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RESEARCH ARTICLE

EFFECT OF INCORPORATING BLOOD MEAL INTO FEED ON THE GROWTH PERFORMANCE OF CATFISH (*CLARIAS GARIEPINUS*)

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Abstract

Aims: To evaluate the effect of incorporating blood meal into the diet of catfish (*Clarias gariepinus*).
Study design: Experimental study to reduce the cost of fish feed.
Place and Duration of Study: a 63-day trial was carried out at the aquaculture experimentation unit of University of Kara, in Togo, from May 28 to July 30, 2024.
Methodology: After a two-week acclimation period, 120 juvenile catfish, with an average weight of 138 ± 0.9 g, were distributed in 2.5 m³ tanks at a density of 20 fish per happa, in triplicate. These fish were fed two isoprotein pellet diets with 42% crude protein, containing 30% blood meal (A1) and 40% blood meal (A2), respectively; they were hand-fed three times a day throughout the trial. A control fishing operation was done every week to record analytical parameters and adjust the ration.
Results: At the end of the trial, the results showed that the highest survival rate, 98.3 ± 1.44%, was recorded in fish fed diet A1, which also exhibited a relatively low feed conversion ratio of 2.23 ± 0.11. The economic analysis revealed a gross profit margin of 1382 FCFA for diet A1, compared to a loss of -2208 FCFA for diet A2.
Conclusion: Therefore, it would be advisable to incorporate blood meal into the catfish diet at a rate of 30%.

Introduction:-

Aquaculture is now one of the fastest-growing food production sectors, with an average annual growth rate of 8.8% (FAO, 2020). Global aquaculture production of animal species increased by 2.7% in 2020 compared to 2019, the lowest annual growth rate in over 40 years. Fisheries production reached an all-time high of 179 million tons in 2018, driven by aquaculture, which provided approximately 90 million tons. It then declined slightly in 2019, before recovering very slightly (0.2%) to 178 million tons in 2020 (FAO, 2022). In Togo, with a fish production of around 25,000 tons per year, the country must import between 70,000 and 80,000 tons of fish to meet the needs of this population estimated at nearly 100,000 tons per year based on 13 kg/pers/year (Focus infos, 2020). Faced with this situation, one solution is the development of aquaculture based on species with high growth potential (Béné et al.,

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2015). Among the promising aquaculture species, the African catfish (*Clarias gariepinus*) stands out for its robustness and its ability to adapt to varied conditions and is very popular in many countries (Compaore et al., 2016). Its culture has considerable potential to improve food security and generate income in rural areas. However, this field faces the challenge of the high cost of fish feed (Tacon and Metian, 2008). Indeed, this cost represents approximately 50 to 70% of the total operating cost in fish farming (El-Sayed, 2004). This is due to fish meal which is the main ingredient in fish feed. To reduce the price of complete feeds, it is necessary to search for alternative high protein sources to replace fishmeal (Dasuki et al., 2013). Several studies have been conducted in this direction (Eyongetta and Oben, 2016; MbagwuChioma et al., 2022) on the incorporation of blood meal into catfish feed. The availability of this ingredient locally led to this study, which aims to help improve catfish farming. More specifically, the goal is to compare two inclusion rates and determine the optimal amount of blood meal in the diet of juvenile catfish, assess its impact on their growth performance and carry out an economic analysis of using the experimental feeds.

Materials and Methods:-

Study environment and rearing system:-

The study was conducted at the aquaculture experimentation unit of the Higher Institute of Agricultural Professions (ISMA) at the University of Kara in Togo. This unit is located in commune 2 of the Kozah prefecture; more precisely, in the Pya canton, about 420 km north of Lome, the capital of Togo. For this feeding trial, concrete tanks of 2.5 m³ containing 1 m³ happas and part of an open circuit were used. The water used came from the Togolese Water Company (TdE). This water was stored in a reservoir for 72 hours before being transferred to the rearing tanks. Each tank was supplied with water using a submersible pump from the water reservoir.

