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Effect of Substitution of Fish Meal by Maggot Meal on Growth Characteristics of *Clarias Jaensis* (Boulenger, 1909)

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Abstract

The aim was to contribute to the valorization of the alternative sources of animal protein. More specifically, it was question to evaluate the effect of substitution of the fish meal by the maggot meal on the survival, growth performances and food production cost of *Clarias jaensis*. To this end, 120 fingerlings were divided in four groups (T0, T1, T2 and T3) repeated 3 times and receiving 0, 50, 75 and 100% of maggot meal. The fish were fed to 5% of ichtyo biomass for 3 months. The treatments did not have any significant effect on survival, FC, SL, LW, WG, ADG and SGR ($P>0.05$). However, the values of the LW (145.12±20.72), WG (104.12±20.72g), ADG (1.16±0.23g) and SGR (1.39±0.14) were higher with T2. The CI (1.46±0.04) of this same treatment were weaker and the condition factor K (1.19±0.22) was higher as compared to other treatment ($P<0.05$). However, the lowest value of the cost of feed consumption and feed production was recorded with the T2 ration (75% of maggots meal) and highest with the control ration T0 (0% of maggots meal) ($P<0.05$). This study revealed that incorporation of the maggot meal in feed increases the growth performances of *Clarias jaensis* fingerlings.

Keywords

Clarias jaensis, survival, fish meal, growth characteristics, maggot meal

1. Introduction

In view of the stagnation of fishery products and the increase in consumption of fish intented for human consumption by 2.4% per year between 1961 and 2017 in developing countries [1], fish farming which is one of the fastest growing animal food producing sector in the world [2] remain an alternative. According to [1], aquaculture accounted for 46% of total production in 2018. Endogenous fish resources like *Clarias jaensis* are essential for sustainable fish farming and therefore for the preservation and enhancement of biodiversity [3]. However, fish farming faces many constraints, including the lack of fry and quality food, coupled with low capital, limited access to appropriate information and lack of market [4]. Food is the most expensive input in intensive fish production (over 50%) and the protein component in the

fish ration remains the most expensive [5]. Thus, in order to obtain economical rations, several tests have been carried out on the substitution of fishmeal with another source of protein, whether of plant origin (cotton flour, soya flour) or animal origin (earthworms, shrimp waste and maggots) [6, 7]. Among these ingredients, maggot meal has proven to be the best alternative [8, 9, 10]. Indeed, its nutritional value especially its crude protein content (42-62%) is comparable to that of fishmeal [11]. In addition, they can be produced using a wide range of household waste [12], animal droppings [13], brewery malting [14] and content ruminal [15, 16, 17]. Its production based on different substrates makes it a source of animal protein available and cheap for fish farming. In addition, the work of [18] showed that maggot meal could completely substitute fish meal without negative growth results, reducing 28% of the cost of production per kilogram of fish.

This work has been initiated with the general objective of contributing to the development of alternative sources of animal protein. More specifically, the aim was to evaluate the effect of maggot meal on the survival rate, growth performance and food production cost of *Clarias jaensis.*

2. Material and Methods

2.1 Zone of the study

The trial took place in the west region of Cameroon and at the Application and Research Farm (FAR) of the University of Dschang (LN 5 °44'-5 °36 'and 5 °44'-5 °37'; LE 10 °06'-9 °94 'and 10 °06'-9 °85' at an altitude of 1392 -1396 m.

2.2 Production of maggots

An enclosure on stilts and rectangular was built at the FAR of University of Dschang with local material (bamboo, shutters and tarpaulins polyethylene paper). The enclosure measured 6 m long and 3 m wide, the height of the walls was 30 cm. The sides of the enclosure supported by planks and bamboos were slightly open to allow good ventilation and flies circulation. The floor was lined with shutters and the roof consisted of a bamboo frame and covered with a tarpaulin made of polyethylene paper. The substrate used was pig manure (35-40 kg) collected on the ground in a pigsty in the town of Dschang. The rearing device consisted of a plastic strainer of 3 mmmesh containing 2 kg of substrate + 10% of bovine blood collected in a 10-liter seal immediately after slaughter and then sealed and transported to the FAR. The strainer was put inside a bowl that was intended to collect the maggots that passed between the meshes. The opening and the bottom of the strainer had a diameter of 26 cm and 10.5 cm while the opening and bottom of the bowl were 28 cm and 11 cm.

