced alternatives, such as agro-industrial by-products and insect-based proteins. While plant-based substitutes (e.g., soybean, cassava) are increasingly used, their anti-nutritional factors (e.g., phytates, lectins) and imbalanced amino acid profiles limit their efficacy (Kumar et al., 2022). Recent studies highlight insect larvae (e.g., black soldier fly, housefly maggots) as promising replacements for fishmeal due to their high protein content, sustainability, and cost-effectiveness (Barragan-Fonseca et al., 2022; Chia et al., 2023). For example, Agbohessou et al. (2021)

demonstrated that maggot meal substitution in tilapia feed improved growth rates by 18% while reducing production costs by 30%. Such innovations align with the broader goal of maximizing aquaculture efficiency through low-cost, nutrient-dense inputs (FAO, 2023). In this perspective, insects have been considered as a new protein source that could be produced locally to feed the fish. Several studies have shown that fly larvae could be potentially used to replace fishmeal in diets for fish (Hardouin et al., 2000; Mensah et al., 2007; Agbohessou et al., 2021). Therefore, maggot meal can stand for a fitting solution to reduce the production cost for fish nutrition.

## MATERIALS AND METHODS

### Study Area

*The study was conducted in Gashua Bade Local Government, Yobe state, North East with latitude of 12 $^{0}$ 52’ 35.39’’N and longitude of 11 01’53.7’’E of Nigeria*.

**Maggot meal collection**

The collection system was made of a plastic culture unit, consisting of two chambers: the top and the bottom. The top chamber of the unit was the maggot culturing chamber and was opened at the top for access to houseflies for laying their eggs on the

Exposed substrate. The base of this chamber was screened with 3mm galvanized wire mesh net to allow the dropping of the maggots. The bottom chamber, with a covered outlet, was the collection chamber where the maggots were collected. During harvesting, the substrate containing maggots was turned up with the aid of a wooden flat bar under intensive sunlight. In an attempt to escape from traces of sunlight, maggots were then passed through the 3mm mesh size net and dropped into the bottom chamber, where they are easily collected through the outlet of the collection chamber. The culture unit was placed on a constructed long wooden platform at least 30cm above the ground. The platform with the culture unit was set up under a shed to avoid the direct effect of sunlight.

**Maggot meal processing**

The processing of maggots was cultured using twenty-five kilograms of cattle blood, poultry droppings and cow dung. The attractants were collected from the Gashua slaughterhouse house and 5kg of rice bran were mixed and spread on a plastic culture unit to constitute the substrate. The odor of fresh blood and subsequently, fermenting substrates attracted the flies, which later laid eggs on it. The eggs

hatched into larvae within two days and were allowed to develop for 48 hours to develop further. The mature maggots were then harvested and washed with a salt solution for feeding the fingerlings. Four diets were formulated at 38% crude protein based on the nutritional requirements of Clarias gariepinus fingerlings containing 25-75% maggot meal at different inclusion levels. The diet was composed of standard amounts of fish meal, maize, Soybean meal, groundnut cake, vegetable oil, di-calcium phosphate, methionine, lysine, salt, vitamin premix and cassava starch as binder. The ingredients were ground, weighed and mixed and pelletized using a plastic sieve. Then sundry and store in an air-tight polythene bag at room temperature until use. The experimental feed was subjected to proximate composition before commencing the feeding trials according to the method of AOAC 2000.

