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Effect of feed supplemented with *Allium sativum* on the survival rate, growth and feed cost of fry *Clarias gariepinus* during pre-fattening in an intensive system

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Abstract
The effect of *Allium sativum* on the survival rate, growth rate and feed cost of production of juvenile *Clarias gariepinus* was studied for eight (8) weeks at the ‘’*Massoma* fish farm’’ located in Douala, Cameroon (04 ° 03'-04 ° 07 'LN and 09 ° 37' - 09 ° 41 'LE). The objective was to contribute to a better production of *Clarias gariepinus* through the use of a phyto-additive. For this purpose, 1500 fingerlings (10 ± 1 g) were divided into five comparable batches with three completely randomized replications. Hence, five experimental rations containing 0; 3.5; 4; 4.5 and 5% *A. sativum* powder were distributed to these groups at 5% of their fish biomass. The results obtained on survival rate, growth characteristics and feed cost were significantly (p<0.05) influenced by the addition of the phyto-additive in the feed. Food consumption (111.98 ± 0.13g), live weight (90.43 ± 4.30g), weight gain (80.36 ± 4.31g), mean daily gain (1.34 ± 0, 07g), the specific growth rate (3.66 ± 0.08% g / d) and the protein efficiency coefficient (1.60 ± 0.02) were significantly higher with the ration ($R_{4.5}$) containing 4.5% *A. sativum* powder and the lowest with the ration without additives. On the other hand, the highest condition factor k (1.10 ± 0.08) was observed with the ration without additive and the total length (22.35 ± 0.51cm) with the treatment therefore the feed was supplemented at 5% (R_5). The lowest consumption index (1.39 ± 0.01) and food production cost (95.12 ± 10.80FCFA) were obtained with the ration R4.5 and R4 respectively. The result of the present study established the potential use of *A. sativum* powder as an additive in the feeding of pre-grows *C. gariepinus* fingerlings. In view of the above, the ration containing 4.5% of *A. sativum* could be sustainable in terms of fish economics, although the search for the optimal rate of supplementation remains open.

Keywords: clarias gariepinus, juveniles, allium sativum, growth, survival

Introduction

The world is marked by an increasingly growing demography (FAO, 2010a) [12]. The population increase is estimated at 13% between 2009 and 2010 and statistics forecast the population at 9 billion in 2050 (FAO, 2016) [13]. This growth is not always followed by that of natural and food resources (Chakraborty and Banerjee, 2010) [6]. This thus poses a serious problem of nutrition for this large population. It is therefore urgent to accentuate the techniques of food production in quality and quantity to meet the needs of this galloping population. This is how the improvement of fish production went directly to the resolution of this problem.

In Africa, the development and growth of the aquaculture sector has unfortunately not kept pace with that of the world in recent decades (FAO, 2016) [13]. The problem of food self-sufficiency is crucial and therefore requires the revival of a rural fish farming activity (Collart and De Bont, 1996) [8].

In Cameroon, fish consumption is estimated at nearly 17.9 kg / person / year, for an annual demand of nearly 400,000 t / year, mostly met by massive imports of frozen fish of around 220,000 t / year, for a total national fish production estimated at nearly 180,000 tones, so less than 5% comes from aquaculture (Abdou, 2010). To solve this problem, the Cameroonian government has resolved to revive aquaculture to meet demand and reduce imports of frozen fish. However, the aquaculture sector in Cameroon is faced with many constraints, the main ones being the insufficiency of fry on the market and the unavailability of feed producing better performance at lower cost because the latter represents about 60 to 75% of the cost operating cycle for each cycle (Agbebi *et al.*, 2013) [4]. To get around this difficulty, several authors have attempted to use foods made from local ingredients (Mabruki *et al.*, 2012) in combination with additives. This is the case with the pods of *Allium sativum* commonly known as garlic, use as a spice and also as a phyto-additive in animal feed. Garlic contains a complex of B vitamins, vitamins A, C and F. It has effects such as lowering cholesterol and triglycerides and also antioxidant properties (Drăgan, 2008) [10]. Garlic contains sulfur compounds, allicin and many other growth promoting substances (Skidmore-Roth, 2003) [34]. Several research studies in fish nutrition have demonstrated the individual or combined capacities to act as a growth promoter in the African catfish in nursery (Ogueji *et al.*, 2017; Adegbesan *et al.*, 2017; Sherifat *et al.*, 2019 ; Nyadjeu *et al.*, 2020) [28, 27]. But the optimal dose of supplementation in the food is still the subject of several controversies because it is not yet known. Taking into consideration the above mentioned, the present work was initiated with the aim of evaluating the effect of Allium sativum as a food phyto-additive on the survival rate, zootechnical performances and the feed cost of producing *Clarias gariepinus* in pre-fattening.

Materials and Methods

Study area

The experiment was carried out at the '*'Massoma* fish farm'' located in the Douala 4 Subdivision, Cameroon, with geographical coordinates 04 ° 03'- 04 ° 07 'Latitude North and 09 ° 37'- 09 ° 41' Longitude Is. This city is located at 7 m of average altitude compared to the sea level. It climate is of equatorial type, very humid with temperature which oscillates between 22 and 35 °C (Njueya, 2012) [24].