Harvests were carried out after seventh day by the filtration method which consists to place the maggot production device in the sun. The maggots fleeing the sunlight pass through the mesh of the strainer and fall into the bowl. Maggots remaining in the substrate were harvested by hand sorting after spreading the substrate in small quantities on other empty strainer. The collected maggots were then immobilized in hot water and dried in a locally manufactured dryer at 60 ℃ to constant weight [14]. The dried maggots were ground by hand grinding to be incorporated into the feed.

2.3 Animal material

Clarias jaensis fingerlings of average size 16.49 ± 1.87 cm and average weight 41 ± 13.46 g, were capture in the natural environment of Santchou and transported in breeding bucket to the study site. The fish were acclimatized for two weeks in the 1 m^3 concrete tanks. During this period, they were fed ad libitum with a standard diet (3A) containing 40% of protein and consisting of wheat bran, soybean meal and fishmeal [19].

2.4 Experimental diet

Four experimental rations were formulated corresponding to treatments T0, T1, T2 and T3 respectively containing 0; 50; 75 and 100% maggot meal. The bromatological compositions and nutritive values of the different diets are shown in Table 1.

120 fish were randomly divided into four comparable groups (L1, L2, L3 and L4) of 30 animals and repeated 3 times. At each group were assigned the treatments T0, T1, T2, T3.

The trial was conducted in 12 polystyrene happa of 1 m^3, mounted in a pond of 102.20 $m^2$and a depth of 0.90 m. The happas were separated from one another by a distance of about 0.5m. The study pond was filled with water from a lake located at 150 m. The daily ration was 5% of the fish ichthyo biomass of each happa. The food was distributed twice at 8:00 am and 6:00 pm during 90 days. 40% of fish from each group were randomly taken each month, measured and weighed individually respectively by an ichtyometer and SF-400 balance (1g precision) to evaluate growth characteris-

tics and adjust the amount of food to distribute.The daily inspection of the happas allow to count the dead fish and to clean the biofouling every 2 weeks to ensure the renewal of water. In order to avoid the dispersion of food during the distribution and to maximize its consumption, a floating hoop under which was placed a bowl to collect the refusals was placed in each happa.

Table 1. Composition of experimental diets

Ingredients (kg)	T0 (0%)	T1 (50%)	T2 (75%)	T3 (100%)
Maize	8	12	12	10
Wheat bran	12.5	5	5	5.5
Manioc meal	1.5	1	1	1
Maggot meal	0	7	10.5	14
Fish meal	14	7	3.5	0
Blood meal	5	5	6	6
Cottonseed cake	10	10	7	8
Soybean meal	36	18	9	0
Shell meal	0	1	1,5	1.5
Bone meal	1	1	1	1
Kitchen salt	0.5	0.5	0.5	0.5
Palm oil	2.5	2.5	2	2.5
Flesh concentrate 5%	5	5	5	5
Total	100	100	100	100
Chemical composition (%/DM)				
Crude protein	40.6	40.0	40.19	39.99
Metabolize energy (Kcal/kg)	2779.0	2730.5	2716.8	2725.0
Calcium	1.7	1.8	1.86	1.72
Phosphorus	1.05	1.12	1.21	1.28
E/P	68.4	68.0	67.59	68.15
Ca /P	1.6	1.55	1.54	1.34
Cost (fcfa)	373	365.50	366.75	356.35

Flesh concentrate 5% content : Crude proteinmin 40% ; Lysine 3.30% ; Methionine min 2.40% ; Calcium min 8.00% ; Phosphorus min 2.05% ; M.E 2078 Kcal/kg ; min= minimum.

2.5 Survival rate and growth characteristics

- Survival rate (%)

$$Sr = \frac{Nf}{Ni} x\ 100$$

Nf: final number of fish, Ni: Initial number of fish;

- Food Consumption (g)

$$FC = Fd - Re$$

FC: food consumption, Fd: food distributed, Re: refusal

- Weight gain (g)

$$wg = wf - wi$$

Wg: Weight gain, Wf: final average weight, Wi: initial average weight;

- Average daily gain (g.d^{-1})

$$ADg = {}^{wg}/_{T}$$

ADg: Average daily gain,Wg: Weight gain (g), T: duration of the assay (day);

- Specific growth rate (%. d^{-1})

$$SGR = \frac{[\ln(wf) - \ln(wi)]x100}{T}$$

SGR: Specific growth rate, wf: final average weight, wi: initial average weight, T: duration of the assay (day);

- Consumption Index (CI)

$$CI = {}^{FC}/_{wg}$$

FC: food Consumption, wg: weight gain

2.6 Economic evaluation

The financial evaluation of the ration was made on the basis of the prices of the different ingredients on the market and the cost of production of the kg of maggots.

