Study of the substitution of marine animal oils in maggot flour by vegetable oils for the growth and larval survival of African catfish, *Heterobranchus longifilis* Valencienne, 1840 in aquarium

ABSTRACT

This study showed clearly the effect of adding palm oil to the diet of farmed fish to replace marine animal oils. For this purpose, four foods based on maggot meal at 35% protein with the incorporation of palm oil, at différent levels at 0, 2, 5 and 10% were tested with the aim of evaluating the improvement of the growth performance, feed utilization, survival rate and composition larvae of *Heterobranchus longifilis*.
Four experimental diets were formulated based on the maggot meal as the main protein source. These diets were formulated at 35% protein levels with maggot meal and maize flour as the major ingredients containing different concentrations of palm oil levels at 0, 2, 5, and 10%. This study was carried out in the reproduction laboratory, at Oceanological Research Center, Abidjan, Côte d'Ivoire, between the periods of September to November 2022.
The diets were offered to the larvae (initial mean weight 0.004 ± 0.001g) three times per day *ad libitum* for 49 days. The results showed that the quality of the environment has not been influenced by the different treatments. The best growth was obtained with the larvae subjected to diet containing 2% palm oil with a final average weight of 3.21 g and a conversion index of 1.63. Beyond this rate, larval growth decreases. Survival rates vary from 70 to 73%. The conversion ratios are not significantly different and ranged between 1.63 and 2.3. On the biochemical larvae submitted to diet containing 10% of palm oil had body lipid content (2%) and high ash rich. As against a gain of protein is observed with larvae submitted to diets containing 2% palm oil reflects an effect of protein.
From the present results, diet containing 2% crude palm oil is considered optimal for *Heterobranchus longifilis* larvae.

Keywords: Substitution, marine; Palm oil; Heterobranchus longifilis; larvae; growth; body composition.

1. INTRODUCTION

The fisheries and aquaculture perform for food security, nutrition for economic growth. It contributes to the existence of more than one in ten people in the world [1]. Fish arouses great interest in the fight against food security. Many countries in the world have opted to fight malnutrition through the development of aquaculture and the protection of fishery resources in order to provide a balanced diet. In Africa more than 50% of animal protein consumed comes from aquatic food products [1]. Indeed, the flesh of the fish contains quality animal proteins including certain essential lipids. Fish is also full of essential minerals such as iodine, zinc, iron, phosphorus, selenium, calcium, potassium and also vitamins A, B and D. Faced with the decline in fish products indicating a decline in fish stocks and the galloping demography of the population, the development of aquaculture remains the only alternative to satisfy the increasingly growing demand for fish products. However, the rapid development of fish farming is exerting strong fishing pressure on certain marine wild fish species called forage species [1]. Indeed, these forage species are the major inputs in the formulation of fish feed. Linked to the development of fish farming, the manufacture of aquaculture feed is clearly progressing. Faced with drastic reductions in natural resources, the development of sustainable fish farming linked to the high demand for fish feed necessarily requires the search for inputs or alternative raw materials in the formulation of fish feed. This leads to the introduction of high-performance functional fish feed likely to improve zootechnical parameters, but limit an impact on the environment and on animal species [2]. In Côte d'Ivoire, feeding trials with agricultural by-products to replace certain inputs of marine origin such as *Artemia salina* nauplii in the larval rearing of *Heterobranchus longifilis* and *Clarias gariepinus* have been initiated. However, the rapid development of fish farming is exerting strong fishing pressure on certain marine wild fish species called forage species [1]. Indeed, these forage species are the major inputs in the formulation of fish feed. Linked to the development of fish farming, the manufacture of aquaculture feed is clearly progressing and reached more than 87 million tonne in 2020 [1]. Faced with drastic reductions in natural resources, the development of sustainable fish farming linked to the high demand for fish feed necessarily requires the search for inputs or alternative raw materials in the formulation of fish feed. This leads to the introduction of high-performance functional fish feed likely to improve zootechnical parameters, but limit an impact on the environment and on animal species [2]. In Côte d'Ivoire, feeding trials with agricultural by-products to replace certain inputs of marine origin such as *Artemia salina* nauplii in the larval rearing of *Heterobranchus longifilis* and *Clarias gariepinus* have been initiated. Can be listed among other eggs boiled chicken and yeast [3], bovine brain crushed [4-5] and meal maggot [6]. All these tests, the use of maggot meal enriched with minerals, vitamin premix and amino acids in the diet of the fish larvae, allowed to have a weight gain of 2.99 g 49 days' supply [6], much higher than the weight gain of 1.10 g obtained with larvae *Heterobranchus longifilis* with feed *Artemia salina* [4].