**Experimental Fish, System and Procedure**

The experimental fish, pure-bred C. gariepinus fingerlings, with an initial mean weight of

(8.85±.03 g), were purchased from a reputable fish farm in Maiduguri, Borno State, Nigeria. The fish were transferred in a jerican from the hatchery to the Department of Fisheries and Aquaculture experimental fish farm, Gashua, Yobe State, Nigeria, where the feeding trial was conducted. Upon arrival, they were acclimatized for three days and were fed commercial feed at 40% crude protein once a day before the experiment commenced. The fish were subsequently fed with 38% diets containing maggot meal designated as T1 (0% inclusion), T2 (25% inclusion), T3 (50% inclusion) and T4 (75% inclusion) for 16 weeks. Fifteen net hapa (1×1×1.2m) were suspended in a polythene collapsible pond with the aid of Kuralon twine tied to iron pegs. The polythene collapsible pond was filled to the brim with borehole water. 10 (10) fish due to the size of the experimental hapa to avoid overstocking, and were randomly allocated in each hapa, and each of the four treatments has three hapas. The water quality parameters in the system were monitored weekly. The feed was manually administered and the fish were fed three times daily at 5% of body weight per day (9:30 am, 1:30 pm and 5:30 pm) for 16 weeks. Feeding rate was subsequently adjusted according to their growth rates per hapa. The fish were denied feed 24h before sampling. The fish were weighed collectively every four (4) weeks intervals, their average weight and length were recorded and the daily amount of feed for each tank was readjusted accordingly.

**Determination of Growth Parameters**

During the feeding trials and at the end of the experiment, growth performance was evaluated using indices such as weight gain, survival rate, specific growth rate, protein efficiency ratio and condition factor with the formulae below

Weight gain(WG)= $final\ weigt\ (FiW) - Initialweight(IiW)$

Specific growth rate (SGR) = 100 $\frac{\text{LL final weight} - \text{LL Initial weight}}{T}$

i. Feed conversion ratio (FCR) =$\frac{\text{Feed intake}}{\text{weight gain}}$

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

Condition factor (K)=$\frac{\text{Body weight}}{\text{Body leng3}} \times 100$

(Wilson, 2002)

Survival rate (SR) =$\frac{\text{Final number of fish}}{\text{Initial number of fish}} \times 100$

(Akinwole and Faturoti, 2006)

**Cost Benefit Analysis**

Cost-benefit analysis for each treatment

The group at the end of the experimental period was estimated. Cost of feed and value of fish were estimated on the prevailing market price in Gashua, Yobe State, Nigeria. The following parameters were calculated as described by Sogbesan, Aderolu and Abarike.

i Incidence of cost (IC) = Cost of feed / Weight of fish produced.

ii Profit index (PI) was estimated using this formula.

PI=value of fish /cost of feed.

iii Net Profit (NP) = sales – expenditure

iv Total cost (TC) = fixed cost (FC) + total variable cost (TVC)

Where FC cost of fingerlings, TVC is = Cost of producing Different diets.

**Data Analysis**.

The data obtained from the study were subjected to One-Way Analysis of Variance (ANOVA), to determine for significance difference of the mean values. Duncan's Multiple Range Test (DMRT) was used to separate the means at P< 0.05 with the aid of Statistix 10.0.

## RESULTS

### Growth Performance and Nutrient Utilization of *Clarias gariepin* Fingerling Fed Experimental Diets

Growth performance and nutrient utilization of *Clarias gariepinus* fed different level of maggot meal are presented in Table 2. The final weight of the experimental fish were from 150.31 to 181.40g, the highest (181.40g) was recorded in fish fed with 75% maggot and least (150.31g) was recorded in fish fed with 0% maggot meal, there was a significant difference (P< 0.05) between fish fed 75% maggot meal compare to all other treatment. However there was no significant difference (P>0.05) between fish fed 0% maggot meal and fish fed 25% maggot meal diet. Similarly the highest weight gain (170.53g) was recorded in fish fed 75% maggot while the lowest (139.42g) was recorded in fish fed 0% maggot meal, there was significant difference ((P<0.05) in weight gain between fish fed 75% maggot meal compare to the rest treatment. However there was no significant different (P>0.05) between weight gain in control and fish fed 25% maggot meal.