- Cost of food consumption = Cost of kg of food x Food consumption
- Cost of food production = Cost of food consumption x Consumption index

2.7 Statistical Analysis

Data on survival, growth characteristics, production costs, and physico-chemical parameters of water were subjected to one-way analysis of variance (ANOVA). When there were significant differences between the means, they were separated by the Duncan test at the 5% significance level. Statistical Package for Social Sciences SPSS 20.0 were used for these analyzes.

3. Results

Table 2 summarizes the effect of fish meal replacement by maggot meal in the feed on the survival and growth performance of *Clarias jaensis*. Except the condition factor K and the consumption index, all other parameters were not significantly affected (P>0.05) by the substitution rate of the maggot meal in the food. The condition factor K of the T2 treatment was significantly higher than that of the other treatments that remained comparable with each other. The consumption index was significantly (P<0.05) lower with this same treatment.

We can observe from Figure 1 that food consumption tends to decline with the incorporation of maggot meal into the ration. Even though no significant difference (P>0.05) was recorded between treatments. The trend of the monthly evolution curves of the consumption is identical in all the groups. However, the curve of animals receiving the T1 ration containing 50% maggot meal remained below that of the rest of the study period. The standard length was higher with the same ration.

Figure 2 illustrates the monthly change in fish weight based on the level of substitution of fishmeal in the diet. It appears that weight has increased steadily throughout the study regardless of treatment. However, the T2 diet containing 75% maggot meal induced a higher live weight at the end of the test. The weight curve of the fish receiving the T0 ration remained below that of the other groups during the first two months of the study and in the third month it joined the T1 and T3 treatment curves containing 50 and 100% of the meal maggots respectively.

The effect of fishmeal replacement by maggot meal on the weight gain, average daily gain and specific growth rate of *Clarias jaensis* show that these characteristics was higher with treatment T2 and lower with treatment T3 containing respectively 75 and 100% of maggot meal. The K factor was also significantly (P<0.05) higher with treatment T2 but lower with T1.

The best consumption index was registered with T2 containing 75% of fish meal. Figure 3 shows monthly evolution of the consumption index of *Clarias jaensis* in function of the level of substitution of fishmeal by maggot meal in the diet. It is observed that the profile of the T1, T2 and T3 diet curves was identical. However, during the third month, the consumption index curve of the T0 ration remained below that of all other diets, contrary to that of the T3 ration which remained above.

Table 3 show the effect of the level of substitution of fish meal by maggot meal on the cost of food consumption and food production cost of *Clarias jaensis*. The substitution of fishmeal by maggot meal significantly influenced (P<0.05) the cost of food consumption and production food consumption. Indeed, the ration T0 (0% of the maggot meal) had a cost of food consumption and production food consumption significantly (P<0.05) higher compared to that of other rations. In addition, the T3 ration (100% maggot meal) that showed low fish growth was significantly (P<0.05) lower in

terms of the cost of food consumption compared to other treatments. However, the lowest production food cost was obtained with the T2 ration (75% fishmeal) while that of the T1 treatments (50% of maggot meal) and T3 (100% of maggot meal) were comparable.

Table 2. Growth characteristics of *Clarias jaensis* in function of treatment

Growth characteristics	Level of maggot meal				P
	T0 (0%)	T1 (50%)	T2 (75%)	T3 (100%)	
Survival rate (%)	100 ±0.00[a]	100 ±0.00[a]	100 ±0.00 [a]	96.67 ±5.77 [a]	0.441
FC(g)	156.52 ±1.46 [a]	147.88 ±2.82[a]	152.33 ±3.86 [a]	150.53 ±6.88 [a]	0.168
Wi (g)	32.75 ± 9.64 [a]	42.25 ±10.24 [a]	32.00 ±10.39 [a]	48.50 ±3.70 [a]	0.404
Wf (g)	135.50 ±32.49 [a]	129.95 ±5.90[a]	145.12 ±20.72 [a]	129.07 ±21.03 [a]	0.358
SLi (cm)	15.38 ±1.49 [a]	16.85 ±1.81 [a]	15.13 ±1.32 [a]	17.65 ±0.53 [a]	0.560
SLf (cm)	23.06 ±2.08[a]	23.41 ± 0.79[a]	23.08 ± 1.65 [a]	22.73 ±2.07[a]	0.903
WG	94.60 ±32.34 [a]	88.95 ±5.90[a]	104.12 ±20.72[a]	88.07 ±21.03[a]	0.355
ADG (g/j)	1.05 ±0.36[a]	0.99 ±0.06[a]	1.16 ±0.23[a]	0.98 ±0.23[a]	0.355
SGR (%)	1.30 ±0.26[a]	1.28 ±0.05[a]	1.39 ±0.14[a]	1.26 ± 0.19[a]	0.353
K	1.11 ±0.24 [b]	1.01 ±0.07[b]	1.19 ±0.22[a]	1.12 ±0.20[b]	0.000
CI	1.65 ±0.01[a]	1.66 ±0.03[a]	1.46 ±0.04[b]	1.69 ±0.05[a]	0.000