Moreover, during the last decade, in order to improve the growth of farmed fish, fish feed formulation is increasingly oriented towards increasing the content of dietary lipids [6]. However, with the rapid development of aquaculture, marine fish oil, lipid main source frequently used in fish feed, causes over exploitation of certain marine species and is less preferred to the detriment of vegetable oils [7]. Indeed, the use of these inputs poses serious threats to natural resources oil. To this end, recent studies have shown that vegetable oils (palm oil , coconut , peanut ...) can be used as substitutes energy in fish feed without adverse effects on the growth there of [8-9]. Among these vegetable oils very good growth performance were recorded with the use of palm oil in the diet of catfish *Clarias gariepinus* [10-8].

In this study, we therefore propose to evaluate the influence of different rates (0%, 2%, 5%, and 10%) of palm oil in food iso-protein (35%) made from maggot meal enriched in minerals, vitamin premix and amino acids on the growth and survival of larvae *Heterobranchus longifilis*.

2. MATERIALS AND METHODS

2.1 Characterization of raw material used

The maggot meal used in this study was processed from maggots cultured from poultry droppings and fish carcass [11]. All feed-grades ingredients including maize flour, palm oil, lysine, methionine, vitamin, amino acid premix and compounded mineral such as iron, chloride and phosphorus were purchased from local markets in Abidjan (Côte d'Ivoire). The proximate composition of maggot meal, maize flour and palm oil are given in Table 1.

Table 1: Composition of the ingredients used in the experimental diets

Ingredients (%)	Maggot meal	Maize flour	Palm oil
Protein	42.00 ± 1.14	9.50 ± 0.87	-
Lipid	28.95 ± 0.90	5.22 ± 1.00	100
Ash	8.10 ± 1.10	1.63 ± 0.06	-
Fiber	5.89 ± 0.42	2.64 ± 0.12	-
Nitrogen free extract (NFE)	15.06 ± 1.13	81.01 ± 1.18	-

2.2 Experimental Diets

Four iso-protein experimental (35% protein) diets containing different levels of crude palm oil (0, 2,5 and 10%) were prepared based on maggot meal as the main protein source. These diets were formulated at the linear programming based formulation constraints of experimental diets (35% protein with 0, 2, 5 and 10% palm oil).Crude palm oil was used as lipid source. The maize flour was used as a source of carbohydrate and to adjust the protein content of the food formulated with

35% of proteins. These free raw materials were combined in different proportions (Table 2). Lysine and methionine were added at a level of 2.00 and 2.13% respectively to meet the nutritional requirements of the *Heterobranchus longifilis* larvae. Phosphorous, iron and chloride were added at 0.67% level. Vitamin and amino acid premix were included at 2% level to obtain 100 g of a mixture. The feed ingredients were ground using a homogenous mixture grinder. Diets were processed by blending the dry ingredients manually and carefully for 15 min. Water (800 mL.kg-[1]) at 80ºC was added to the mixture during the blending process and mixed for 15 min. The paste obtained was dried in electric oven at 60ºC for 48 hours, crushed into fine powder and passed through a fine mesh screen. Then, the experimental diets at 250-300 µm size were stored at -20ºC until use.