Biological material:-

The experiment was conducted on young catfish *Clarias gariepinus* with an average weight of 138 ± 0.9 g. These fish came from the Shalom farm located in Kovié in the Zio Prefecture (Maritime Region, Togo).

Experimental material:-

The trial was carried out with two locally produced isoproteic diets containing 42% crude protein, made from six (6) ingredients, whose composition is shown in Table 1.

Table 1: Formula of experimental diets (g)

INGREDIENTS	A1	A2
Corn	25	32
Roasted soybeans	30	13
Fish meal	10	10
Blood meal	30	40
VMC	3	3
Palm oil	2	2
Total	**100**	**100**

A1 and A2: Diet containing 30% and 40% blood meal, respectively; VMC = Vitamin mineral concentrate

Experimental procedure:-

To assess the effect of incorporating blood meal into the diet on the growth performance of the catfish *Clarias gariepinus*, juveniles of this fish, with an average weight of 138 ± 0.9 g were used. After two weeks of acclimatation, they were distributed in concrete tanks at a density of 20 fish per happa (MbagwuChioma et al., 2022) and fed with two isoproteicpellet feeds containing 42% crude protein in triplicate. These were the local feeds, A1 and A2, containing 30 and 40% blood meal, respectively (Table 1). The fish were manually fed three times a day (8 a.m., 12 p.m., and 4 p.m.), every day for two months, with both feeds at a rate of 2.8 to 2% of the fish biomass. The physicochemical parameters of the water (temperature, pH and dissolved oxygen) were recorded twice a week. Water was renewed once a week. A control fishing operation was carried out once a week to collect data for calculating growth parameters and readjust the ration according to the fish biomass per happa.

Blood meal manufacturing procedure:-

Fresh beef blood was obtained from the Kara slaughterhouse. To prevent the blood from clotting, it was immediately poured into a 25-liter plastic container upon receipt, without any anticoagulant. The production of blood meal followed the procedure of Boma and al. (2020). The blood collected in the container was gently heated for 10 minutes, with a maximum temperature of 100°C. This helps to eliminate germs and evaporate the water. After heating, the blood clots were pressed to extract the water. The dehydrated clots were then dried, ground in a mortar, and sifted to obtain blood meal.

Production of experimental local feeds:-
The production of the experimental feeds followed the procedure of Adjankeand al. (2016). Thus, after sieving and weighing the floury ingredients according to the recipe indicated in Table 1, they were separated into two batches: those containing starch (corn and roasted soybeans) and those without (blood meal, fish meal, and VMC). Hot water was added to the mixture of starch-containing ingredients to gelatinize them. The remaining non-starch ingredients were added and thoroughly mixed. A little water and palm oil were added to the mixture, followed by a manual pelletizer to form pellets that were dried on a tarpaulin in the sun, then harvested and stored in pots for use during the trial.

Analysis parameters:-
To estimate fish growth during the trial, characterize the efficiency of using the different experimental diets, and perform an economic analysis of this trial, the following parameters were calculated (Table 2).

Table 2: Formulas for the analysis parameters of the experiment

Analytical Parameters	Formulas
Production parameters	
WG: Weight Gain (g)	
IDG: Individual Daily Growth (g/d)	
FCR: Feed Conversion Ratio	
S: Survival Rate (%)	
Economic parameters	
DC: One Kilogram of Diet Production Cost (F CFA)	
FC: One Kilogram of Fish Production Cost (F CFA)	
GPM: Gross Profit Margin (F CFA)	

Aiw: Average initial weight; Afw: Average final weight; D: Quantity of feed distributed; Bi: Initial biomass; Bd: Biomass of dead fish; Bf: Final biomass; Ni: Initial number; Nf: Final number. Pi: Price per kg of the ingredient on the local market; ri: Incorporation rate of the ingredient in the feed.

Statistical analysis:-
The effect of blood meal incorporation in *Clarias gariepinus*diet was evaluated by comparing the different production and feed utilization parameters using one-way analysis of variance (ANOVA 1). The Fischer LSD test was used to assess significant differences at the 5% threshold between the different treatments. Statistical analyses were performed using STATISTICA 5.0 software.