a and b: the means with the same letter on the same line are not significantly different (P>0.05). P= Probability, SGR = Specific growth rate, SLi =initial standard length, SLf = Final standard length, FC = Food consumption, ADG = Average daily gain, CI = Consumption index, K = Condition factor.

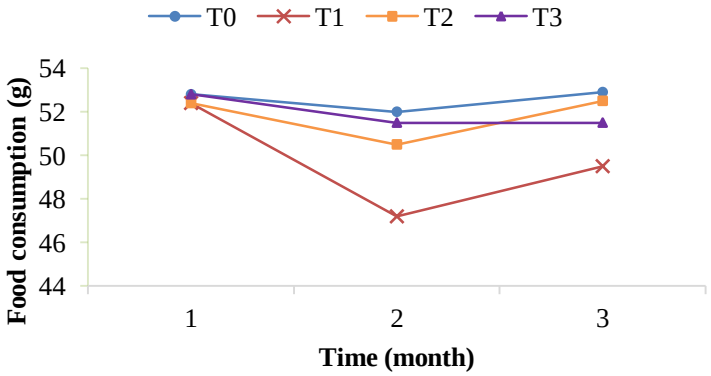

Figure 1. Monthly evolution of food consumption in function of the level of substitution of fish meal by maggot meal.

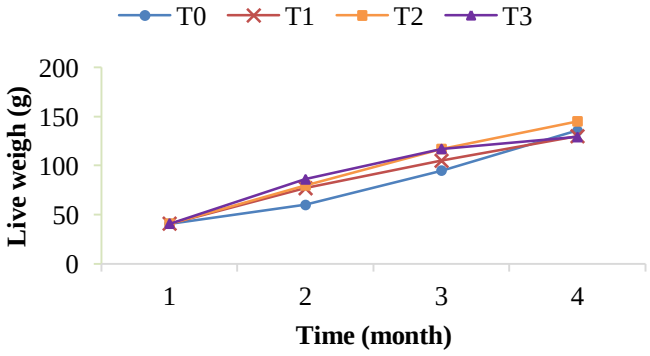

Figure 2. Monthly evolution of live weight in function of the level of substitution of fish meal by maggot meal.

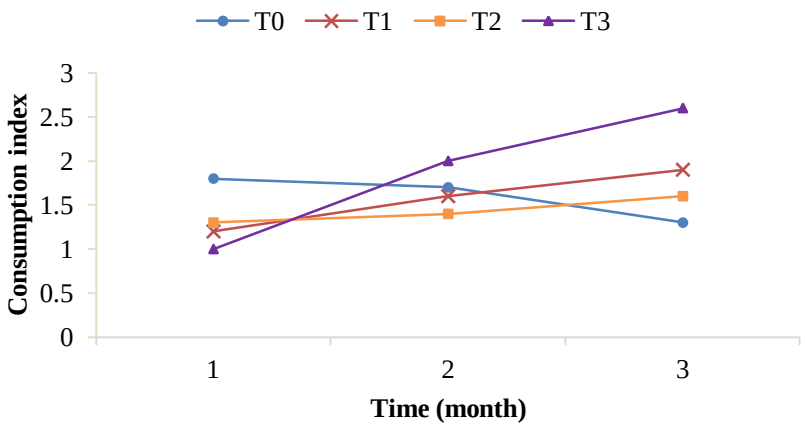

Figure 3. Monthly evolution of food consumption in function of the level of substitution of fish meal by maggot meal.

Table 3. Cost of food consumption and food production of *Clarias jaensis*

Economic	Level of maggot meal				
characteristics	T0 (0%)	T1 (50%)	T2 (75%)	T3 (100%)	P
CFC	58.38 ±0.54^{a}	54.11 ±1.01^{b}	55.91 ±1.42^{b}	53.07 ±1.70^{b}	0.004
CFP	96.61 ±1.80^{a}	89.97 ±3.38^{a}	81.83 ±4.13^{b}	89.89 ±5.72^{a}	0.014

a and b: the means with the same letter on the same line are not significantly different (P>0.05). P= Probability, CFC = Cost of food consumption, CFP = Cost of food production

4. Discussion

The survival rate was high in all treatments except T3 where it was 96.67%. These results are similar to those obtained by [20] who reported survival rates ranging from 73.3 to 100% in Nile tilapia fed on a feed containing maggot meal. The low survival rate with T3 treatment is thought to be due to the action of piscivorous birds at the beginning of the trial and not to the diet.