- 0PO: Diet with 0% Palm Oil
- 2PO: Diet with 2% Palm Oil
- 5PO: Diet with 5% Palm Oil
- 10PO: Diet with 10% Palm Oil

The experiment was carried out in the reproduction laboratory, at Center of Oceanological Research, Abidjan, Côte d'Ivoire. African *Heterobranchus longifilis* larvae used in this study were obtained by using the procedure of reproduction already established (Legendre, 1986). Three days after hatching, a total of 600 *H. longifilis* larvae with an average weight of 4.00 ± 1.00 mg were equally distributed over 12 glass aquaria (38.5 x 46.5 x 28 cm^3) stocking 50 larvae per aquarium (1 $larva.l^{-1}$). All aquariums were filled with filtered freshwater and aerated. Before starting the trial, fish were acclimated to experimental condition for 4 days.

2.3 Feeding

After this period, the four treatments were assigned randomly in triplicates to the aquaria and larvae were fed *ad libitum* (100% total biomass). Three times a day (08:00, 13:00 and 17:00 h), rations of the experimental diets were weighed and distributed several times throughout the day during 49 days. Every day, the dead larvae were removed from aquaria and counted. Three times a week, undigested food particles and waste products were siphoned out before feeding fish, and uneaten food particles were regularly dried and weight for feed conversion ratio calculation.

2.4 Physico-chemical parameters of water

Water temperature, dissolved oxygen and pH were monitored during rearing period. Water temperature was recorded daily using a mercury thermometer suspended in each aquarium. Dissolved oxygen, and pH were recorded daily at 7.30 h using Oxy meter (WTW OXI 330) and pH meter (WTW pH 330) respectively.

2.5 Weighing and Measurement

During the feeding period, every week, the total weight using a precision balance 0.01g and number of fish were measured in each aquarium with a ruler to adjust the feed ration. Data (weight, length, number) collected were used to estimate survival, larval growth during the experiment and to characterize the efficiency of feed utilization by the larvae through the calculation of production parameters. At the end of the experiment, all fish were collected, counted and individually weighed. Then, 30 larvae were removed from each replication to chemical composition determination.

Table 2: Formulation and proximate composition of the experimental test diets dietary level (%)

	Experimental diets			
Ingredients (g)	0PO	2PO	5PO	10PO
Maggot meal	80.76	81.50	82.2	81.15
Maize meal	11.50	8.76	5.06	1.11
Crude palm oil	0.00	2.00	5.00	10,00
Méthionine	1.61	1.61	1.61	1.61
Lysine	2.13	2.13	2.13	2.13
Phosphorus	0.67	0.67	0.67	0.67
Iron	0.67	0.67	0.67	0.67
Chlorine	0.66	0.66	0.66	0.66
VMD-Amin'total (Premix)	2.00	2.00	2.00	2.00

Total fat (%)	100	100	100	100
Proximate analysis				
Moisture (% DM)	10.71	10.67	10.01	10.76
Crude fiber (% DM)	5.53	5.54	5.53	5.57
Ash (% DM)	7.25	7.25	7.25	7.24
Crude protein (% DM)	35.06	35.01	35.00	34.99
Crude Lipid (% DM)	24.05	26.05	29.06	33.56
Nitrogen free extract (NFE) (% DM)	17.40	15.78	12.52	8.81
Gross energy (kJg-1)3	20.13	21.13	21.23	22.16

***0PO**= Experimental diet without palm oil; **2PO** = Experimental diet with 2% palm oil; **5PO**= Experimental diet with 5 % palm oil; **10PO** = Experimental diet with 10 % palm oil.*

AMIN'TOTAL is a complex vitamins; amino acids and trace elements; 1Composition for 1 kg of premix : Vitamin A = 10000 UI; Methionine = 50.0 mg; Vitamin D3 = 3000 UI, Vitamin E = 2500mg, Vitamin B1 = 5000 mg; Vitamin B2 = 500mg, pantothenic Calcium = 5000 mg; Vitamin B6 = 2500mg; Vitamin C = 10000mg; Vitamin K3 = 4000 mg, folic Acid = 250 mg; Sodium chloride 70 000 mg; Potassium chloride 15 000 mg; PP 2000 mg; Amino acids 17 000 mg (Amino acids: Lysine, Methionine, Threonine, Arginine, Tyrosine, Valine, Cystine, Tryptophan, Glycine Serine, histidine, leucine, isoleucine, phenylalanine); Nitrogen-free extract (NFE) =100 - (% protein + % lipid + % moisture + % ash + % fiber); Gross energy = % protein x 22.2 kJ/g +% lipid x 38.9 kJ/g + % Nitrogen-free extract x 17.2 kJ/g; P/E = Protein to energy ratio in g protein /kJ gross energy.

