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Research Article

Survival, Growth Response, Chemical and Biochemical Characteristics of the Carcass of *Clarias jaensis* (Boulenger, 1909) Post Fingerlings Fed Various Dietary Energy

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ABSTRACT

This study aimed to improve the knowledge on the growth of post fingerling *Clarias jaensis* endogenous catfish of Cameroon in order to enhance it. For this purpose, 360 males and females with a mean weight and total length of (97 ± 9 g and 24 ± 1,5 cm) were divided into four comparable groups receiving 13.75 MJ/kg, 14.04 MJ/kg, 15,82 MJ/kg and 16.11 MJ/kg repeated 3 times (15 males and 15 females/repetition). Results shows that the energy level did not have a significant effect on the percent survival, consumption index, and K factor. All other growth characteristics were significantly affected (P<0.05) by the energy level. The highest feed consumption (337.37 ± 5.07 g) was recorded with 16.11 MJ/kg. Live weight (244.41 ± 35.0 g), total length (31.12 ± 2.12 cm), weight gain (146.27 ± 33.86 g), mean daily gain (1.08 ± 0.25 g), specific growth rate (0.67 ± 0.11%/day) and dry matter (31.63 ± 1.55%) where higher in fish fed 14.04 MJ/kg.

The males outperformed the females with regard to all growth characteristics. Lipid content (8.31 ± 0.14%) where higher in the group receiving 16.11 MJ/kg (P<0.05). Protein, ash and all biochemical characteristics of the carcass were not significantly affected (P>0.05) by the energy level.

Keywords: *Clarias jaensis*, Energy, Growth, Post fingerlings, Survival

INTRODUCTION

Due to the growing demand in relation to the population explosion, fishing alone can no longer satisfy the need for fisheries resources in a sustainable way. Indeed, it is limited because of pollution, diseases, climate change, destruction and degradation of habitat by human actions and especially overexploitation that threatens nearly 30% of the fishery resources [1,2]. Aquaculture is proposed as an alternative to remedy this situation. The practice of aquaculture, which continues to grow over the years contributes to preserving natural stocks, repopulating the inland and marine waters [3,4]. It also helps maintain fish consumption and satisfy the protein demand of the world's population, estimated to reach 9 billion in 2050 [5]. Aquaculture is therefore a means of achieving one of the development objectives which is ensuring a sustainable environment through the preservation and enhancement of biodiversity. Despite the diversity of fish resources in Cameroon, the main species raised were introduced. Today, the need to domesticate endogenous farmed aquaculture species that have the advantage of better adapting to environmental conditions is a solution to increase the aquaculture potential, preserve and enhance biodiversity. That is why an interest has been granted to an endogenous fishery resource belonging to the family Clariidae. This family is characterized by its hardiness, omnivorous diet,

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rapid growth (3 g/day) correlated with its ability to efficiently transform the compound feed and its highly appreciated meat [6,7]. The domestication of *Clarias jaensis* requires a knowledge of its farming techniques, particularly feeding, because it accounts for nearly 70% of production costs. In addition, one of the important aspects of nutrition is the determination of nutritional needs. The protein requirements of *Clarias jaensis* and the effect of food energy on growth characteristics of *Clarias jaensis* fingerlings have already been studied [8,9]. However, no work on the determination of its energy requirement from the post-fingerlings size to the commercial size has been recorded. The energy level of the diet regulates feed consumption, affects growth, protein utilization efficiency, and body fat accumulation [10]. It's in this context that, this work was initiated with the general objective of contributing to the best knowledge of endogenous Claridae growth, through the determination of their energy requirements.

MATERIAL AND METHODS

This study is the follow-up to that carried out by on *Clarias jaensis* Fingerlins. Indeed, our research team had carried out a first work on the determination of the energy requirement of fingerlings of *Clarias jaensis* [9]. The difference between this present work and that of lies in the determination of the energy requirements of *Clarias jaensis* from the post-fingerlings size to the commercial size [9]. In this work we also evaluated the effect of food energy level on the chemical and biochemical characteristics of the carcass of *Clarias jaensis*. Therefore, the methodology used in this work is similar to that used by Tsoupou K. S. G [9].

Zone of the study

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

Animal material

360 male and female post fingerlings of *Clarias jaensis* with average weight and average total length of 97 ± 9 g and 24 ± 1,5 cm were captured from those in the natural environment of Santchou and stocked in a breeding pond at the study site. The fish were acclimatized for two weeks in 1 m³ concrete tanks previously. 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 [7].

