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Growth Performance of *Clarias gariepinus* (Burchell, 1822) fed with Local Feed without Fish Meal

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Abstract In fish farming, feed accounts for a large proportion of production costs because of the use of fish meal and fish oil. The aim of this study was to develop a local feed from available local resources. To this end, a local feed balanced in essential amino acids and based on maggots (*Musca domestica*), earthworms *(Eisenia fetida*) and brewer's yeast as a total replacement for fishmeal was tested on *Clarias gariepinus* fry of average initial weight Pmi= 4.39± 0.01g for 90 days. Tested with three replicates, the feeds (control feed T0 - imported (*Gouessant*) and local feed T1) were used to feed fry distributed in tanks (volume 0.5m^3 each) with a density of 100 individuals / tank. Results showed that no significant differences were found in final weight and weight gain (p>0.05), whereas survival and protein intake differed significantly (p<0.05) between T0 and T1. Feed utilisation parameters showed better utilisation of the T1 local feed, with a consumption index of 1.01 and a protein efficiency coefficient of 1.9. Economic analysis showed that local feed T1 was about half the cost of commercial feed T0. Nevertheless, further investigations are required to determine the impact of using this local feed on the organoleptic quality and reproductive capacity of the products obtained.
Keywords *Clarias gariepinus*; Total replacement; Local feed; Reproductive capacity

1 Introduction

Demographic pressure and rising global fish consumption have encouraged intensive, and often irresponsible, fishing. This overfishing has endangered many wild fish species. Biodiversity is also under serious threat from pollution of the natural environment and overfishing with prohibited gear, leading to the disappearance of certain aquatic species (Welly et al., 2020)

In this context, aquaculture, and in particular fish farming, appears to be the answer to reducing overfishing and satisfying the growing consumption of fish. In many African countries, like Guinea, aquaculture is being developed (FAO, 2024). Despite Guinea's considerable potential, fish farming is practised extensively, seasonally in ponds, puddles and reservoirs (MPAEM, 2015).

Furthermore, the development of aquaculture in Guinea is coming up against a number of problems, including a lack of high-performance feed on the local market at prices that fish farmers can afford. The main activity of rural Guinean populations is agriculture, which plays an unprecedented economic and social role (MPAEM, 2015).

In West Africa, maggots or black soldier fly (*Hermetia illucens*) and housefly (*Musca domestica*) larvae are increasingly used in fish feed (Djissou et al., 2020; Gangbazo Kpogue et al., 2024). Known for their high nutritional quality (protein and essential amino acid content in particular), maggot meal is increasingly used in the manufacture of fish feed because of its short production cycle and affordable price. Maggots are also biodegraders of organic waste, the management of which is a major environmental concern in Africa (Odjo et al., 2018).

The economic interest of aquaculture is highly dependent on the availability and cost of feed (Djissou et al., 2016). Reducing feed costs, and consequently controlling the production cost of farmed fish, is therefore one of the priorities in aquaculture (Djissou et al., 2020). In fact, fish meal is an essential and practically unavoidable ingredient in aquaculture feeds due to its richness in Essential Amino Acids (EAA), the profile of which corresponds remarkably well to the needs of fish (Médale et al., 2013). However, according to Vodounnou et al (2025), the high cost of fish meal, coupled with its unavailability and variable quality on the local market, does little to improve the economic profitability of aquaculture. There is therefore an urgent need to find alternatives to fish meal for use in aquaculture. Increasingly, both plant and animal protein sources are being used as partial or total substitutes for fish meal (Médale et al. 2013; Djissou et al., 2020). The use of animal protein sources (termites, maggots and earthworms) and plant sources (peanut, sunflower and soybean cakes, bean meal and brewer's yeast) in aquaculture as substitutes for fish meal has thus been initiated (Gougbédji et al., 2020; Atchamou et al., 2024; Djissou et al., 2016) in several species, including *Clarias gariepinus*, with variable performance.

Clarias gariepinus is an omnivorous species with carnivorous tendencies and a high growth and economic potential. In Guinea, this species of great piscicultural interest is one of the species that fish farmers are most familiar with. Nevertheless, its production faces a number of difficulties, including the high cost and quality of the feed used, which is crucial to the development of the industry.

In replacement of the fish meal, the proteinic sources must bring the ten essential amino acids (EAA) required for fishes (Médale et al., 2013). To satisfy the essential amino acids requirements for *Clarias gariepinus* fingerlings, the experimental diets without fish meal based on a mixture of earthworm and maggots (proteinic sources) were tested on *Clarias gariepinus* (Djissou et al., 2016; 2025) and *Oreochromis niloticus* (Djissou et al., 2020) with good performances of growth and feed utilization for the pre-growing of fingerlings in Benin. This study was therefore initiated with the aim of promoting fish farming by developing a high-performance local feed that is free of fish meal and fish oil, and at a lower cost for the growth of fingerlings in Guinea.