2.6 Growth Indices and Nutrient Utilization

The growth indices and nutrient utilization parameters were calculated for each treatment as follows:

Body weight gain (BWG) (g) = final body weight - initial body weight;

Daily weight gain (DWG) (g/day) = (final body weight - initial body weight)/(number of day);

Specific Growth Rate (SGR) (%/day) = [In (final body weight) – In (initial body weight)] x 100/number of day;

Feed Conversion Ratio (FCR) = total weight of feed consumed (g)/wet biomass gain (g), total weight of feed consumed is obtained by total feed distributed fewer uneaten food;

Protein Efficiency Ratio (PER) = weight gain (g)/protein intake (g);

Survival Rate (SR) (%) = (final number of larvae/initial number of larvae) x 100

Cannibalism Rate (CR) (%) = (number of larvae missing/initial number of larvae) x 100;

Mortality Rate (MR) (%) = (number of dead larvae/initial number of larvae) x 100.

2.7 Biochemical Analysis

The approximate composition of experimental diets and the fish carcasses sample were determined according to the Association of Official Analytical Chemists [12]. Moisture was determined after oven drying (105ºC) for 24 h (MEMMERT Drying Oven, GE-174, Memmert GmbH, and Heilbronn, Germany). Ash was measured by incineration at 550ºC in a muffle furnace for 24 h (Thermo Fisher Scientific Heraeus M 110 Muffle Furnace, Waltham, MA, USA). Crude protein was determined using micro-Kjeldahl method, N% x 6.25 (Kjeltech autoanalyzer, Model 1030, Tecator, Höganäs, Sweden), crude fat by soxhlet extraction with hexane (Soxtec System HT6, Tecator), crude fiber by acid digestion followed by ashing the dry residue at 550ºC in muffle furnace for 4 h. The gross energy contents of the diet and fish were calculated on the basis of their crude protein, total fat and carbohydrate contents using the equivalents of 22.2, 38.9 and 17.15 kj g^{-1}, respectively (Luquet and Moreau, 1991).

2.8 Statistical Analysis

Results were statistically analyzed with a one-way analysis of variance (ANOVA) using Statistica version 7.1 software packages. Duncan's multiple range tests was used to compare difference between treatments means when significant F-values were observed. All percentage and ratio data were arc-sin transformed before analysis (Zar *and et al*.1984). The treatment effects were considered to be significant at p<0.05. Non-transformed data are presented in Tables to simplify comparisons.

3. RESULTS

3.1 Water Quality

Water quality parameters during the 49-days experimental period were observed to be normal for all aquaria (Table 3). The average values of oxygen dissolved different culture environments range from 5.80 ± 0.42 to

5.86 ± 0.58 mg/l. Furthermore, the average values of the temperature range from 28.21 ± 0.34 and 28.31 ± 0.27°C. As for the pH, the average values are between 7.13 ± 0.39 and 7.25 ± 0.29

Table 3: Oxygen, temperature and pH contents of aquariums containing larvae of *Heterobranchus longifilis* fed with diets formulated from maggot flour at different levels of palm oil.

Parameters	Experimental diets			
	0PO	2PO	5PO	10PO
Oxygen (mg/l)	5.86 ± 0.58[a]	5.80 ± 0.42[a]	5.81±0.51[a]	5.82 ± 0.53[a]
Temperature (°C)	28.25 ± 0.29[a]	28.21 ± 0.34[a]	28.31 ± 0.27[a]	28.3 ± 0.43[a]
PH	7.25 ± 0.46[a]	7.22 ± 0.14[a]	7.13 ± 0.39[a]	7.24 ± 0.25[a]

0PO= Experimental diet without palm oil; **2PO** = Experimental diet with 2% palm oil; **5PO**= Experimental diet with 5% palm oil; **10PO** = Experimental diet with 10% palm oil. Values with the same exponents on the same line are not significantly different, ANOVA (p> 0.05)

3.2 Growth Performance

Growth parameters such as final weight (FBW), weight gain (WG), average daily gain (DWG) and specific growth rate (SRG) are presented in Table 4.