Experimental diet

Four isoproteic experimental diets were formulated with different energy levels 13.75 MJ/kg, 14.04 MJ/kg; 15.82 MJ/kg, and 16.11 MJ/kg of food (Table 1). The chosen energy levels refer to those of Clarias gariepinus and the principal source of energy was palm oil. The chemical compositions of different diets were analyzed by method [11].

Table 1: Composition of expérimental diets.

	Energy level (MJ/kg)			
Ingredients (g/Kg)	13.75	14.04	15.82	16.11
Maize	280	245	225	203
Wheat bran	60	51	35	38
Cottonseed cake	15	13	10	15
Soybean meal	30	44	60	45
Fish meal	567	570	565	570
Shell meal	1	1	1	1
Bone meal	1	1	1	1
Palm oil	26	55	83	107
Premix 2%	20	20	20	20
Total	1000	1000	1000	1000
Chemical composition				
Crude protein (%)	39.76 ± 0.49	40.06 ± 0.75	40.66 ± 0.37	40.56 ± 0.50
Crude energy (MJ/kg)	13.75 ± 0.10	14.04 ± 0.16	15.82 ± 0.09	16.11 ± 0,11
Crude lipid (%)	7.00 ± 0.00	11.33 ± 0.28	12.00 ± 0.00	15.33 ± 0.57
Ash (%)	2,93 ± 0.05	1.96 ± 0.05	2.70 ± 0.17	2.06 ± 0.05

Fish were randomly divided into four comparable groups repeated 3 times with 15 males and 15 females per repetition. Each group was randomly assigned to one of the experimental rations R_1 (13.75 MJ/kg), R_2 (14.04 MJ/kg), R_3 (15.82 MJ/kg) and R_4 (16.11 MJ/kg).

The trial was conducted in 12 polystyrene happas of 1 m³ (like cages), built in a pond of 100 m² area and depth 0.90 m. This pond consists of a water inlet and outlet pipe and was filled with water from a lake located 150 m away. Note that the happas were cleaned 3 time per week to facilitate the flow of water and therefore, the renewal of water inside the happas. The food was served in a circular floating frame placed on the surface of the water of each happa, distributed twice a day (8 am and 6 pm) in pellet form and representing 3% of the ichtyobiomasse. Below the floating frame was placed a bowl to collect uneaten food. 20% of fish from each group were randomly taken each month and the total length were measure using an ichtyometer. Also, fish sample were weighed individually using SF-400 balance (1 g precision) to evaluate growth characteristics and adjust the amount of food to distribute. Uneaten food were collected every day, sun-dried, and weighed to estimate feed consumption. The physico-chemical parameters of the water (temperature, dissolved oxygen, and pH) were measured weekly and are summarized in Table 2.

Table 2: Physico-chemical characteristics of pond water.

	Temperature	pH	Oxygen
Mean	21,48 ± 0,71	6,70 ± 1,04	3,61 ± 2,57

At the end of the experiment, 24 fish from each group were sacrificed to determine the chemical and biochemical composition of their carcasses.

Percent survival and growth characteristics

Percent survival (%)

sr=fn/in × 100

fn: Final number of fish,

in: Initial number of fish

Food Consumption (g)

FC=Fd-Re

FC: Feed consumption,

Fd: Food distributed,

Re: Refusal

Weight gain (g)

wg=wf-wi

Wg: Weight gain,

Wf: Final weight,

Wi: Initial 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=[ln(wf)-ln(wi)]x100/T

SGR: Specific Growth Rate,

wf: Final weight,

wi: Initial weight,

T: Duration of the assay (day)

Consumption Index (CI)

CI=FC/wg

FC: Food Consumption,

Wg: Weight gain

Chemical and biochemical composition of the carcass

The dry matter content was determined after drying in an oven at 105°C for 24 hours. Protein, lipid and ash content was determined by the method [11].

5 g of flesh of each fish was dilacerated and diluted in 5% of physiological saline (NaCl) and centrifuged at 5000 rev/minute. The homogenate obtained was used to determine total cholesterol, HDLC (High Density Lipoprotein Cholesterol), and TGS (Triglycerides), according to the method described in the notice of kit. Low Density Lipoprotein Cholesterol (LDLC) was obtained using the following formula: LDLC=Total Cholesterol-(HDLC+TGS/5).

Statistical analysis

The data on growth characteristics were subjected to two-way Analysis of Variance (ANOVA) (sex and energy level) and that of chemical and biochemical analysis of the carcass to one-way ANOVA (energy level). When there were significant differences between the means, they were separated by the Duncan test at 5% significance level. SPSS 20.0 statistical software was used for these analyses.