Biological material

1500 fry of *Clarias gariepinus* with an initial mean weight of 10 ± 1 g and a mean total length of 10.43 ± 0.58 cm were used for the study. These juveniles were obtained following artificial reproduction on site on the farm. They were acclimatized in fastanks for 2 weeks and fed with a local food made of three ingredients: fishmeal, soybean meal, corn (Lacroix, 2004) until the start of the trial.

The phyto-additive *Allium sativum* supplemented in the food was obtained from the market of the city of Dschang located in the Western Region of Cameroon, pilled then dehydrated at 50 °C using a ventilated oven. A constant weight was obtained and ground using a Moulinex.

Breeding structure and experimental device

For breeding, 15 fastanks of 0.30 m3 of water volume each were used. Each fastank was equipped with a water supply system and an Ø 32 mm pressure hose overflow which kept the water level constant in the tank and also served as a drain. Then, a refuse collection basin was installed at the bottom of each fastank and at the vertical of which was placed on the surface of the water a circular floating frame which served as a feeder and also made it possible to orient the remains of food not eaten right in the bottom basin.

Experimental rations

Five isoprotein rations were formulated following a staple food (Table 1). From the basic food, 4 other rations were obtained by adding respectively to this basic formulation 3.5; 4; 4.5 and 5% *Allium sativum* powder. The ingredients used were purchased from the same feed mill in the city of Douala, in order to ensure their traceability, ground, mixed and separated according to the different rations then granulated from a granulator 2 mm in diameter; then dried in the sun for 6 hours. The granules were stored in opaque bags. The bromatological composition of the basic ration is summarized in Table 1.

Table 1: Experimental ration for the juveniles of *Clarias gariepinus* in pre-grow-out

Ingredients	Quantity (kg)
Corn	8
Cassava flour	3
Cotton cake	3
Soybean meal	35
Blood meal	5
Fish meal	40
Bone meal	1
Palm oil	3
Premix	2
Total	100.00
Chemical composition	
CP (%)	45.59
ME (kcal / kg)	3106.82
Ca (%)	3.00
P (%)	1.72
E/P	68.15
Ca/P	1.74

CP = Crude Protein; ME = Metabolize energy; Ca = Calcium; P = phosphorus E/P = Energy/Protein Ca/P = Calcium/phosphorus ratio

Rations

R_0 = basic ration (control)
$R_{3.5}$ = basic ration + 3.5% *Allium sativum* powder
R4 = basic ration + 4% *Allium sativum* powder
$R_{4.5}$ = basic ration + 4.5% *Allium sativum* powder
R_5 = basic ration + 5% *Allium sativum* powder

Conduct of the test

To carry out this study, 1500 fry of *Clarias gariepinus* were randomly divided into five batches comparable in size and weight with three replicates per batch in fifteen (15) square fastanks. Each fastank was stocked with 100 individuals and the water was renewed every two-thirds (2/3). To each batch was randomly assigned one of the experimental rations R_0 (staple food), $R_{3.5}$ (staple food + 3.5% *A. sativum* powder), R_4 (staple food + 4% *A. sativum*), $R_{4.5}$ (staple food + 4.5% *A. sativum* powder) and R_5 (staple food + 5% *A. sativum* powder) previously formulated. Animals were fed at 5% of their fish biomass twice a day at fixed times (7-8 a.m. and 5-6 p.m.) (Hecht *et al.*, 1988; Tomedi *et al.*, 2008; Ani *et al.*, 2013) [16, 36, 5] during the 8 weeks of the test, and the quantity was readjusted after each control fishery. Food refusals were also collected every two days thanks to the basin placed on the bottom of the trays vertically to a frame floating on the surface of the water which was intended to guide the food not consumed in the basin. Thus, these refusals were dried in the sun to constant weight and then weighed to assess food consumption. Every month, a control fishery was carried out and 25% of the fish from each fastank were weighed individually using a 1g precision SF-400 brand electronic balance and measured using a precision icthyometer 1mm. This made it possible to assess the growth characteristics of the fish and readjust the amount of feed to be distributed during the following month.

Along with the data collection, the physico-chemical parameters of the water were obtained in situ between 6 and 7 a.m. in each fastank. It involved taking the temperature with an HTC2 thermometer and the pH, ammonia, nitrites and nitrates of the water using a JBL kid. At the end of the test, all the fish were counted, weighed and measured.

