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The effect of incorporation of maggot protein in the diet on the zootechnical and financial parameters of tilapia *Oreochromis niloticus* at the juvenile stage

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ABSTRACT: The conclusions of studies on the incorporation of maggot meal in fish feed and its impact on zootechnical parameters are controversial due to the protein content of maggots varying from one author to another. The aim of this study was to evaluate the effect of maggot protein in the feed on the growth performance of tilapia *Oreochromis niloticus* fry at the juvenile stage during 75 days of rearing. The study involved the incorporation of maggot protein at different rate into the diet of 0.8 ± 0.1 g Nile tilapia reared in a concrete tank. Three diets (D20, D30 and D40) with maggot protein contents of 20, 30 and 40% respectively, competing with a local industrial reference feed (RD) ALIMPOI, were randomly applied in duplicate to the fish. The initial rationing rate applied was 20% the first month, 15% the second month and 10% the third month. The survival rates (Ts) were 99.89 ± 0.9, 98.96 ± 0.65, 99.59 ± 0.41 and 99.91 ± 0.7% respectively for RD, D20, D30 and D40 diet. The results obtained show that the best growth and feed efficiency performances were obtained with the RD (45.80g) and D40 (44.32g) diets. Maggot protein incorporated at 40% in Nile tilapia feed improves its growth performance (45.80 ± 8.93, 24.73 ± 5.37, 24.75 ± 4.66 and 44.32 ± 7.97 g, respectively for RD, D20, D30 and D40 diets). The use of feed containing maggot meal generated respective production cost reduction rates of 47.53, 53.65 and 64.67% for D20, D30 and D40 compared to the reference feed.

KEYWORDS: fish, ciclidae, growth, feeding, fly larvae protein.

1 INTRODUCTION

Global production of captured and farmed fish is currently estimated at around 178 million tonnes, including 87.5 million tonnes for aquaculture [1]. As a result, aquaculture has become an essential alternative for increasing fish production and meeting the animal protein needs of the world population.

In the aquaculture sector, the production of Nile tilapia is experiencing impressive growth, making it, after salmon and shrimp, the third most successful aquaculture product in international trade ([2], [3]). Since 1988, the contribution of *Oreochromis niloticus* has increased more than 1.6 times, from 45% to more than 70% in 2010 [4]. In 2018, the total aquaculture production of Nile tilapia was approximately 4.53 million tonnes (8.3% of the total global aquaculture production) [5]. This is thanks to its hardiness, the quality of its flesh, which is well appreciated by consumers, and it's very interesting aquaculture potential. Furthermore, this species has extreme dietary plasticity and uses almost all the food offered to it. However, the use of cereal bran in its raw state results in low feed efficiency and therefore low fish yield [6]. The low fish productivity generated by the use of cereals and their raw by-products is due to the presence of high levels of non-assimilable elements and significant food losses [7]. In addition, high-performance imported feeds providing a complete diet for fish are produced in developed countries. Thus, the high cost of these imported feeds (40 to 60% of the production cost) [8] and the irregularity of their availability make the development of fish farming difficult in developing countries [9]. The high cost of these foods is due to the increasing price of fish meal and oil on the international market [10]. These constraints have directed research in recent years towards alternative sources of protein, notably maggot flour. Partial or complete replacement of fish meal or oil with that of black soldier fly larvae allows equivalent results to be obtained ([11], [12]). For these authors, maggot flour has a composition similar to that of fish. The objective of this study was to determine the best rate of incorporation of maggot proteins in the diet of juvenile Nile tilapia. It should allow to conclude on the interest of using this rate of incorporation of maggot proteins in the diet to increase the growth of fish.

2 MATERIALS AND METHODS

2.1 EXPERIMENTAL DIETS

In this experiment, three diets were formulated from local by-products and the maggot protein. Maggots used to formulate the diets were produced from blowflies (Calliphoridae), kept captive in dome-shaped mosquito nets. A solar dryer made from a Chinese bamboo device covered with a transparent plastic sheet was used to dry the maggots. The three formulated diets were designated as D20, D30 and D40 (containing respectively 20, 30, and 40% of the maggot protein rate). The test diets were compared to a locally produced industrial reference diet (RD) (ALIMPOI). The proximate composition of experimental diets was shown in Table 1. These raw materials, made up of agricultural and industrial by-products, were purchased from feed producers in the commune of Yopougon in Abidjan. All diets were prepared according to the method of [13].