RESULTS

The effects of energy level on percent survival and growth characteristics are shown in Table 3 and illustrated by Figures 1-3. It appears that, except the percent survival and K factor, the growth characteristics were significantly affected by the energy level (P<0.05).

Table 3: Growth characteristics of post-fingerling *Clarias jaensis* in function of energy level.

	Energy level (MJ/kg)				
Growth characteristics	13.75	14.04	15.82	16.11	P
FC (g)	355.11 ± 2.66^{a}	360.61 ± 12.64a	375.93 ± 17.17^{b}	390.98 ± 5.27c	0.00
			LW (g)		
♀	214.00 ± 37.93^{Aa}	214.00 ± 17.51^{Aa}	186.13 ± 35.21^{Aab}	181.00 ± 18.42Ab	0.03
♂	197.75 ± 37.87^{Aa}	263.00 ± 29.70^{Bb}	206.61 ± 33.14^{Aa}	194.50 ± 10.00^{Aa}	0.00
♂♀	203.60 ± 37.94a	244.41 ± 35.08^{b}	200.31 ± 34.45^{a}	190.39 ± 14.18a	0
			TL (cm)		
♀	28.72 ± 1.30^{Aa}	28.63 ± 0.71^{Aa}	27.56 ± 1.74^{Aab}	27.21 ± 1.60 ^{Ab}	0.06
♂	28.71 ± 3.69^{Aa}	32.63 ± 0.85^{Bb}	30.55 ± 1.89 ^{Bc}	29.43 ± 0.83 ^{Bca}	0.00
♂♀	28.72 ± 3.01^{a}	31.12 ± 2.12b	29.63 ± 2.29 ^{a}	28.76 ± 1.50 ^{a}	0
			WG (g)		
♀	122.33 ± 38.58 ^{Aa}	123.36 ± 22.83^{Aa}	94.12 ± 35.69 ^{Aab}	88.57 ± 23.85 Ab	0.04
♂	96.36 ± 40.03 ^{Aa}	160.27 ± 32.17^{Bb}	103.88 ± 36.46 ^{Aa}	92.25 ± 12.47 ^{Aa}	0.00
♂♀	105.71 ± 40.74a	146.27 ± 33.86^{b}	100.88 ± 35.80a	91.13 ± 16.25a	0.00
			ADG (g)		
♀	0.90 ± 0.28 ^{Aa}	0.91 ± 0.16^{Aa}	0.69 ± 0.26 ^{Aab}	0.65 ± 0.17 ^{Ab}	0.04
♂	0.71 ± 0.29 ^{Aa}	1.18 ± 0.23^{Bb}	0.76 ± 0.27 ^{Aa}	0.68 ± 0.09 ^{Aa}	00.0
♂♀	0.78 ± 0.30a	1.08 ± 0.25^{b}	0.74 ± 0.26a	0.67 ± 0.12a	0.00
CI	3.35 ± 1.00^{a}	2.61 ± 0.71^{b}	4.34 ± 1.95^{c}	4.43 ± 0.88^{c}	0.00
			SGR (%)		
♀	0.62 ± 0.14 ^{Aa}	0.63 ± 0.11^{Aa}	0.51 ± 0.15 ^{Aa}	0.49 ± 0.13 ^{Aa}	0.09
♂	0.48 ± 0.16 ^{Aa}	0.69 ± 0.10^{Bb}	0.50 ± 0.15 ^{Aa}	0.47 ± 0.06 ^{Aa}	0.00
♂♀	0.53 ± 0.17^{a}	0.67 ± 0.11^{b}	0.51 ± 0.15^{a}	0.48 ± 0.08^{a}	0.00
			K (%)		
♀	0.89 ± 0.08 ^{Aa}	0.91 ± 0.04 ^{Aa}	0.88 ± 0.10 ^{Aa}	0.90 ± 0.09 ^{Aa}	0.91
♂	0.76 ± 0.10 ^{Ba}	0.75 ± 0.05^{Ba}	0.72 ± 0.06^{Ba}	0.76 ± 0.03^{Ba}	0.25
♂♀	0.81 ± 0.11 a	0.81 ± 0.09 ^{a}	0.77 ± 0.10 ^{a}	0.80 ± 0.08 ^{a}	0.46

Note: ^{a}, ^{b} and ^{c}: The means with the same tiny letter in the same line are not significantly different (P>0.05); A and B: The means with the same capital letter in the same column are not significantly different (P>0.05); P=Probability, LW=Live Weight, TL=Total Length, FC=Feed Consumption, WG=Weight Gain, ADG=Average Daily Gain; CI=Consumption index, SGR=Specific Growth Rate, K=Condition factor.