Fish fed 75% maggot meal produce a better specific growth rate (1.02%/day) specific growth rate value (SGR) followed by 0.98 and 0.87%/day, for fish fed 50 and 25% maggot meal, the lowest (0.79%/day) was recorded in fish fed 0% maggot meal. Growth Performance and Nutrient

Utilization of Clarias gariepin Fingerling Fed Experimental Diets

Growth performance and nutrient utilization of Clarias gariepinus fed different levels of maggot meal are presented in Table 2. The final weight of the experimental fish was from 150.31 to 181.40g, the highest (181.40g) was recorded in fish fed with 75% maggot and the least (150.31g) was recorded in fish fed with 0% maggot meal. There was a significant difference (P< 0.05) between fish fed 75% maggot meal compared to all other treatments. However, there was no significant difference (P>0.05) between fish fed 0% maggot meal diet and fish fed a 25% maggot meal diet. Similarly, the highest weight gain (170.53g) was recorded in fish fed 75% maggot, while the lowest (139.42g) was recorded in fish fed 0% maggot meal. There was a significant difference (P<0.05) in weight gain between fish fed 75% maggot meal compared to the rest treatments. However, there was no significant difference (P>0.05) between weight gain in control and fish fed 25% maggot meal. Fish fed 75% maggot meal produced a better specific growth rate (1.02%/day). Specific growth rate value (SGR followed by 0.98 and 0.87%/day, for fish fed 50 and 25% maggot meal. The lowest (0.79%/day) was recorded in fish fed 0% maggot meal. There was a significant (P< 0.05) difference

Between fish fed 75% maggot meal compared to fish fed 50% and 25% maggot meal. However, there was no significant (P> 0.05) difference between fish fed 25% and 50% maggot meal. The best feed conversion ratio (FCR) was observed in fish fed 75% (1.48) maggot meal, while the poorest (1.87) was recorded in fish fed 25% maggot meal. All the treatment groups significantly (P<0.05) differ from each other; however, there was no significant (P >0.05) difference between fish fed 0 and 50% maggot meal. Protein efficiency ratio (PER) ranges from 3.67 to 4.48. The highest PER value was observed in fish fed 75% maggot (4.48), while he lowest (3.67) was observed in fish fed 0% maggot meal. There was a significant difference (P<0.05) in PER among the treatment groups. However, there is no significant variation (P>0.05) between fish fed 0 and 25% maggot meal.

**Cost-Benefit Indices of Claria gariepinus Fed Maggot Meal**

The cost-benefit indices of Clarias gariepinus fed maggot meal are presented in Table 3. The cost of producing different feeds was highest in fish fed 0% maggot meal (₦1500), while the least was recorded in fish fed 75% maggot meal (₦1200). There was a significant (P< 0.05) difference in all the treatment groups. Total expenditure obtained in this study was highest (₦3910) in fish fed 0% maggot and the least (₦3613) expenditure was recorded in fish fed 75% maggot meal. There was significant (P< 0.05) variation among all the treatment groups. Net profit (NP) revealed the highest value (₦1377) in fish fed 75% maggot and the lowest (₦1090) in fish fed 0% maggot. There was a significant (P<0.05) difference in all the treatment groups. Incidence cost (IC) recorded a higher value (10.76) in fish fed 0% maggot meal, and the lowest was recorded in fish fed

75% (7.07), respectively. There was a significant ($P<0.05$) difference in all the treatment groups. Profit index (PI) revealed the highest value (4.17) in fish fed 75% maggot meal, and the lower value (3.33) in treatment fed with 0, 25 and 50% maggot meal. There was a significant ($P<0.05$) difference between fish fed 100% maggot meal and fish fed 0% but similar to fish fed 25% maggot meal. The total cost recorded the highest in fish fed 0% maggot meal; there was a significant difference between fish fed 0 and 75% maggot meal, but similar to fish fed 25% maggot meal.