Table 1. Proportion (%) of ingredients used in experimental diets

Ingredients	Diets		
	D20	**D30**	**D40**
Soybean meal	51.5	43	36.0
Copra cake	5.5	5.5	3.0
Cotton meal	15.0	15.0	14.0
Low rice flour	3.0	3.5	7.5
Wheat bran	6.5	6.0	4.0
Maggot flour	17	25.5	34
Palm oil	0.75	0.75	0.75
Seashell four	0.25	0.25	0.25
Salt	0.25	0.25	0.25
Premix	0.25	0.25	0.25
TOTAL	**100**	**100**	**100**

D20 = Diet with 20% maggot protein and 80% vegetable protein; D30 = Diet with 30% maggot protein and 70% vegetable protein and D40 = Diet with 40% maggot protein and 60% vegetable protein.

Composition per 2.5 kg of premix: Vitamin A = 10,000,000 IU; Vitamin D3 = 2,000,000 IU; Vitamin E = 6,000 mg; Vitamin K3 = 1,500 mg; Vitamin B1 = 500 mg; Vitamin B2 = 1,500 mg; Vitamin B6 = 800 mg; Vitamin B12 = 5 mg; Vitamin B9 = 1,500 mg; Vitamin B3 = 8,000 mg; Vitamins C = 10,000 mg; Choline Chloride = 100,000 mg; Manganese = 60,000 mg; Cobalt = 100 mg; Zinc = 40,000 mg; Selenium = 100 mg; Iodine = 500 mg; Copper = 3,000 mg; Iron = 40,000 mg; Antioxidant = 30,000 mg

2.2 EXPERIMENTAL CONDITION AND FISH FEEDING

Total of 3200 *Oreochromis niloticus* juvenile (0.8 ± 0.01 g) were used for this study. They were distributed in concrete tanks at stocking density of 60 fry/m^3 and fed with four diets. Daily feed rations were determined based on total biomass and then served in four meals (08 a.m., 11 a.m., 2 p.m., and 5 p.m.). The initial fry ration rate applied was 20% in the first month, 15% in the second month and 10% in the third month. The feeding experiment was for a period of 75 days. Control fishing was carried out every 15 days. Wet weight was determined on an electronic digital balance SARTORIUS L 6200 S (accuracy of ± 0.001 g). The operation consisted initially of evaluating weight from a sample of 30 fish per tank. Food ration was readjusted proportionally to the biomass of the pond.

2.3 WATER QUALITY PARAMETERS

Water quality assessment was carried out using a HANNA portable multiparameter model, type HI 9828. During this operation, physicochemical parameters such as temperature, pH, dissolved oxygen, were recorded in the concrete tanks every other day and three times a day at 06: 00, 12: 00 and 17: 00, before feeding the fish using the method of [14].

2.4 ANALYTICAL METHODS

The feed ingredients, experimental diets and fish samples were analyzed according to [15] for dry matter, crude protein, crude lipid, crude fiber, nitrogen free extract (NFE) and ash. The gross energy contents of the diets and fish samples were calculated using factors of 22.22, 38.9 and 17.2 kJ. g^{-1} of protein, lipid and nitrogen free extract respectively [16].

2.5 MEASUREMENT OF GROWTH PERFORMANCE, FEEDS UTILIZATION PARAMETERS AND ECONOMIC VALUES

Weight Gain (WG) = Final fish weight (g) – Initial fish weight (g)

Average daily Gain (ADG) = Gain (g) / Time (days)

Feed conversion ratio (FCR) = Feed intake (g) / Weight Gain (g)

Protein efficiency ratio (PER) = Weight gain (g) / Protein intake (g)

Survival Ratio (SR %) = (Final fish / Initial fish) × 100

Specific Growth Rate (SGR %) = [(LnFW-LnIW) × 100] / Time (days)

Where FW is the final weight of fish, IW is the initial weight of fish and Ln is natural log.

Feed Used (FU) (kg) = Daily ration (kg) x Rearing time (days)

Cost of Feed Used (CFU) (F.CFA) = Feed Used (kg) × CF (F.CFA)

Where CF is the cost of 1 kg of feed

Production Cost (PC) (F.CFA) /kg fish produced = Cost of Feed Used / Weight Gain (kg)

Reduction Rate (RR. CF) of kg of tested feed compared to control feed (%) = [(Cost of 1 kg control feed – Cost of 1 kg tested feed) ×100] / Cost of 1 kg control feed.