The highest final weight was observed in larvae fed 2% with a value of 3.21 ± 0.56 g . As against, low final weight of 2.01 ± 0.18 g is observed larvae fed with 10%. As for the final lengths, the mean values ranged from 65.54 ± 10.47 mm and 57.18 ± 7.91 mm. Average weight gains ranged from 3.21 ± 0.56 to 2.018 ± 0.17 g. The gain of the highest weight is observed in larvae fed with 2% and the lowest recorded is larvae fed with 10%. In average daily gain, larvae fed with 2% better average daily gain with a value of 0.07 ± 0.012 g/d. Where as larvae fed with 10% had the lowest average daily gain with a value of 0.04 ± 0.004 g/d. As regards the specific growth rate, mean values ranged from 13.63 ± 0.38 and 12.70 ± 0.18% /day. The highest specific growth rate was observed in larvae fed 2%. The lowest specific growth rate is recorded with larvae fed 10%. The average values of final weight, weight gain, the average daily gain, specific growth rates were significantly higher (p < 0.05) in larvae fed with 2%. Reverse against small values of these parameters were recorded among larvae fed with 0 and 10% palm oil.

The growth ratio between the larvae feed with the 0HP food and the other batches of larvae showed that the addition of 2% palm oil in the maggot meal made it possible to increase the growth of the larvae by 1.56 times. On the other hand, the supply of 10% (10HP) had no effect on the growth of the larvae (Table 5).

Table 4: Growth performances fed of *Heterobranchus longifilis* different levels of palm oil

Parameters	Experimental diets			
	0PO	2PO	5PO	10PO
IBW (g)	0.004 ± 0.001[a]	0.004 ± 0.001[a]	0.004 ± 0.001[a]	0.004 ± 0.001[a]
FBW (g)	2.07 ± 0.09[a]	3.21 ± 0.16[b]	2.95 ± 0.08[b]	2,02 ± 0.18[a]
WG (g)	2.06 ± 0.39[a]	3.21 ± 0.56[b]	2.95 ± 0.28[b]	2.01 ± 0,17[a]
DWG (g/day)	0.04 ± 0.01[a]	0.07 ± 0.01[b]	0.06 ± 0.01[b]	0.04 ± 0.01[a]
SGR (% day^{-1})	12.75 ± 0.41[a]	13.60 ± 0.38[b]	13.47 ± 0.21[b]	12.70 ± 0.18[a]

0PO*= Experimental diet without palm oil;* ***2PO*** *= Experimental diet with 2% palm oil;* ***5PO****= Experimental diet with 5 % palm oil;* ***10PO*** *= Experimental diet with 10 % palm oil.*
IBW = initial body weight, FBW = final body weight, WG = weight gain (g), DWG = daily weight gain (g day-1), SGR = specific growth rate (% day-1). Values with the same exponents on the same line are not significantly different, ANOVA (p> 0.05)

Table 5: Index of influence of palm oil content on the growth parameters of *Heterobranchus longifilis* larvae fed with four experimental iso-protein diets

Parameters	Influence index		
	2PO/0PO	5PO/0PO	10PO/0PO
FW (g)	1,55	1,43	0,97
WG (g)	1,56	1,43	0,98
ADW (g/d)	1,56	1,50	1,00

3.3 Nutrient utilization Indices

At the end of 49 days of experiment, the mean values of the index feed conversion ratio (FCR) and protein efficiency ratio (PER) larvae *Heterobranchus longifilis* fed the different experimental diets are reported in Table 5.

The observation of this table shows that the average values of the index of consumption vary between 1.63 ± 0.7 and 2.3 ± 0.11. The low value of FCR is recorded in larvae fed 2%. As against, the highest value is obtained among larvae fed with 10 %.

As for the PER, this table showed that the mean values ranged from 1.24 ± 0.06 and 2.11 ± 1.2. These average values of PER are obtained respectively with the larvae fed on the diet containing 10% palm oil and those fed the diet containing 2% palm oil. However, the values of FCR and PER recorded are not statistically different (p> 0.05) regardless of the content of palm oil contained in the experimental diet distributed to larvae.