## Discussion

The significant improvement in growth performance and feed efficiency observed in Clarias gariepinus fingerlings fed 75% maggot meal (T4) underscores the potential of insect-based proteins as sustainable alternatives to fishmeal in aquaculture. The weight gain (170.53 g) and specific growth rate (SGR: 1.02% $day^{-1}$) recorded in T4 surpass values reported in earlier studies using plant-based substitutes, such as soybean or groundnut meal (Adewole et al., 2022), and align closely with findings from recent trials evaluating black soldier fly larvae in tilapia diets (Čičková et al., 2023). This superior performance can be attributed to maggot meal's rich nutritional profile, which includes high-quality protein (60–65% crude protein), balanced amino acids (e.g., lysine, methionine), and essential fatty acids (Barragan-Fonseca et al., 2022). Unlike plant proteins, which often contain anti-nutritional factors (e.g., phytates, tannins) that impair digestion (Kumar et al., 2023), maggot meal exhibits high digestibility (82–88%) and bioavailability, enabling efficient nutrient absorption (Shumo et al., 2021). The remarkably low feed conversion ratio (FCR: 1.48) in T4 highlights the metabolic efficiency of maggot meal. This value is lower than FCRs reported for Clarias gariepinus fed fishmeal-based diets (1.6–1.8) in similar studies (Ogunji et al., 2021), suggesting that maggot meal not only matches but potentially exceeds fishmeal in supporting growth. The protein efficiency ratio (PER: 194.60) further validates this, as it reflects optimal nitrogen retention and utilization—a critical factor in protein-rich aquaculture systems. These results contrast with lower PERs observed in Nile tilapia fed tamarind seed meal (Abdulmalik et al., 2017), likely due to differences in species-specific metabolic pathways

or the presence of protease inhibitors in plant ingredients. The economic analysis revealed that the 75% maggot meal diet (T4) delivered the highest net profit (₦1,377) and profit index (4.17), outperforming conventional fishmeal-based feeds. While this profit index is slightly lower than values reported for soybean meal replacements in catfish (Adewole et al., 2022), it underscores the cost-effectiveness of maggot meal, particularly given its reliance on low-cost organic waste substrates (e.g., poultry manure, food scraps) for production (van Huis, 2022). This aligns with circular bioeconomy principles, where waste valorization reduces dependency on finite marine resources and mitigates the environmental impacts of feed production (European Commission, 2023). For instance, maggot farming emits 75% fewer greenhouse gases than fishmeal production and requires 90% less land than soybean cultivation (Čičková et al., 2023), making it a scalable solution for sustainable aquaculture. The mineral composition of maggot meal, particularly its calcium (2.1%), phosphorus (1.8%), and zinc (120 mg/kg) content (Compaore et al., 2023), likely contributed to enhanced osmoregulation and skeletal development in T4 fish. These minerals are critical for enzyme activation and immune function, reducing susceptibility to stressors like fluctuating water quality (Dzepe et al., 2021). Additionally, maggot meal contains chitin, a prebiotic fiber that modulates gut microbiota and improves disease resistance in fish, a functional benefit absent in plant- or fishmeal-based diets (Hlongwane et al., 2023). While this study demonstrates the viability of maggot meal, challenges remain. For example, palatability issues may arise at inclusion levels >75%, as observed in carp fed high insect-meal diets (Li et al., 2022).Furthermore, standardization, Maggot production protocols (e.g., substrate optimization, pathogen control) are essential for industrial adoption.

**Conclusion**

This study positions maggot meal as a transformative ingredient in aquaculture feed, capable of bridging the protein gap while advancing sustainability goals. By reducing reliance on overexploited fishmeal and mitigating the ecological footprint of feed production, maggot-based diets exemplify the innovation needed to meet global seafood demand, projected to rise by 15% by 2030 (FAO, 2023). Policymakers and industry stakeholders must prioritize investment in insect farming infrastructure and regulatory frameworks to unlock this potential

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Table 1: Composition of the Experimental Diets.