2 Methodology

2.1 Experimental set-up

The experiment was carried out in an open circuit in six (06) circular above-ground concrete tanks, completely randomized, with a total volume of 0.5 m^3 each with of water supplied by borehole and a compressor (FIAC, axair 100L 2CV 10B 230 V) at a flow rate of 3 L min^{-1}. Half of the surface of each tank was covered with a screen to prevent direct sunlight penetration and, above all, the development of chlorophyll algae under the effect of solar radiation. A total of 600 *Clarias gariepinus* fingerlings, with an average initial weight of 4.39±0.07 g, were placed in the tanks at a stocking density of 100 fingerlings per tank. The fingerlings (tested with three replicates) were acclimatized for one week before starting the trial.

2.2 Obtaining the protein sources used to replace fish meal

The rearing of alternative animal protein sources was conducted at the experimental site. Earthworms (*Eisenia foetida*) were reared for 90 days (one production cycle) on a pig-manure substrate following the method described by Vodounnou et al. (2016). Maggots (*Musca domestica*) were reared on a substrate composed of soybean meal and chicken viscera, according to Odjo et al. (2018). Earthworm and maggot meals were processed in the same manner as the chicken viscera: the biomass was washed, drained, and gently cooked over low heat, then dried and ground into flour. The resulting meals were sealed in airtight plastic bags and stored under refrigeration until use.

2.3 Bromatological analysis

Diet T1 was analyzed according to AOAC (2005) procedures. Amino acids from diet were analyzed with a Waters HPLC method. These amino acid analyses were carried out using the method previously described by Bosh et al. (2006). Aminobutyric acid was added as an internal standard prior to hydrolysis. After experimentation, proteins, lipids and ash of 20 homogenized carcasses of fish taken randomly after 3 days from experiment in each diet. Crude protein (%N X 6.25) was determined by the Kjedahl method, fat by the hot method (Soxhlet type) and ash after incineration of the samples in a muffle furnace at 550 °C for 12 hours.

2.4 Feed formulation, manufacture and feeding frequency

The batches *of C. gariepinus* were fed two different diets during this experiment. The control diet T0 (*Gouessant*) is an imported commercial feed. The experimental diet is made up of ingredients including earthworms, maggots and brewer's yeast used as a source of protein that completely replaces fish meal (Table 1). With a feeding frequency of 4 times a day, the fish were fed for 90 days at a ration rate of 5% with the tested feeds.

Table 1 Feed composition of the imported feed (T0) and the local feed (T1) developed

Ingredients	T0 (%)	T1 (%)
Rice bran	-	5
Soy flour	-	25
Brewer's yeast	-	5
Cotton cake	-	15
Earthworm meal	-	12
Maggot flour	-	30.5
Palm oil	-	3
Vitamin	-	1
Minerals	-	1
Starch	-	2
Methionine	-	0.5
Crude protein	42	40
Fats and oils	11	12.9
Total ash	7.9	6.5

To make the food, the ground ingredients were weighed and mixed until a homogeneous powder was obtained, to which palm oil was added. Water was then added to obtain a malleable paste. A pelletiser with a mesh size of 1.5 and 2 mm was used to produce the pellets, depending on the development of the fish. The manufactured feeds were dried in the sun before being stored in boxes for conservation (-4 °C) before distribution (Table 2).

Table 2 Composition in essential amino acids (EAA) of the local feed developed (g.kg^{-1} of feed)

Essential amino acids	T1	EAA requirements of *C. gariepinus**
Threonine	8	5-5.6
Valine	7	7.1-8.4
Methionine	9	6-6.4
Isoleucine	11	6-7.3
Leucine	19	8-9.8
Phenylalanine	13	12-14
Histidine	9	4-4.2
Tryptophan	6	1.2-1.4
Lysine	14	12-14.3
Arginine	20	10-12

Table caption: : * NRC (2011)

2.5 Water physico-chemistry and biological monitoring

Water quality was monitored every 3 days by determining (twice a day) physico-chemical parameters such as temperature, dissolved oxygen, pH, conductivity and TDS using a multiparameter (ORCHIDIS SN-ODEOA-2138). Control fishing took place every two weeks, followed by emptying and cleaning of the tanks. The number and biomass of fish in each tank were determined by counting and using a centesimal- precision scale (TANITA KD-192).

2.6 Zootechnical and economic parameters

Growth, feed utilization and economic performances were determined by the average final weight (AFW), the Percentage Weight Gain (PWG), the Specific Growth Rate (SGR), the Survival Rate (SR), the Consumption Index (CI), the Protein Intake (PI), the Protein Efficiency Coefficient (PEC), the cost of manufacturing one kilogram of experimental local feed, the costs associated with manufacturing one kilogram of feed, the total production cost per kilogram of fish and the profit per kilogram of fish. The following formulas were used:

Pmf= Final biomass (g) / Final number of fish.