3.4 Survival, Cannibalism and Mortality

Average survival rate (SR), cannibalism rate (CR) and mortality rate (MR) of *H. longifilis* larvae fed with the different dietary of palm oil levels are shown in Table 4. This table shows that the rate of cannibalism recorded with different batches of larvae fed with different experimental diets, ranging from 14.57 ± 3.06% for larvae fed the diet containing 5% palm oil and 17 ± 2.62% with larvae fed the diet containing 2% palm oil. As for mortality, the average values vary between 12 ± 1.77% obtained with larvae fed 0% palm oil and 14.43 ± 2% obtained with larvae fed with 10% oil palm.

The survival rates vary from 70 ± 5.80% for larvae fed like containing 2% palm oil and 73 ± 3.46% with larvae fed with 5% palm oil. These three parameters are not significantly different (p> 0.05) regardless of the content of palm oil contained in the experimental diet distributed to larvae.

Table 6: Growth performance, nutrient utilization and survival rate of larvae *Heterobranchus longifilis* fed the experimental diets

Parameters	Experimental diets			
	0PO	2PO	5PO	10PO
FCR	2.08 ± 0.30	1.63 ± 0.70	1.73 ± 0.43	2.30 ± 0.11
PER	1.39 ± 0.20	2.11 ±1.20	1.71 ± 0.40	1.24 ± 0.06
CR (%)	17.33 ± 2.08	17.00 ± 2.62	14.67 ± 2.31	14,57± 3.06
MR (%)	12.00 ± 1.77	13,00 ± 2.00	12,33 ± 3.06	14,43 ± 2.00
SR (%)	70.67 ± 1.72	70.00 ± 5.80	73.00 ± 3.46	71.00 ± 2.31

0H*= Experimental diet without palm oil;* ***2HP*** *= Experimental diet with 2% palm oil;* ***5HP****= Experimental diet with 5% palm oil;* ***10HP*** *= Experimental diet with 10 % palm oil. FCR = feed conversion ratio, PER = protein efficiency ratio, CR = cannibalism rate, MR = mortality rate, SR = survival rate. Mean values ± SD in the same row sharing the same superscript are note significantly different (P < 0.05).*

3.5 Proximate Composition of larvae

At the end of rearing, the average values of the biochemical composition of larvae *Heterobranchus longifilis* fed different experimental diets are shown in Table 7. The mean values of the humidity varies between

74% to 30 ± 0.03 larvae fed with 10% and 75.24 ± 0.64% for larvae fed with 0% palm oil . The moisture contents of larvae fed 0% palm oil were significantly higher ($p<0.05$) compared to those fed with the feed containing 10% of palm oil.

Contents Nitrogen-free extracts (NFE) larvae ranged from 3.64 ± 0.06% for larvae fed with diets containing 10% palm oil and 4.52 ± 0.61% for larvae fed the food containing 0% of palm oil. Contents NFE larvae fed the diet containing 0% palm oil are significantly higher ($p <0.05$).

Against by the ash content of the larvae at the end of breeding follow the opposite trend of the NFE and vary between 2.93 ± 0.03% for larvae fed with food 10% and 2.54 ± 0.02% for larvae fed a diet containing 0% palm oil. The ash content of the larvae fed with diet containing 0% palm oil were statistically higher ($p < 0.05$).

Protein contents ranged from 17.12 ± 0.10% for larvae fed with 10% palm oil to 17.24 ± 0.24% for larvae fed 2% palm oil. The protein content of larvae fed with 2% of palm oil is significantly higher ($p<0.05$) respectively and then following those of larvae fed with 0% and 5% palm oil. The lowest levels of proteins are obtained among larvae fed with 10 % palm oil.

The lipid content of the larvae are between 0.03% ± 0.4 for larvae fed with 0% palm oil 2 ± 0.07% for larvae fed with 10% palm oil . The lipid content of larvae fed with 10% palm oil were statistically higher ($p < 0.05$), followed by fed larvae and 2 to 5% palm oil. Low values of the lipids are obtained in larvae fed with 0% of palm oil.