Reduction rate (RR. PC) of feed cost to produce 1 kg of fish (%) = [(Feed cost to produce 1 kg control fish – Feed cost to produce 1 kg tested fish) x 100] / Feed cost to produce 1 kg control fish.

2.6 STATISTICAL ANALYSIS

Results were presented as mean ± SD (standard deviation) for three or two replicates. The statistical analyses were carried out using one-way analysis of variance (ANOVA). The Tukey's multiple range test and Duncan's multiple-range test were used to compare differences among treatment means. Treatment effects were considered significant at $P \leq 0.05$. The analyses were performed using Statistica 7.1 software.

3 RESULTS

3.1 BIOCHEMICAL COMPOSITION OF FORMULATED FEEDS

The approximate biochemical compositions of the different experimental foods are summarized in Table 2. They were determined by calculation considering the biochemical compositions of the ingredients in the literature and those of the maggots in this study. The protein contents of RD, D20, D30 and D40 foods ranged from 30.12% (D20) to 34.56% (RD). The fiber contents ranged from 5.93% (RD) to 7.23% (D20). Lipid contents ranged from 6.67 (RD) to 9.05% (D40). Ash contents ranged from 6.27% (D40) to 6.91% (RD) and moisture contents ranged from 8.74% (D20) to 9.03% (D40).

Table 2. Biochemical composition (% dry matter) of experimental diets

parameters	Diets			
	RD	D20	D30	D40
M	8.87 ± 0.06	8.74 ± 0.08	8.87 ± 0.09	9.03 ± 0.08
CP	34.56 ± 0.12	30.12 ± 0.11	30.17 ± 0.13	30.15 ± 0.10
CL	6.67 ± 0.06	7.44 ± 0.07	7.81 ± 0.07	9.05 ± 0.08
Ash	6.91 ± 0.08	6.48 ± 0.09	6.30 ± 0.07	6.27 ± 0.06
CF	5.93 ± 0.07	7.23 ± 0.09	7.17 ± 0.08	7.18 ± 0.07
NFE	37.06	39.99	39.68	38.32
GE (Kj. g^{-1})	16.64	16.45	16.56	16.80

RD= Reference diet; D20 = Diet with 20% maggot protein and 80% vegetable protein; D30 = Diet with 30% maggot protein and 70% vegetable protein and D40 = Diet with 40% maggot protein and 60% vegetable protein; M = Moisture, CP = Crude protein, CL = Crude lipid, CF= Crude fiber, NFE = Nitrogen free extract

Nitrogen free extract (NFE) = 100 – (% Moisture + % Protein+ % Ash +% Lipid + % Fiber)

GE= Gross Energy = 22.2 × % Protein + 38.9 × % Lipid + 17. 2 × % Nitrogen free extract [16]

CF = Cost of feed

3.2 PHYSICOCHEMICAL PARAMETERS OF WATER

The physicochemical parameters of the water in the tanks collected during the study were presented in the table 3. Water temperatures recorded during the rearing experiments in the different treatments fluctuated from 28.73 ± 1.05°C (D30) to 28.93 ±1.1°C (RD). As for pH, the average values obtained ranged between 7.94 ± 1.38 (D40) and 10.04 ± 1.53 (RD). Dissolved oxygen concentrations ranged from 5.94 ± 2.14 (D20) to 6.49 ± 2.98 mg. L^{-1} (RD). No significant differences (p > 0.05) were observed to the temperature, pH and dissolved oxygen of the pond water.

Table 3. Physicochemical parameters of water recorded in tanks during our study

Parameters	Diets			
	RD	D20	D30	D40
pH	8.41 ± 1.53^{a}	8.30 ± 1.36^{a}	8.02 ± 1.32^{a}	7.94 ± 1.38^{a}
T°C	28.93 ± 1.10^{a}	28.73 ± 1.05^{a}	28.79 ± 1.07^{a}	28.75 ± 1.03^{a}
O2 (mg. L^{-1})	6.49 ± 2.98^{a}	5.94 ± 2.14^{a}	6.30 ± 2.23^{a}	6.18 ± 2.26^{a}

Each value is the mean ± Standard deviation. Means with the same letters in the same row are not significantly different (p>0.05). ANOVA and Duncan's multiple-range test.