PGP= 100 x (Final average weight (g) - Initial average weight (g)) / Initial average weight

IC = Quantity of feed ingested(g) / Weight gain(g)

PI= Ration distributed x Crude protein / Final number of fish.

CEP= Weight gain(g) / Protein intake(g)

TCS (in %/d) = [Ln (Mf) - Ln (Mi) / t(d)] x 100

TS (in %) = (Number of final individuals / Number of initial individuals) x 100.

Cost per kilogram of feed from usual by-products =∑ (unit price of raw materials x proportions used)

Cost of manufacturing one kilogram of feed =∑ (cost of substrates+ milling price) x 100 / Rd with Rd the ration distributed

Total cost of a kilogram of feed= cost of a kilogram of feed from the usual sub-products + costs associated with manufacturing a kilogram of feed.

Total production cost per kilogram of fish= Total production cost per kilogram of feed x IC

Profit= Selling price per kilogram of fish - total production cost per kilogram of fish

2.7 Statistical analysis

Statistical analysis was carried out according to standard one-criterion analysis of variance (ANOVA) methods using Statistica version 6 software with a significance level of 5%. The Fisher LSD test was used for paired comparisons of means.

3 Results and Discussion

3.1 Farm water quality

Throughout the trial period, mean temperature values of around 28.4±0.6°C and 29.3±0.4°C were recorded at the T0 and T1 regime ponds, respectively. These measured temperatures are within the range (26 °C~30 °C) recommended by (Ipungu et al., 2019) for good growth of *Clarias gariepinus.* With regard to dissolved oxygen, the values recorded during the experiment were 4.22±0.9 mg·L^{-1} for regime T1 and 5.80±0.29 mg.L for regime T0. These recorded values are higher than the 3 mg/L reported by Ipungu et al. (2019) and are favourable for the growth of *C. gariepinus*. For pH, values of 5.38±0.42 and 5.68±0.31 respectively for T1 and T0 farm waters. The pH values indicate a slight acidity in the rearing water. However, they are likely to allow good growth of *C. gariepinus* (Ipungu et al., 2019). The values recorded for conductivity were 62.7±2.19 for the T0 regime and 72.6±1.26 µs/cm for the T1 regime, in contrast to TDS, where the values recorded were 42.9±1.11 and 49.2±1.37 ppm for the T0 and T1 regimes respectively.

3.2 Zootechnical and economic parameters

The zootechnical and economic performances obtained with the feeds tested after 90 days are presented in Table 3. Growth parameters such as Pmf, TCS, PGP reveal that there is no significant difference (p>0.05) in performance obtained between the local feed T1 and the imported feed (control - T0) with the exception of TCS. These results corroborate the work of Djissou et al. (2016) who used maggots and earthworms as a total replacement for fish meal to feed *C. gariepinus* fingerlings with similar growth performance (Table 3).

Table 3 Zootechnical and economic parameters obtained with the experimental systems

Zootechnical parameters	Experimental regimes	
	T0	T1
Pmi (g)	4.40± 0.01a	4.39± 0.01a
Pmf (g)	140.30± 5.71a	139.68± 1.26a
TS (%)	98.33± 3.11a	93.00± 0.66b
IC	1.11± 0.04a	1.01± 0.02b
CEP	1.01± 0.24a	1.9± 0.05b
TCS (%/d)	4.23± 0.02a	4.10± 0.01a
PGP (%)	3091.14± 131.61a	3081.70± 23.85a
PI	50.99± 2.11b	61.18± 0.84a
Economic parameters		
Cost per kg (GNF/Kg)	-	5 265
Manufacturing costs per kg of feed (GNF/Kg)	-	2 860
Total cost per kg of feed (GNF/Kg)	15 052	8 125
Total production cost per kg of fish (GNF/Kg)	16 708	8 206
Selling price per kg of fish (GNF/Kg)	22 578	22 578
Profit (GNF/Kg)*	5 875	14 373

Table caption: T0= Control food, T1= Local food. Values with the same letters on the same line are not significantly different ($p>0.05$). Values are expressed as mean± standard deviation. * Prices are in GNF and are based on exchange rates in November 2025. Labour and processing costs were included by adding 20% to the ingredient costs (Azaza et al., 2006).