Results and discussion:-

Results:-

Water physicochemical parameters
The water physicochemical parameters recorded during the test were temperature, dissolved oxygen, and pH. The mean temperature values were 27.34 ± 0.82 °C for batch A1 and 27.12 ± 0.81 °C for batch A2; the mean pH values were 6.98 ± 0.47 for batch A1 and 6.93 ± 0.37 for batch A2. The dissolved oxygen concentrations were 0.94 ± 0.81 mg/L for batch A1 and 0.78 ± 0.69 mg/L for batch A2.

Growth parameters
The average values of growth parameters according to treatments are presented in Table 3.

Table 3: Average values of growth parameters for different groups of fish subjected to different treatments.

Aliment	Aiw (g)	Afw (g)	Ni	Nf	D (g)	S (%)	WG (g)	IDG (g)	FCR
A1	137.27	215.25^{a}	20.00	19.67^{a}	3443.45^{a}	98.33^{a}	77.98^{a}	1.24^{a}	2.23^{a}
A2	137.92	197.35^{b}	20.00	19.00^{b}	3189.70^{b}	95.00^{b}	59.43^{b}	0.94^{b}	2.75^{b}

A1 and A2: Diet containing 30% and 40% blood meal, respectively;Aiw and Afw: Average initial weight and Average final weight; Ni and Nf: Initial number and final number of fish;D: Quantity of feed distributed; S: Survival rate; WG: Weight gain; IDG: Individual daily growth; FCR: Feed conversion ratio. Numbers in columns with different letters are statistically different ($P < 0.05$).

The survival rate of the different fishgroup at the end of the trial ranged from 95.0 ± 0.0% to 98.3 ± 1.4%. The survival rate was higher in group A1 compared to group A2, with a significant difference between these two groups ($P < 0.05$).

Feed utilization is characterized by the Feed Conversion Ratio (FCR). It was noted that feed conversion was lower in the fish of groupA2 compared to those of group A1, with a significant difference between these two groups ($P < 0.05$).

The Individual Daily Growth (IDG) values of the different fish groups at the end of the trial show that fish in group A1 gained weight daily faster than those in groupA2, with a significant difference between thetwo groups ($P < 0.05$).