3.3 GROWTH PERFORMANCE AND FEED UTILIZATION

The results of growth parameters (average final weight, average daily weight gain, specific growth rate) and feed processing (apparent feed conversion ratio, protein efficiency coefficient) as well as survival rate are presented in the table 4. The survival rates (Ts) were 99.89 ± 0.9, 98.96 ± 0.65, 99.59 ± 0.41 and 99.91 ± 0.7% respectively for RD, D20, D30 and D40 diet. There was no significant difference between the four diets (P > 0.05). After 75 days of rearing, the mean final weights were 45.80 ± 8.93, 24.73 ± 5.37, 24.75 ± 4.66 and 44.32 ± 7.97 g, respectively for RD, D20, D30 and D40 diets. The mean daily weight gains were 0.6 ± 0.12 g for RD, 0.32 ± 0.07 g for D20, 0.31 ± 0.07 g for D30 and 0.58 ± 0.11 g for D40. Calculated weight-specific growth rates (SGR) ranged from 4.5 ± 0.27 (D20) to 5.36 ± 0.27%/day (RD). The multiple comparison test (Tukey's HSD test) showed that the RD and D40 diets gave significantly higher growth parameters (P ≤ 0.05) than the other diets. However, there was no significant difference (P > 0.05) between the D20 and D30 diets. The tested foods were characterized by significantly lower mean apparent consumption index values for the RD (0.8 ± 0.17) and D40 (0.84 ± 0.18) diets and higher for D20 (1.07 ± 0.22) and D30 (1.02 ± 0.19). The mean values of protein efficiency coefficients ranged from 3.22 ± 0.72 for the D20 diet to 4.34 ± 0.85 for the RD diet. The RD and D40 diets remained significantly different from the D20 and D30 diets.

Table 4. Growth performance, survival rate, feed conversion ratio and protein efficiency ratio at juvenile stage of Oreochromis niloticus

Parameters	Diets			
	RD	D20	D30	D40
SR (%)	99.89 ± 0.59	98.96 ± 0.65	99.59 ± 0.41	99.91 ± 0.7
IW (g)	0.80 ± 0.01	0.80 ± 0.01	0.80 ± 0,01	0.80 ± 0.01
FW (g)	45.80 ± 8.93^{a}	24.73 ± 5.37^{b}	24.75 ± 4.66^{b}	44.32 ± 7.97^{a}
WG (g)	45.00 ± 8.93^{a}	23.93 ± 5.37^{b}	23.95 ± 4.66^{b}	43.52 ± 7.97^{a}
ADG (g/day)	0.60 ± 0.12^{a}	0.32 ± 0.07^{b}	0.31 ± 0.07^{b}	0.58 ± 0.11^{a}
SGR (%/day)	5.36 ± 1.27^{a}	4.50 ± 1.97^{b}	4.56 ± 1.24^{b}	5.26 ± 1.26^{c}
FCR	0.80 ± 0.17^{a}	1.07 ± 0.22^{b}	1.02 ± 0.19^{b}	0.84 ± 0.18^{a}
PER	4.34 ± 0.85^{a}	3.22 ± 0.72^{b}	3.38 ± 0.66^{b}	4.07 ± 0.78^{a}

RD= Reference diet; D20 = Diet with 20% maggot protein and 80% vegetable protein; D30 = Diet with 30% maggot protein and 70% vegetable protein and D40 = Diet with 40% maggot protein and 60% vegetable protein

Each value is the mean ± Standard deviation; Means has the different letters in the same row are significantly different at p = 0.05. ANOVA and Tukey's multiple tests.

3.4 Biochemical Composition Of Carcass

The biochemical composition of the juvenile tilapia *Oreochromis niloticus* carcasses at the end of the feeding experiments were presented in the table 5.

After 75 days of rearing, no significant differences were observed between the moisture, ash, protein, lipid, and energy contents of the carcasses of fish fed with the different experimental diets. The carcass protein content was higher in fish fed with RD (51.11 ± 0.17%) and D40 (50.83 ± 0.31%) and do not present any significant difference ($p > 0.05$). The lowest carcass protein contents were recorded with fish fed with D20 and D30 (49.47 ± 0.15% and 49.82 ± 0.17% respectively). The results of statistical analyses showed that the lipid contents of the carcass were significantly identical in the diets RD (16.85 ± 0.15%) and D40 (17.91 ± 0.12%). As for the ash contents of the carcasses, they varied from 18.85 ± 0.16% (D20) to 20.43 ± 0.13% (RD). The energy contents of the fish carcasses were between 17.90 (RD) and 18.25 kJ. g^{-1} (D40).