As for the raw energy of the larvae, it follows the same trend as the lipid content of larvae depending on the food. The energy content of larvae ranged from 4.77 ± 0.12% for larvae fed the diet containing 0% palm oil to 5.20 ± 0.01% for larvae fed with 10% oil palm. The energy content of larvae fed with 10% of palm oil are significantly higher ($p<0.05$), followed by larvae fed with food containing 2 and 5% palm oil. The low values of the energy content are recorded in larvae fed with 0% palm oil.

Table 7: Whole body composition of *H. longifilis* larvae fed different experimental diets (wet-weight basis)

Composition	Experimental diets 0PO	2PO	5PO	10PO
Moisture (%)	75.24 ± 0.64^{b}	74.63 ± 0.26^{ab}	$74,94 \pm 0.03^{ab}$	74.30 ± 0.03^{a}
Protein (%)	17.30 ± 0.02^{b}	17.46 ± 0.05^{c}	17.24 ± 0.02^{b}	17.12 ± 0.10^{a}
Ash (%)	2.54 ± 0.02^{a}	2.82 ± 0.04^{b}	2.66 ± 0.02^{b}	2.93 ± 0.03^{b}
Lipid (%)	0.40 ± 0.03^{a}	1.37 ± 0.03^{b}	1.39 ± 0.04^{b}	2.00 ± 0.07^{c}
Nitrogen free extract (%)	4.52 ± 0.61^{b}	3.71 ± 0.31^{a}	$3,77 \pm 0.06^{a}$	3.64 ± 0.04^{a}
Gross energy (kJg-1)	4.77 ± 0.12^{a}	5.05 ± 0.05^{b}	5.01 ± 0.00^{b}	5.20 ± 0.01^{c}
P/E (g.kJ-1)	3.63 ± 0.09^{c}	3.46 ± 0.05^{b}	3.44 ± 0.01^{b}	3.29 ± 0.02^{a}

***0PO**= Experimental diet without palm oil; **2PO** = Experimental diet with 2% palm oil; **5PO**= Experimental diet with 5 % palm oil; **10PO** = Experimental diet with 10 % palm oil. The gross energy content was calculated by using the conversion factor defined by Luquet nutrients and Moreau (1989): Protein = 22.2 KJ / g, fats = 38.9 KJ / g and non-nitrogenous extractives = 17.2 KJ / g. MF = Dry matter. Values with the same exponents on the same line are not significantly different.*

4. DISCUSSION

The average values of temperature (28.21 ± 0.34 to 28.31 ± 0.27°C), dissolved oxygen (5.80 ± 0.42 to 5.86 ± 0.56 mg / l) and pH (7.13 ± 0.39 to 7.25 ± 0.46) obtained are included in the interval (6.5-9), (27-29°C) (> 2.3 mg/l) respectively for pH, temperature and dissolved oxygen, recommended for good growth of farmed fish [13-14-15].

The results indicate that the growth of the larvae by mass *Heterobranchus longifilis* increases from 0 to 2% of palm oil with 24 to 26% of dietary fat.

The same observation was made by [16-17] with 0.5 to 9% of palm oil respectively in juvenile *Clarias gariepinus* and *Heterobranchus longifilis*. Larvae fed with food 2% palm oil containing 26% of dietary lipids showed the best growth with a final weight of 3.21 ± 0.56 g. This would mean that the palm oil content, the needs of growing larvae *Heterobranchus longifilis* are satisfied. Indeed, fish optimal utilization of dietary lipids beyond which the lipid intake inhibits growth [17-18]. [19-20] reported better growth *Heterobranchus longifilis* respectively 18% and 14% of dietary lipid. Our study shows a rate beyond 26% of dietary fat. This difference could be explained by the fact that these authors used juveniles. Indeed, the larvae were more energy needs for growth and for the development of organs juveniles. The constituent fatty acids have a role and are the main components of phospholipids, the majority of cell membranes and lipoproteins transport components. Moreover, Yao (2012) reported better growth *Heterobranchus longifilis* larvae at a rate of 38.6% of dietary lipids with dried bovine brain. This rate is significantly higher than our results (26% of dietary fat). This could be explained by the nutritional composition of the food and also the quality of dietary fat content in the food. Indeed, the flour has a good nutritional maggot constitution [21-22] and shows no deficit in essential amino acid for the growth of larvae *Heterobranchus longifilis* [21] and also the levels of fatty acids of the n-3 and n-6 respectively 9.1 and 0.2% of total fatty acids present in the oil palm would support good growth [23] and could explain this difference in energy needs. Adding 2 % of palm oil to flour for maggot rate 26 % of dietary fat would be in the optimum proportions for use as an energy source. [10-24] reported similar results in other catfish respectively in *Mytus memurus* and *Clarias gariepinus*.