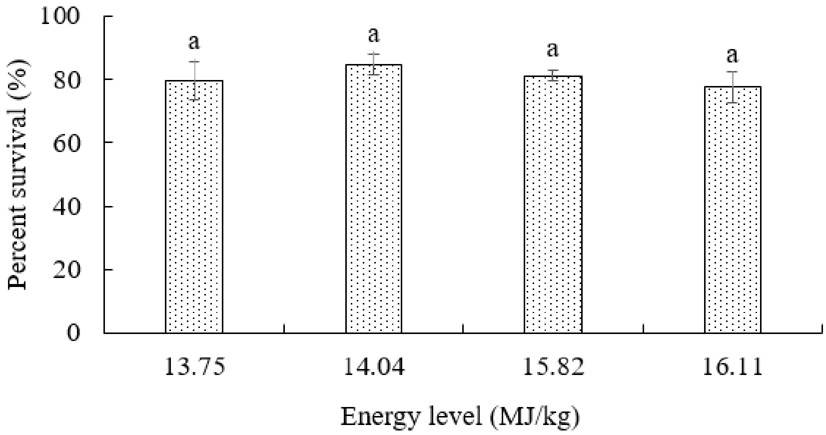

Figure 1: Effect of energy level on percent survival of post-fingerling *Clarias jaensis*

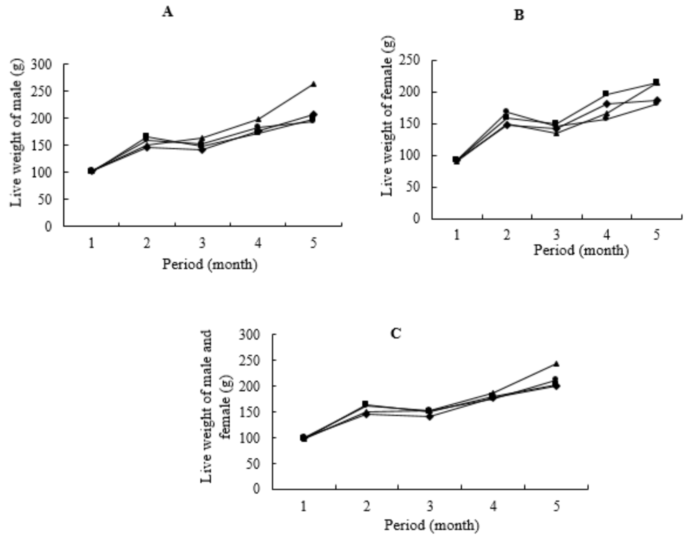

Figure 2: Monthly evolution of live weight of male (A), female (B), and the both sex (C) of post-fingerlings *Clarias jaensis* in function of energy level. **Note:** (—■—): 13.75 MJ/kg; (—▲—): 14.04 MJ/kg; (—◆—):15.82 MJ/kg; (—●—):16.11 MJ/kg

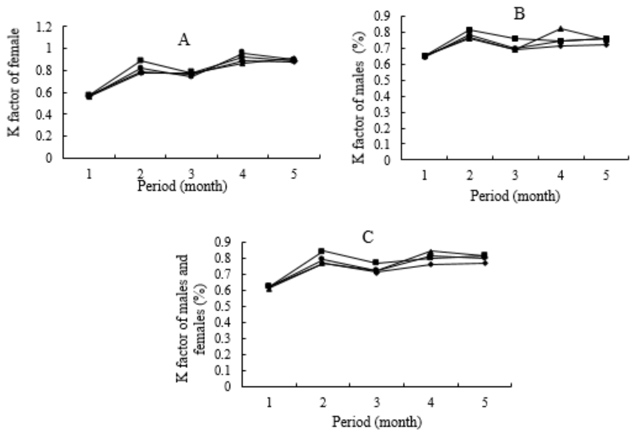

Figure 3: Monthly evolution of K factor of female (A), male (B), and both sexes (C) of post fingerlings *Clarias jaensis* in function of energy level **Note:** (—■—): 13.75 MJ/kg; (—▲—): 14.04 MJ/kg; (—◆—):15.82 MJ/kg; (—●—):16.11 MJ/kg

As shown in Figure 1, there was no significant difference (P>0.05) in percent survival between the four diets. However, the highest percent survival (84.86% ± 3.26%) was obtained with the ration containing 14.04 MJ/kg and the lowest (77.6% ± 4.68%) was obtained with the ration containing 16.11 MJ/kg of energy.

The feed consumption of fish that received the ration containing 16.11 MJ/kg of energy were significantly (P<0.05) higher. On the other hand, those who received rations at 13.75 followed by 14.04 MJ/kg of energy, recorded the lowest feed consumption and were comparable (Table 2).