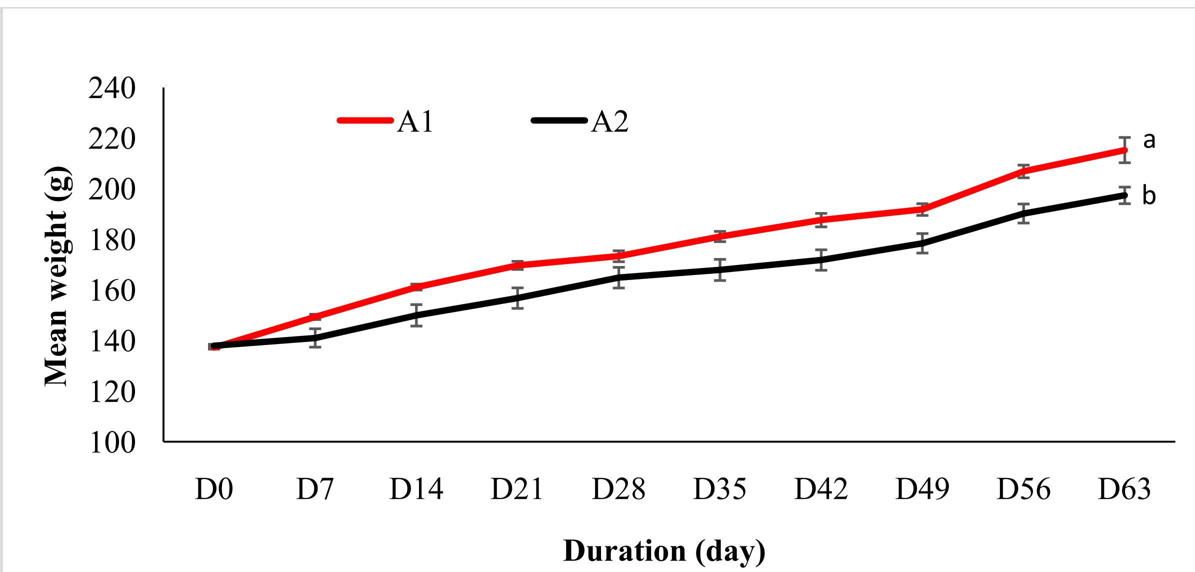

Figure 1: Weight gain of *Clarias gariepinus*batches fed different diets

A1 and A2: Diets containing 30% and 40% blood meal, respectively. Curves with different letters are statistically different ($P<0.05$).

Figure 1 shows the progression of the average individual weight of the fish in the different groups during the trial. Growth was effective in all groups from the beginning to the end of the trial. At the start, the average weight of the fish in both groups was the same. However, from that point until the end, a growth divergence was observed. The fish in group A1 ended up with a higher average final weight than those in group A2 ($P < 0.05$).

Economic analysis of feed Use:-

The cost per kilogram of feed was determined based on the price of raw materials available on the local market and the percentage incorporation of different ingredients in the formula. Thus, after calculation, the local pelleted feed containing 30% blood meal (A1) costs 585 FCFA per kilogram, while the feed containing 40% blood meal (A2) costs 620 FCFA per kilogram. The feed cost of producing one kilogram of fish was estimated by multiplying the price of one kilogram of feed by the feed conversion rate. Thus, one kilogram of fish produced with feed A1 costs 1,305 CFA francs compared to 1,705 CFA francs with feed A2. This calculation shows that producing a kilogram of fish with feed A2 is more expensive than with feed A1.The trial of incorporating blood meal into catfish feed is mainly a production trial. For this, we deliberately ignored other operational costs, only considering the costs of the feed at production value, water pumping, feeding, and control fishing. Table 4 shows the gross profit margin of using the different diets for each group of fish during the trial.

Table 4: Gross profit margin by treatment

Category	A1	A2
Recipe		
Total fish biomass produced (kg)	4,5	2,97
Price per kilo of fish (FCFA)	2500	2500
Total recipe (FCFA)	**11125**	**7425**
Expenses		
Feed (FCFA)	6043	5933
Water pumping (FCFA)	1000	1000
Feeding (FCFA)	1200	1200
Control fishing (FCFA)	1500	1500
Total expenses (FCFA)	**9743**	**9633**
Gross profit margin (FCFA)	**1382**	**-2208**

A1 and A2: Diet containing 30% and 40% blood meal, respectively. Water pumping: using the pump to supply the tanks with water.Feeding: distribution of feed to the fish. Control fishing: weekly water renewal and measurement of fish biomass.

This calculation highlights the economic benefits of using feed A1 instead of feed A2. The A1 diet seems more developed with local by-products, while still maintaining satisfactory growth performance.

Discussion:-

Physicochemical water parameters:-

During the trial, the average values of the water's physicochemical parameters (temperature, pH, and dissolved oxygen) recorded corresponded to the ranges required for optimal growth of catfish. The average temperature recorded during the trial falls within the optimal growth range for catfish according to Hecht (2013). The average pH value recorded was between 6.5 and 9, as recommended by Kanangire (2001) for good growth of *Clarias gariepinus*. The average dissolved oxygen content of the water recorded was low, but it does not affect young catfish because they have a supra-branchial organ that allows them to use atmospheric oxygen (Fagbenro and Sydenham, 1988).