Table 5. Carcass chemical composition of fish used for our study

Parameters	Diets			
	RD	D20	D30	D40
Moisture	76.87 ± 0,15^{a}	77.08 ± 0.17^{a}	76.97 ± 0.18^{a}	77.15 ± 0.16^{a}
Crude protein	51.11 ± 0.17^{b}	49.47 ± 0.15^{a}	49.82 ± 0.17^{a}	50.83 ± 0.31^{b}
Ash	20.43 ± 0.13^{b}	18.85 ± 0.16^{a}	19.21 ± 0.17^{a}	19.42 ± 0.16^{ab}
Crude lipid	16.85 ± 0.15^{a}	18.65 ± 0.14^{b}	18.22 ± 0.15^{b}	17.91 ± 0.12^{ab}
GE (Kj. g^{-1})	17.90^{a}	18.06^{a}	18.14^{a}	18.25^{a}

Each value is the mean ± Standard deviation. Means with the same letters in the same row are not significantly different (p>0.05). ANOVA and Duncan's multiple-range test.

GE= Gross Energy = 22.2 × % Protein + 38.9 × % Lipid + 17. 2 × % Nitrogen free extract [16]

3.5 Cost-Benefit Analysis

The costs of the different experimental feeds are summarized in the table 6. The costs in FCFA per kilogram of the experimental feeds were 780, 305.98, 283.51, and 261.66 for the RD, D20, D30 and D40 feeds respectively. The highest value was obtained for the RD feed and the lowest for the D40 feed. The use of maggot meal helped to reduce the cost per kilogram of the formulated feed. Compared to the reference feed (RF), the observed values generated a reduction rate of approximately 60.77% for D20, 63.65% for D30 and 66.45% for D40. The production costs (PC) per kilogram of fish were respectively 624 FCFA.kg-1 (RF), 327.39 FCFA.kg-1 (D20), 289.18 FCFA.kg-1 (D30), and 219.79 FCFA.kg-1 (D40). The highest value was obtained for fish fed with RD feed and the lowest for D40 feed. The use of feed containing maggot meal generated respective production cost reduction rates of 47.53, 53.65 and 64.67% for D20, D30 and D40. Regarding the time required to produce (PT) one gram of live weight, it was 1.66 (RD), 3.13 (D20), 3.13 (D30) and 1.8 days (D40).

Table 6. Evaluation of feed costs and fish subjected to test diets

Parameters	Diets			
	RD	D20	D30	D40
CF (FCFA/Kg)	780	305.98	283.51	261.66
CFU (FCFA/Kg)	624	327.39	289.18	219.79
RR. CF/AR (%)	-	60.77	63.65	66.45
RR. PC/AR (%)	-	47.53	53.65	64.67

CF= Cost of 1 kg of feed; CFU = Cost of feed used; PC= Production cost of 1 kg of fish;
RR. CF/RD = Reduction Rate of CF compared to reference diet (RD); RR. PC/RD = Reduction Rate of PC compared to reference diet (RD).

4 Discussion

Water quality was maintained within the recommended limits for the culture of freshwater tilapia *Oreochromis niloticus*. Indeed, the pond water temperatures recorded during the culture experiments ranged from 28.73 ± 1.05 (D20) to 28.93 ± 1.10°C (RD). These values were similar to those obtained by [17] which were between 27.30 ± 0.80 and 29.40 ± 0.80°C. As for the pH values recorded, the average values obtained ranged between 7.94 ± 1.38 (D40) and 8.41 ± 1.53 (RD), these values were higher than those of other authors ([18], [17]) obtained in studies prior to ours. This observed difference could be explained by the use of running water (SODECI) in the present study. However, these results remain within the recommended limits which is 25 to 35°C for temperature [19] and 5 to 11 for pH [20]. The dissolved oxygen concentrations were between 5.94 ± 2.14 (D20) and 6.49 ± 2.98 mg. L^{-1} (RD) these data were consistent with those of [21] whose values oscillated between 4.4 to 6.1 mg. L^{-1} with an overall average of 5.19 ± 0.92 mg. L^{-1}.