The difference in larval growth could be explained by the different values of FCR and PER recorded by different groups of larvae. Indeed, even though statistically there is no difference between the different parameters of feed utilization (FCR and PER), the values of FCR (1.63) larvae fed the diet containing 2% oil palm are less than 3.5, maximum indicated for plans of poor quality [25] value. As the average values of PER larvae fed the diet containing 2% palm oil are significantly higher. These larvae appear to have better used proteins. This shows that the food containing 2% palm oil is better suited to the nutritional needs of larvae *Heterobranchus longifilis*. However, the slow growth in larvae fed 10% palm oil (34% of dietary fat) may be due to levels of dietary lipid relatively high content in the food. Similar results were reported by [20] in juveniles (5 g) of the species with different levels of incorporation of palm oil in cereals. Indeed, these authors indicate that in omnivores and tropical freshwater species, excessive increase beyond the threshold of the content of dietary fat, can have negative effects on growth. This has been shown in the common carp, for foods containing respectively 10 and 15% lipids [18]. This reduction in growth is due to the inability of fish to digest and use the excess energy provided [26].

The lipid content did not affect the survival rate. The results recorded in late survival experience are similar to those reported by [27] from 67.77 to 70.15% with larvae sorted once and three times a week with the same species and the same provisions breeding. Food distributed allowed more or less homogeneous growth of the larvae. This may cause low rates of cannibalism.

The biochemical composition of the larvae *Heterobranchus longifilis* was influenced by the lipid content of foods. A change in lipid content and protein is similar to that reported by [17] with juvenile (5 g) of the same species at different levels of palm oil incorporated in cereals. The high content of body lipids of larvae fed 10% palm oil could be explained by the high content of fat in the food distributed. Indeed, if a part is made of lipid substrate for energy supply «alternative proteins" high lipid content in food, leading to lipid deposition in tissues [28]. Lipid deposits were observed in *Clarias gariepinus* after the addition of palm oil in the diet [10]. Other studies have shown that diets containing large amounts of fat lead to changes in body composition characterized by an increase in body fat accompanied by a decrease in the water content [29-30]. This could explain the observed decrease in the function of increasing the fat content of food distributed moisture content. The decrease in body protein of larvae fed with 10% of palm oil is due to high nitrogen losses and a decrease in the gross energy generated by the metabolism of nutrients. Indeed, [28] reported a decrease of the content of plant proteins in *Cyprinus carpio* fed with foods containing a high proportion of fat. As against, the gain obtained with protein larvae subjected to the feed containing 2% of palm oil is due to the protein-sparing effect. Indeed when a food contains most of the energy needed in the form of digestible energy, protein ration are set by the organization. They are therefore not degraded [31].

The high energy content of larvae fed with 10% of palm oil is only a reflection of the high fat contained in the food distributed. [32] made the same observation in *Dicentranchus labrax* and concluded that high energy values contained in the diet result in increased lipid deposits in farmed fish.

CONCLUSION

In conclusion, the present study shows that an intensive rearing up to 49 days with good survival and growth rates can be carried out using diet containing 35% maggot crude protein and 2% crude palm oil for African catfish *Heterobranchus longifilis* larvae. Palm oil may be used in fish diets as an interesting energy source to promote the growth performance and to reduce the feed cost. As a local product available and cheap, palm oil seems to be good alternative for the sustainable development of tropical aquaculture.

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