Growth parameters:-

At the end of the trial, the survival rates achieved were well over 90%, which indicates excellent survival—a key factor for the economic viability of aquaculture. Similar studies, like those by Tacon and Metian (2008), reported comparable survival rates using diets enriched with alternative proteins. Additionally, Khalil (2017) achieved survival rates of up to 97% when incorporating animal meal into catfish diets. It is believed that the results obtained in this study are due to the use of blood meal, a highly protein-rich ingredient that is well-liked by this species.Indeed, Gatlin et al. (2007) reported that protein-rich ingredients can strengthen the fish's immune system, contributing to a high survival rate. Growth parameters varied significantly from one diet to another. We observed high growth and relatively low feed conversion ratio in fish fed the A1 diet. According to Tacon and Metian (2008), better feed assimilation promotes not only growth but also muscle development of fish. Studies such as Hossain (2007) have shown similar weight increases with protein-enriched diets, reinforcing the idea that blood meal can be an effective alternative in african catfish diet.

Regarding individual daily growth, the results obtained (0.94 and 1.24 g/day) in this trial were similar to those reported (1.1–1.7 g/day) by Yi and Lin (2001) in integrated cage aquaculture systems. These low daily growth rates could be due to the low water turbidity during the experimental period. In this trial, the recorded feed conversion ratios ranged from 2.23 to 2.75. A FCR below 3 is considered satisfactory in aquaculture, indicating efficient feed-to-biomass conversion. Naylor et al. (2000) reported similar FCRs when using alternative protein meals, supporting the idea that blood meal could be a viable option compared to traditional fish meals.Catfish love protein, but blood meal lacks certain elements (lysine and methionine), which leads to poor absorption in fish fed food containing 40% blood meal compared to those on the other feed. According to Bureau et al. (2000), better protein digestibility leads to lower FCR, which is good for aquaculture profitability. Studies in Cameroon by Eyongetta and Oben (2016) on using blood meal for the growth and mortality of juvenile catfish, with feeds containing 0 to 20% blood meal, showed that growth performance was better in fish fed feed containing 10% blood meal.Moreover, Mbagwu Chioma et al. (2022) conducted a study in Nigeria on the effect of incorporating blood meal into the diet on the zootechnical performance of juvenile *Clarias gariepinus*, with inclusion rates ranging from 0 to 100%. They found that including blood meal at 25% in the fish diet has no negative effect on fish growth. This suggests that low inclusion rates of this ingredient would lead to good growth performance in catfish. At the end of this study, an inclusion rate of 30% proved to be beneficial for the growth and survival of juvenile catfish.

Economic Analysis:-

This section aims to compare the economic results obtained with feeds A1 and A2, which exhibited different growth performances, in order to identify which is the most profitable. Traditionally, farm balance sheets involve preparing an operating statement including total costs and revenues generated (Iga-Iga, 2008). In aquaculture, feed accounts for about 70% of total costs, and its cost is the most significant factor in overall expenses (El-Sayed, 2004). So, this approach allows us to assess the gross margin that each type of feed could generate. By comparing the relatively similar costs with production value, we get a positive gross margin with the feed containing 30% blood meal and a negative one with the feed containing 40% blood meal. From an economic standpoint, the 30% blood meal feed seems to offer the best balance between quality and price compared to the 40% blood meal feed.

Conclusion:-

The main goal of this study was to improve catfish farming by figuring out the optimal amount of blood meal to include in their feed and checking how it affects the growth and economic performance of young catfish. By testing two isoproteic pellet diets with 42% protein, containing 30% and 40% blood meal respectively, the results showed higher survival rates and a relatively low feed conversion rate in the fish fed with the diet containing 30% blood meal, showing the effectiveness of this feed.From an economic point of view, feeding with 30% blood meal offers the best compromise in terms of quality and cost compared to feeding with 40% blood meal. These growth and economic performances highlight the benefits of including blood meal in catfish feed at a 30% rate, which could not only optimize production costs but also improve fish well-being. This study paves the way for innovative feeding practices that could revolutionize catfish aquaculture while addressing current economic and ecological challenges.

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Competing Interests

The authors declare that they have no conflict of interest related to this article.

Authors' Contributions:-

Amakoé ADJANKE is the principal investigator and was involved in all phases of this study, including data analysis and interpretation, and the writing of the article. Nafiou MAHAMADOU conducted the experimentation, data collection, and the initial drafting of the document; Ali Kpatcha KADANGA, Essodolom TAALE and Atti TCHABI contributed to the editing of the article.

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