Live weights of females receiving energy levels of 13.75 MJ/kg and 14.04 MJ/kg were significantly higher (P<0.05) compared to those who received higher energy levels (Table 3). However, in males, this characteristic were significantly (P<0.05) higher only in the group fed at 14.04 MJ/kg and lower in the ration containing 16.11 MJ/kg of energy. In addition, males in the group fed at 14.04 MJ/kg showed significantly higher (P<0.05) live weight than females. The same result was observed in the group receiving 15.82 MJ/kg and 16.11 MJ/kg, although there was no significant difference (P>0.05). However, the reverse has been observed in fish fed at 13.75 MJ/kg of energy. Irrespective of sex, live weight was significantly (P<0.05) higher at 14.04 MJ/kg and lower at 16.11/kg. Figures 2A-2C show the monthly variation of live weight of males, females, and both sexes. In males and both sexes combined, the weight of the fish was higher in the group 14.04 MJ/kg from the third month until the end of the test. However, in females, the weight was higher in the 13.75 MJ/kg group from the same period to the end, while at 14.04 MJ/kg it tended to increase towards the end of the test.

In males, females, and sex combined, weight gain and mean daily gain were significantly (P<0.05) higher in group fed at 14.04 MJ/kg than in the other groups (Table 3). However, they were lower with rations containing 16.11 MJ/kg of energy. However, regardless of the characteristics considered, males had significantly high values in the 14.04 MJ/kg group compared with females. Similar results were observed in the group fed at 15.82 MJ/kg and 16.11 MJ/kg but were not significant (P>0.05). The reverse was recorded with the group fed at 13.75 MJ/kg.

Total fish length was significantly (P<0.05) affected by energy levels. In fact, in the group that received 14.04 MJ/kg, females, males, and both sexes combined had higher total lengths compared to other groups (Table 3). As well as weight gain and average daily gain, total length was significantly higher in males compared to females in the same group and in the group fed at 15.82 MJ/kg and 16.11 MJ/kg.

The consumption index was significantly affected by the energy level (P<0.05). The lowest value of the consumption index was recorded in the group that received the ration at 14.04 MJ/kg followed by 13.75 MJ/kg and the highest was recorded in the group that received the highest energy level (Table 3).

In males, females, and both sexes combined, the specific growth rate was also higher (P<0.05) with diets containing 14.04 MJ/kg and lower in the group receiving 16.11 MJ/kg (Table 3). This characteristic was significantly higher in females compared to males in all groups except the one fed at 14.04 MJ/kg where the difference was significant (P<0.05).

Figures 3A-3C show the monthly variation of the K factor. This characteristic was greater at the end of the trial in males and for both sexes combined.

Whatever the sex, the energy level did not significantly affect the K factor, but it was greater in the group fed at 13.75 and 14.04 MJ/kg (Table 3). The high value of K factor was registered in the group fed at 14.04 MJ/kg for females and 13.75 MJ/kg and 16.11 MJ/kg for males. However, there was no significant difference (P>0.05). Moreover, whatever the level of energy, females had a significant high K factor than males.

The effect of the energy level on the chemical composition of the carcass is shown in Table 4. In general, it is apparent that, all characteristics were significantly affected by the energy level of the diet (P<0.05), except for the ash content. The lipid content increased significantly with the increasing energy level of the ration. The lowest dry matter and ash contents were recorded in the group fed with the ration containing 13.75 MJ/kg of energy and the highest values were observed in fish fed at 14.04 MJ/kg. The high protein levels were obtained in the group that received rations at 14.04 MJ/kg and the low value was registered with the energy level 15.82 MJ/kg followed by 16.11 MJ/kg.

The effect of energy level on cholesterol, LDL, HDL, and TGS is summarized in Table 5. It appears that the energy level did not significantly affect these characteristics (P>0.05). Nevertheless, cholesterol was lower at 13.75 MJ/kg as LDL and triglycerides, and higher at 16.11 MJ/kg, while LDL and triglyceride was higher in fish fed at 15.82 MJ/kg. However, the group receiving 13.75 MJ/kg recorded higher HDL and the lowest were observed at 15.82 MJ/kg of energy.

Table 4: Chemical composition of *Clarias jaensis* Carcass in function of energy level.