The use of maggot meal does not appear to affect the Survival rate of fry receiving the test rations. The survival rate (98.96 ± 0.61 to 99.91 ± 0.7%) of our results was higher than those of [22] as well as [23] whose values ranged from 89.4 to 94.4%. The results of the present study were similar to those of [24] who obtained a rate varying from 95 to 100% in juveniles of *Lates niloticus* fed with soybean meal. But lower than those of [25] who obtained results of 100% survival on tilapia *Oreochromis niloticus* fed for 60 days. The values of the final average weight after 75 days of testing were 45.80 ± 8.93, 24.73 ± 5.37, 24.75 ± 4.66 and 44.32 ± 7.97 g, respectively for RD, D20, D30 and D40 foods. These average weights were higher than those of [26] who obtained 17.25 g after three months, as well as [18] whose weights ranged between 25.60 g and 31.57 g. The good growth of the fish could be explained by the presence of maggot protein in the feed, unlike the two tests mentioned above, whose feed inputs consisted solely of agricultural by-products. Daily weight gains in the present study were 0.6 ± 0.12 g for RD, 0.32 ± 0.07 g for D20, 0.31 ± 0.07 g for D30 and 0.58 ± 0.11 g for D40. These daily increases were higher than those in pond studies (0.28 g/d – 0.35 g/d) by [22]. The good growth performance of subjects receiving the D40 diet (0.58g/day) similar to the reference diet (0.6g/day) would justify that the incorporation rate of maggot protein at 40% in the diet of Tilapia *Oreochromis niloticus* is the best, as mentioned in other research at larval stage [27]. Indeed, the D40 diet boosted the growth of fry thanks to good digestibility of maggot protein. However, these results differ from those of [22] who recorded good performance when maggot flour was incorporated at 50%. Indeed, unlike the work [22], this study consisted of evaluating the effect of maggot protein and not flour on the growth parameters of *Oreochromis niloticus* in the pre-fattening phase. In addition, the protein value of maggot flour can vary from one author to another, depending on the nature of the production substrate, the time of harvesting the larvae and the drying system [28]. As for the specific growth rate (SGR), our tests (4.5 to 5.36%/day) are superior to those of [22] which recorded values varying from 0.04 to 0.05%/day and to those of [25] which obtained an SGR varying from 0.83 to 0.90%/day. With respect to feed conversion indices (FCR), the present results (0.8 to 1.07) were better than those (1.02 – 4.58) recorded in work carried out in concrete tanks [29] against 2.8 to 6 in [22]. These low indices highlight the high digestibility of maggot proteins by Nile Tilapia fry.

The results of the biochemical composition of fish carcasses showed that the ash and protein content increased with the high incorporation rates of maggot protein in the different diets. The minerals provided by maggot meal in feed would be very well utilized and retained by *Oreochromis niloticus*. Similar results were obtained with this species by [30]. Regarding proteins, the incorporation of maggot protein in feed did not affect the protein contents of fish carcasses. The reference [31] report the same results in this species. The lipid contents of fish carcasses decrease with high rates of maggot protein incorporation, conversely those of energy increase. The high lipid contents obtained in fish fed with D20 and D30 diets influenced the energy retained and daily lipid gain of the fish.

Analyses of the various financial costs related to feeding showed that the use of feed containing maggot protein resulted in economic gain and satisfactory growth performance thanks to good digestibility of maggot proteins. The use of D20, D30 and D40 feeds generated a saving in feed cost (feed cost to produce one kilogram of fish) by respective rates of 47.53, 53.65 and 64.67%, compared to the RD reference. The results of this work are in line with those of previous works which recorded reduction rates of 63.34 to 70.48% [18] and 13% - 21% [31]. Compared to the RD reference, the D40 feed offers the best quality/price ratio and helps to enhance fish growth while producing at a lower cost compared to the other two (D20 and D30), thanks to its good nutritional quality. In tropical fish farming, the high-performance D40 feed could therefore be the one that optimizes economic results and fish production performance.

5 CONCLUSION

At the end of this study, the maggot protein allowed good growth in the zootechnical performance of the tilapia *Oreochromis niloticus* at the pre-fattening stage. It therefore appears that maggot meal can completely replace fish meal in the diet of tilapia *Oreochromis niloticus*. In addition, feed containing maggot protein has led to a reduction in the cost of fish production. Finally, the best results recorded with the D40 diet in terms of impact on zootechnical performance and on the reduction of fish production costs, allow it to be retained as the ideal rate of incorporation in the diet of Nile tilapia, Brazilian strain.

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