Food consumption was not significantly affect by the substitution of fish meal by the maggot meal but was lower (147.48) with T1 treatment than other treatments where it remained comparable between them. On the other hand, the consumption index was significantly (P<0.05) lower (1.46) with the T2 ration (75% of maggot meal) compared to the T0, T1 and T3 rations. These results translate a better valorization of the T2 food by *Clarias jaensis* fingerlings compared to other treatments. [20] found similar results for *Oreochromis niloticus* fed rations containing maggot meal. In addition, [21] reported the best consumption index for *Oreochromis niloticus* with the ration containing fish meal that was 100% substituted with maggot meal.

The highest values of live weight, weight gain, average daily weight gain and specific growth rate although mostly insignificant (P>0.05), were recorded with the T2 diet containing 75% maggot meal followed by the control diet T0 without maggot meal. These results are comparable to those reported by Olaniyi and Salau (2013) in *Clarias gariepinus*. This can be explained by the high level of crude protein 40-61.4% in maggot meal associated with its good amino acid profile favoring the growth of fish as well as its high fiber content makes it easily digestible [22, 23]. Note however that these results are contradictory to those obtained by [24] and [21] who found that the fingerlings of *clarias gariepinus* and *Oreochromis niloticus* had significantly higher weights and specific growth rates (P <0.05) with feed containing 100% of maggot meal. According to [22] maggot meal contains proteins whose biological value is close to that of peanut cake and soy flour. A combination of maggot flour with these ingredients as a partial replacement for fish meal would be reasonable and would achieve good results. The lower data on live weight, weight gain, average daily gain and specific growth rate were observed with T1 and T3 diets (50 and 100% maggot meal). These low values may be due to the high fiber content of the maggot meal used and/or the presence of certain anti-nutritional factors present in the ration. Contrary to the results obtained in this work, some authors have reported that maggot meal induces good growth at 50% [22] while others have achieved good performance at 100% [21]. This difference may be related to the production process of maggots (drying and substrate used). However, weight gains in this study regardless of treatment are below that obtained by [5] in *Clarias gariepinus* expose to diets containing 0, 50 and 100% of maggot meal. The specific growth rates were also lower than those obtained by [24] for the same species. These poor performances are

due to the breeding system used, the other ingredients used and especially the temperature. In fact, the temperatures recorded during this study were lower (21 ℃) than the standard (27-32 ℃) recommended by [25] for a good growth of catfish.

Condition factor K, which reports fish overweight, was greater than 1 regardless of treatments. However, it was significantly higher ($P<0.05$) with T2 treatment (75% maggot meal). These values obtained show, according to [26] that the fish were in good condition throughout the period of the test.

The dietary production and food consumption costs of maggot meal diets were significantly ($P <0.05$) low compared to non-maggot meal diets. The high costs (58.38 and 96.61 FCFA) of the ration T0 (0% of maggot meal) are due to the presence of a large quantity of fishmeal (14%) which generally represents the protein component the most expensive (450 FCFA/kg). However, the T2 diet had significantly lower ($P <0.05$) food production and consumption costs than other diets. This result is correlated with its relatively lower consumption index (1.46). [7] recorded similar results in *Clarias gariepinus* fed a feed containing maggot meal. According to Alphonsus *et al*. (2009) maggot meal is an alternative source of viable protein that reduces the production cost of catfish. For [18], the replacement of fish meal with 50% and 100% maggot meal reduces the production cost per kilogram by approximately 18 to 28% due to the low cost of this ingredient.

5. Conclusion

At the end of this study on the effect of fish meal replacement by maggot meal on the growth performance of *Clarias jaensis*, we can conclude that survival and growth performance were not significantly affected by the treatments except the condition factor k and consumption index. However, the growth characteristics were better with T2 treatment (75% of maggot meal). Regardless of the level of substitution of fishmeal, maggot meal tends to reduce the feed cost of *Clarias jaensis*. Thus, the T2 diet containing 75% maggot meal induced the lowest cost of production compared to other treatments.

6. Recommendation

We can recommend that fish farmers substitute fish meal with 75% maggot meal to improve growth performance and reduce the feed cost of *Clarias jaensis*.

7. Perspective

Work will have to be done to study the effect of maggot meal on the histology and organoleptic characteristics of *clarias jaensis.*

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