	Energy level (MJ/kg)				
Chemical characteristics (%)	3000	3100	3200	3300	P
Dry matter	27.51 ± 0.56^{a}	31.63 ± 1.55^{b}	29.60 ± 1.40^{c}	31.21 ± 1.10^{b}	0
Ash	3.90 ± 0.57 ^{a}	4.03 ± 0.72 ^{a}	4.01 ± 0.52 ^{a}	3.95 ± 0.42 ^{a}	0.276
Proteins	19.3 ± 0.16^{ab}	20.89 ± 0.77^{a}	18.14 ± 1.42^{b}	18.30 ± 1.42^{b}	0.031
Lipids	3.9 ± 1.29^{a}	5.81 ± 0.56^{a}	6.55 ± 1.68^{ab}	8.31 ± 0.14^{b}	0.008

Note: ^{a}, ^{b} and ^{c}: The means with the same letter on the same line are not significantly different (P>0.05); P=Probability.

Table 5: Biochemical parameters of *Clarias jaensis* Carcass in function of energy level.

	Energy level (MJ/kg)				
Biochemical characteristics (mg/dl)	13.75	14.04	15.82	16.11	P
Cholesterol	10.77 ± 1.54	10.85 ± 2.63	11.73 ± 2.34	12,88 ± 3.44	0.44
LDL	2.00 ± 1.54	3.09 ± 0.79	4.35 ± 2.88	4,17 ± 1.40	0.09
HDL	4.43 ± 2.01	4.00 ± 0.60	3.51 ± 0.91	3.82 ± 1.36	0.61
TGS	25.03 ± 4.31	26.12 ± 5.85	31.48 ± 9.83	28.94 ± 7.86	0.28

Note: LDL=Low Density Lipoprotein, HDL=High Density Lipoprotein, TGS=Triglycerides, P=Probability

DISCUSSION

Percent survival ranged from 77.6% to 84.86% and was comparable in all diets. But, the low value was registered with the high energy level. We don't have information on the effect of energy level on the survival of post-fingerling fish. However, the low percent survival in fish receiving the most energy could be explained by the low digestibility of the excess of lipids in their diet. Indeed, at low temperature, as was the case in this study, digestibility in fish is not good. The poorly-eaten food could rot and cause swelling of the belly and death of the fish. Our results show that the best growth characteristics were obtained in the fish receiving the ration containing 14.04 MJ/kg of energy compared to other rations. The increase in energy level leads to a significant increase in feed consumption (P<0.05) and the highest is obtained with the ration that contains the most energy (16.11 MJ/kg). According to this result, the high level of energy in the ration will improve its palatability, which does not corroborate that of Clarias gariepinus, whose food consumption decreases with increasing energy consumption [12]. This difference could be attributed to the use of palm oil in the formulation of our experimental food. Indeed, the inclusion of oil in the food improves food consumption [13]. Most studies have reported that the decrease in growth of fish fed on diet with excessive fat would result from the inability of fish to digest and use the excess energy provided by fat [14].

The consumption index was significantly affected by the energy level and was better with the ration containing 14.04 MJ/kg. This ration was better valued compared to the one containing the most energy (16.11 MJ/kg), although this one was the most consumed. In fact, the excess of energy would improve the feed consumption without favoring a good digestion of the food. This result is different from those of Memis D and El-Dakar who found that the best consumption index is obtained in fish that receive more energy in their diet [15,16]. This difference would be explained by the species and size of the fish used in their study.

Live weight, total length, weight gain, average daily gain, and specific growth rate varied significantly (P<0.05) with energy level. Independently of sex, these characteristics were higher with the diet containing 14.04 MJ/kg and lower with the one containing the highest energy level (16.11 MJ/kg). These results are contrary to those of on rainbow trout fed with three types of food containing different energy levels [15]. These authors observed that the weight, total length, K factor and specific growth rate were better with the food containing the most energy. We attribute this result contradiction to the type of species and the quality of food used. On the other hand, reported that the growth characteristics of post-fingerling Clarias gariepinus are better with the ration containing 13.75 MJ/kg digestible energy and 40% protein [12]. This result does not agree with ours, not because of the type of food, but probably because of the species used [17]. Indeed, their main sources of energy were palm oil and maize as in our study.

In the present study, except the K factor, the growth characteristics of males were in general significantly higher than those of females in the diets containing 14.04 MJ/kg, 15.82 MJ/kg, and 16.11 MJ/kg and the opposite was observed with the ration containing the lowest level of energy (13.75 MJ/kg). This variation in weight may be due to the sexual dimorphism that appears in adult Claridae. However, the males and females with the best growth performance were obtained with the ration containing 14.04 MJ/kg. Similar results have been reported, after giving diets with different energy levels (10.87 MJ/kg to 15.08 MJ/kg) to Clarias gariepinus, had obtained a decrease in weight from the lowest energy level to the highest level [18]. The weight of males was also higher than the one of the females. On the other hand, had rather observed an increasing weight and total length of males and females of Rhamdia quelen with increasing energy levels [19]. It should be noted that these differences in results are not only related to the species, but to the quality of the food because in our study, palm oil was used as the main energy source, whereas the other works used soybean oil. It could be said that the presence of palm oil in *Clarias jaensis* food would reduce its digestibility.