| Ingredients | 0% | 25% | 50% | 75% |
|---|---|---|---|---|
| Soyabean | 40.40 | 40.40 | 40.40 | 40.40 |
| Fish meal | 41.40 | 30.30 | 20.20 | 10.10 |
| Maggot meal | 0.00 | 11.10 | 21.20 | 31.30 |
| Groundnut cake | 2.00 | 2.00 | 2.00 | 2.00 |
| Maize | 12.20 | 12.20 | 12.20 | 12.20 |
| Vegetable oil | 0.50 | 0.50 | 0.50 | 0.50 |
| Methionine | 0.50 | 0.50 | 0.50 | 0.50 |
| Lysine | 0.50 | 0.50 | 0.50 | 0.50 |
| Ascorbic acid | 0.50 | 0.50 | 0.50 | 0.50 |
| Vitamin premix | 0.50 | 0.50 | 0.50 | 0.50 |
| Di-calcium phosphate | 0.30 | 0.30 | 0.30 | 0.30 |
| Salt | 0.20 | 0.20 | 0.20 | 0.20 |
| Binder | 1.00 | 1.00 | 1.00 | 1.00 |
| Total | 100 | 100 | 100 | 100 |

Table 2**:** Growth Performance and Nutrient Utilization of *Clarias gariepinus* Fingerling Fed Experimental Diets**.**

| Parameters | 0% | 25% | 50% | 75% | SEM |
|---|---|---|---|---|---|
| FI (g) | 250.22[d] | 270.10[a] | 262.00[b] | 253.00[c] | 1.20* |
| IW (g) | 10.89 | 10.86 | 10.88 | 10.87 | 0.13[ns] |
| FW (g) | 150.31[c] | 155.63[c] | 162.47[b] | 181.40[a] | 3.01* |
| WG (g) | 162.30[c] | 144.76[cd] | 151.59[b] | 170.53[a] | 3.01* |
| SGR (%/day) | 0.95[c] | 0.96[b] | 0.98[b] | 1.02[a] | 0.02* |
| FCR | 1.79[b] | 1.87[a] | 1.73[c] | 1.48[d] | 0.20* |
| PER | 3.67[d] | 3.81[c] | 3.98[b] | 4.48[a] | 0.79* |
| K | 1.82[a] | 1.66[b] | 0.59[d] | 01.29[d] | 0.20* |
| SR (%) | 64.42 | 71.12 | 70.00 | 72.44. | 7.41[ns] |

Means across the same row bearing different superscripts differs significantly (P<0.05)

Key: ns= not significant

IW = initial weight, FW = final weight, WG = weight gain, FI = feed intake, SGR = specific growth rate, FCR = feed conversion ratio, PER = protein efficiency ratio, K = condition factor, SR = survival rate

Table 3.Cost and benefit analysis of *Clarias gariepinus* fed experimental diet**.**

| Parameters | 0% | 25% | 50% | 75% | SEM |
|---|---|---|---|---|---|
| Weight gain (g) | 139.42[c] | 144.76[c] | 151.59[b] | 170.53[a] | 3.01* |
| Cost of feed (₦) | 1500.0[a] | 1400.0[ab] | 1300.0[bc] | 1200.0[c] | 73.28* |
| Cost of fish (₦) | 800 | 800 | 800 | 800 | |
| Cost of feeding (₦) | 610 | 630 | 620 | 613 | |
| Fueling/water cost (₦) | 1000 | 1000 | 1000 | 1000 | |
| Expenditure | 3910[a] | 3830[ab] | 3720b[c] | 3613[c] | 73.28* |
| Unit price of fish (₦) | 500 | 500 | 500 | 500 | |
| Value of fish (₦) | 5000 | 5000 | 7500 | 7500 | |
| Net profit(₦) | 1090[c] | 1176[bc] | 1280[ab] | 1377[a] | 73.27* |
| Incidence cost | 10.76[a] | 9.67[a] | 8.56[b] | 7.03[c] | 0.37* |
| Profit index | 3.33[c] | 3.57[c] | 3.85[ab] | 4.17[a] | 0.264* |
| Total cost (₦) | 2300[a] | 22007[ab] | 2100[bc] | 2000[c] | 210.35* |

Means across the same row bearing different superscripts differs significantly (p<0.05)