As for nutritional requirements, the crude protein content of the diet tested in this study (40%) is within the range of optimal requirements for catfish *(Clarias gariepinus, Heterobranchus bidorsalis and Heteroclarias)*, which is between 40% and 42.5% (Monebi and Ugwumba, 2013). Several studies have shown that total replacement of fish meal by maggot or earthworm meal reduced the growth rate of fish such as *Heterobranchus longifilis* (Sogbesan et al., 2007), *Heteroclarias* (Monebi and Ugwumba, 2013) and *Clarias gariepinus* (Djissou et al., 2016). The results of these studies contradict our results, which show good use of the local feed with a better consumption index (1.01) and ingested protein (61.18), in addition to the good growth performance obtained. Meeting the essential amino acid requirements of *C. gariepinus* also contributed to this performance. In fact, when formulating fish feed, meeting the growth requirements of fish depends not only on the quantity of protein provided by the feed, but also on its quality, i.e. the nature of the amino acids provided, particularly the essential ones. In our work, the results obtained are therefore explained by the quality of the feed (protein and essential amino acids) which satisfies the needs of *C. gariepinus* for good growth. Furthermore, Djissou et al. (2016; 2017) showed that fish meal can be completely replaced by a combination of *Azolla filiculoides*, brewer's yeast, maggot and *Dialium guineense* leaf in the diet of *Oreochromis niloticus* with good growth performance. However, when the essential amino acid composition of the feed does not meet the needs of the fish, this influences the net energy value of the proteins and increases the metabolism of the fish, as well as polluting the environment with nitrogenous waste (Medale and Kaushik, 2009).

It should be noted that the biological value of the protein source depends on its essential amino acid profile (Table 2) as well as its digestibility. The values of CEP and PGP (Table 3) recorded with the test feed are due not only to the protein sources used as total replacements for fish meal (earthworm, maggot and brewer's yeast), which are rich in EAA (Adesina, 2012), but also to the diet of *C. gariepinus*. The PER obtained are generally lower than those obtained by Nyinawamwiza (2007), who completely replaced fish meal with groundnut, soybean and groundnut meal in the diet of *C. gariepinus*. Nevertheless, the local feed would be well digestible for the fish in view of the feed utilisation parameters obtained.

An optimal profile of essential amino acids is a prerequisite for fish growth (Medale et al., 2013). The feed tested in this study is of high quality in protein value because it contains all the EAAs with higher values with the exception of methionine (Djissou et al., 2020). In fact, lysine and methionine are the first limiting EFAs in many fish feeds, mainly in those based on unusual protein sources. In addition, lysine is one of the amino acids involved in growth processes and is known to act together with arginine to increase the activity of the latter (Furuya et al., 2023). Its normal level in the local feed clearly explains the better growth rates recorded. Similarly, the better growth recorded with the tested feed can also be justified by the optimal level of phenylalanine, which is within the recommended range (NRC, 2011), an amino acid capable of increasing the growth rate of catfish (Furuya et al., 2023). The results indicate that *C. gariepinus* fingerlings efficiently utilized the local feed tested with total replacement of fish meal by the combination of earthworm, maggot and brewer's yeast meal.

Feed is the most expensive input in fish farming, accounting for up to 60% of total production costs (Gangbazo Kpogue et al., 2024). Analysis of the economic parameters showed that the cost of producing one kilogram of fish was 8206 GNF for the local feed, compared with 16708 GNF for the imported control feed. The profit obtained with the local feed was 14373 GNF per kilogram of fish produced, compared with 5875 GNF for the imported commercial feed. This shows the profitability of feeding *C. gariepinus* local feed without fish meal made from local by-products. Nevertheless, for industrial production of local feed T1, electricity, various taxes and transport must be taken into account in determining the production cost per kilogram of feed. The use of these proteins in fish feed helps to recover animal and industrial waste and to clean up the environment by recycling animal and industrial production waste.

The observed difference in survival could be attributed to the digestibility of feed T1, which was formulated using ingredients such as soybean and cottonseed meal. These ingredients contain antinutritional factors, such as gossypol, fibre and tannins (Imorou Toko et al., 2008). These factors lead to poor nutrient absorption or mortality related to digestive disorders.

4 Conclusion

Profitable fish farming requires the use of protein sources other than fish meal. However, large quantities of plant and animal proteins exist that are not used in human food and could partially, or even totally, replace fish meal in fish farming. Here, the results show that the use of local sources of protein (maggots, earthworms and brewer's yeast) as a total replacement for fish meal in the diet of *C. gariepinus* makes it possible to obtain good growth performance and feed utilization with improved profitability. These results are of great interest because they allow us to conclude that feed formulas based on local by-products can be developed without fish meal and fish oil with good performance. Nevertheless, further investigations are required to ascertain the impact of using this local feed on the organoleptic quality of the muscle of the fish produced, as well as the impact of this feed on the reproductive capacity of adult *C. gariepinus*, i.e. on the quality of the gonads of broodstock fed with this local feed.

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