The maximum value of the average daily gain (1.08 g/day) obtained in this study is less than 2.26 g/day reported by in hybrid catfish (*Heterobranchus longifilis* × Clarias gariepinus) and 3 g/day obtained by in Clarias gariepinus [7,20]. This could be justified by the physico-chemical characteristics of the water that were not within the range recommended for breeding of Claridae. In fact, the feed consumption is a function of temperature and oxygen and the maximal consumption of catfish is obtained at 34°C [21]. For a better digestion and growth of catfish, it is important to have a temperature comprised between 27.5°C-32.5°C [22].

The K factor was comparable between treatments but significantly lower in males compared to females in all diets except for the one containing the least energy. This factor was less than 1 in all fish groups and according to, this result indicates that the fish were in poor physical condition during the test [23].

Except the ash, the energy level significantly affected the chemical characteristics of the carcass (P<0.05). Dry matter, protein and ash were better with the ration which contains 14.04 MJ/kg compared to the other groups. Since this ration was the most valorized by fish, it has led to better tissue development. These results do not corroborate those of who found that it is rather the food containing the most energy that has recorded the highest values of these characteristics except protein [15]. In addition, the lipid content has increased with increasing energy level which is similar to the results of the same author. These results also corroborate those of and in which the lipid content of the carcass of fish increases with the energy level of the diet [24,25]. However, these results are different from those reported by in which the increase in energy level in the diet had no significant effect on the lipid content of the carcass [26]. This difference could be explained by the use of palm oil in the formulation of our rations because the increase of the palm oil content in the diet generally leads to an increase of lipid deposits in the adipose tissue [27].

The biochemical composition of the *Clarias jaensis* carcass did not significantly vary with energy level. However, the lowest cholesterol, LDL, TGS, and high HDL concentrations were observed in fish with the lowest energy level (13.75 MJ/kg, followed by 14.04 MJ/kg). Fish fed the diet with the most energy have a high concentration of cholesterol and especially LDL (bad cholesterol) in their flesh. Note that fish is generally appreciated because it contains omegas 3 and 6, useful for health. However, the quality and quantity of its diet could promote the deposit of bad cholesterol, which is not good for the consumer.

CONCLUSION

Except the percent survival and K factor, the energy level has significantly affected the other growth characteristics. The highest feed consumption was obtained with the ration containing the most energy (16.11 MJ/kg). The best consumption index, weight, total length, weight gain, mean daily gain, and specific growth rate were significantly higher with the diet containing 14.04 MJ/kg. The energy level had a non-significant effect on the biochemical composition of the carcass but a significant effect on the chemical composition apart from the ash, who was higher at 14.04 MJ/kg as dry matter and proteins. Lipids were higher in the ration containing the most energy. This study showed that the optimal energy level for the growth of *Clarias jaensis* post fingerlings is 14.04 MJ/kg kcal/kg.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Lazard J, Levêque C. Introductions et transferts d'espèces de poissons d'eau douce. Cah Agric. 2009;18(2-3):157-163.
2. FAO. La situation mondiale des pêches et de l'aquaculture.2012.
3. FAO. La situation mondiale des pêches et de l'aquaculture 2020. La durabilité en action. 2020.227p.
4. Boujard T, Gélineau A, Covès D, Corraze G, Dutto G, Gasset E, et al. Regulation of feed intake, growth, nutrient and energy utilisation in European sea bass (*Dicentrarchus labrax*) fed high fat diets. Aquac. 2004;231(1-4):529-545.
5. La Cà, Et Sa, De Tous Àl. La situation mondiale des pêches et de l'aquaculture.2016.
6. Legendre M, Linhart O, Billard R. Spawning and management of gametes, fertilized eggs and embryos in Siluroidei. Aquat Living Resour. 1996;9(S1):59-80.
7. Justin AI, Béni HL, Pascal MM. Socioeconomic and zootechnic characterization of the fish farming in the high and low altitude rural zones in the South-Kivu (DRC): Which link with the fish farming history? 2020.
8. Komguep NR, Efole TE, Defang FH, Nana TA, Mube KH, Tagning ZP. Effects of dietary protein level on growth performance of pre-growing catfish *Clarias jaensis* (boulanger 1909) fingerlings in captivity. J Aquac Res Dev. 2021;12:658.
9. Gwladys TK, Thomas EE, Junior MO, Joseph T. Effect of various levels of metabolize energy on growth performance of *Clarias jaensis* fingerlings (Boulenger, 1909). Int J Res Granthaalayah. 2018.
10. Saravanan S, Schrama JW, Figueiredo-Silva AC, Kaushik SJ, Verreth JA, Geurden I. Constraints on energy intake in fish: The link between diet composition, energy metabolism, and energy intake in rainbow trout. Plos One. 2012;7(4):e34743.
11. Aoac. Association of official analytical chemist. Official methods of analysis.2000.
12. Aliu B, Otuagomah J. Growth response of Clarias gariepinus post fingerlings fed various dietary protein and digestible energy levels. J Adv Biol Biotechnol. 2017;12(2):1-5.
13. Otchoumou KA, Blé MC, Alla YL, Corraze G. Utilisation des huiles végétales en pisciculture en remplacement des huiles de poisson: Cas de l'huile de palme dans l'alimentation des juvéniles du poisson-chat *Heterobranchus longifilis*.
14. Kaushik SJ, Médale F. Energy requirements, utilization and dietary supply to salmonids. Aquac. 1994;124(1-4):81-97.
15. MEMİŞ, D, Gün H. Effects of different diets on the growth performance, gonad development and body composition at first sexual maturity of rainbow trout (*Oncorhynchus mykiss*). Turkish J Vet Anim Sci. 200428(2), pp.315-322.
16. El-Dakar A, Hassanen G, Shalaby S, Ghoniem S, Zenhom O. Survival, growth, feed efficiency and carcass composition of rabbitfish, Siganus rivulatus, fed different dietary energy and feeding levels. Mediterr Aquac. 2010;3(1):18-27.
17. Chaitanawisuti N, Rodruang C, Piyatiratitivorakul S. Optimum dietary protein levels and protein to energy ratios on growth and survival of juveniles spotted Babylon (*Babylonia areolata* Link) under the recirculating seawater conditions. Int J Fish Aquac. 2010;2(2):58-63.
18. Çek Ş, Yilmaz E. The effect of varying dietary energy on gonad development at first sexual maturity of the Sharptooth catfish (*Clarias gariepinus* Burchell, 1822). Aquaculture International. 2009;17:553-563.
19. Reidel A, Boscolo WR, Feiden A, Romagosa E. The effect of diets with different levels of protein and energy on the process of final maturation of the gametes of Rhamdia quelen stocked in cages. Aquac. 2010;298(3-4):354-359.
20. Keremah RI, Deekae SN, Akalokwu UA. Growth and Feed utilization of Catfish Hybrid (*Heterobranchus longifilis* x *Clarias gariepinus*) Fingerlings fed practical diets. Greener J Agric Sci. 2013;3(4):286-290.
21. Masser MP, Grant WE, Neill WH, Robinson EH. A simulation model representing effects on dietary energy/protein ratio and water temperature on growth of channel catfish (*Ictalurus punctatus*). Ecol Model. 1991 ;54(1-2):17-35.
22. Hogendoorn H, Jansen JA, Koops WJ, Machiels MA, Van Ewijk PH, Van Hees JP. Growth and production of the African catfish, *Clarias lazera* (C. & V.): II. Effects of body weight, temperature and feeding level in intensive tank culture. Aquac. 1983;34(3-4):265-285.
23. Costa AM. Somatic condition, growth and reproduction of Hake, *Merluccius merluccius* L., in the Portuguese coast. Open J Mar Sci. 2013.
24. Ghiasvand Z, Matinfar A, Valipour A, Soltani M, Kamali A. Evaluation of different dietary protein and energy levels on growth performance and body composition of narrow clawed crayfish (Astacus leptodactylus). Iran J Fish Sci. 2012;11(1):63-77.

25. Abed FH, Salama M, Dahhar AA. Effect of dietary proc tein and metabolizable energy levels on growth and feed utilization of Sea Bass (*Decentrarshus laborax*) larvae. Journal of the Arabian Aquaculture Society. 2013;8(1):1-8.

26. Marammazi JG, Kahkesh F. Effects of dietary protein and energy levels on growth performance, feed utilization and body composition of juvenile shirbot *Barbus grypus* (Heckle, 1843). Iran J Fish Sci. 2011;10(3):461-474.

27. Ayisi CL, Zhao J, Rupia EJ. Growth performance, feed utilization, body and fatty acid composition of Nile tilapia (*Oreochromis niloticus*) fed diets containing elevated levels of palm oil. Aquac Fish. 2017;2(2):67-77.