Studied parameters and characteristics

- Survival rate = (Initial number of fish-mortality) X100 / (Initial number of fish)
- Growth characteristics
- Food consumption (g) = Quantity of food served – Refused
- Total length gains (TLG) = initial total length - final total length
- Weight gain (WG) = Final weight-initial weight
- Average daily gain (ADG) = (Final weight - initial weight) / Time (number of days)
- Specific growth rate (SGR) = ((ln final weight – ln initial weight) X100)) / (Time (number of days) ; ln = neperien logarithm
- Consumption index (CI) = Quantity of food consumed / (Final Weight-Initial weight)
- Condition factor K = (W / LT ^{3}) x 100 (Ricker, 1975) W = Weight (g) LT = Total length (cm)
- Protein Efficiency Ratio (PER) = Weight Gain / (Protein Ration Consumed)
- Financial evaluation
  The financial evaluation of the ration was made on the basis of the prices of the various ingredients on the market and on the basis of the production cost per kilogram of *Allium sativum.*
- Cost of food consumption = Cost per Kg of food x Food consumption
- Food production cost = Food consumption cost x Consumption index

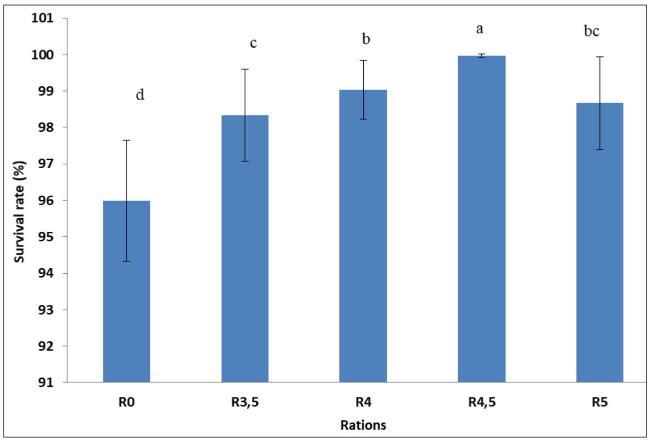
Statistical analyzes

One-way ANOVA was used to test the effect of the rate of *Allium sativum* supplementation on the survival rate and growth characteristics. When there were significant differences between the means, they were separated by Duncan's test at the 5% threshold. The statistical software SPSS 21.0 was used for this purpose.

Results

Effect of feed supplemented with *Allium sativum* on the survival rate of pre-fattening juveniles of *Clarias gariepinus*

The influence of feed supplemented with the phyto-additive *Allium sativum* on the survival rate of juveniles of *Clarias gariepinus* (Figure 1) shows that there was a significant difference (p<0.05). The highest value (99.97 ± 0.04%) was recorded with the $R_{4.5}$ ration followed by that of the R_4 treatment (99.33 ± 1.27%) which is otherwise significantly comparable to R_5 (98, 67 ± 1.27%). The lowest survival rate (96.00 ± 1.66%) was obtained in individuals fed with feed containing no additive (R_0).



a, b and c: histograms with the same letters are not significantly different (p> 0.05) R_0-R_5: Rations containing respectively 0; 3.5; 4; 4.5 and 5% of *Allium sativum*

Fig 1: Effect of supplementation with *Allium sativum* in the feed on the survival rate of *Clarias gariepinus* in pre-growth

Effect of feed supplemented with *Allium sativum* on the growth characteristics and production feed cost of pre-fattening juveniles of *Clarias gariepinus*

The effect of supplementation *A. sativum* in the feed on the growth characteristics and the feed cost of production of *Clarias gariepinus*.

Juveniles during pre-fattening is summarized in Table 2 and illustrated by Figures 2 to 5.

In general, it emerges that the growth characteristics almost all increased significantly (p<0.05) with the increasing level of the additive in the feed.

Table 2: Growth characteristics of *Clarias gariepinus* in magnification with respect to the rate of supplementation of *Allium sativum* in the feed

Growth characteristics	Supplementation rate (%)					
	R_0	$R_{3,5}$	R_4	$R_{4,5}$	R_5	p
FC (g)	108.37±1.08 ^{c}	103.70±0.18 ^{d}	102.20±0.02 ^{e}	111.98±0.13 ^{a}	110.01±0.08 ^{b}	0.00
LW (g)	63.93±5.43 ^{d}	75.73±5.14 ^{c}	79.70±6.98 ^{b}	90.43±4.30 ^{a}	88.40±5.56 ^{a}	0.00
TL (cm)	19.49±0.73 ^{d}	20.97±0.76 ^{c}	21.44±0.93 ^{b}	22.19±0.64 ^{a}	22.35±0.51 ^{a}	0.00
WG (g)	53.84±5.41 ^{d}	65.67±5.15 ^{c}	69.63±6.96 ^{b}	80.36±4.31 ^{a}	78.32±5.53 ^{a}	0.00
ADG (g)	0.90±0.09 ^{d}	1.10±0.09 ^{c}	1.16±0.12 ^{b}	1.34±0.07 ^{a}	1.31±0.09 ^{a}	0.00
CI	2.02±0.06 ^{a}	1.58±0.11 ^{b}	1.47±0.07 ^{c}	1.39±0.01 ^{d}	1.40±0.08 ^{d}	0.00
SGR (%g/j)	3.07±0.15 ^{d}	3.36±0.12 ^{c}	3.44±0.15 ^{b}	3.66±0.08 ^{a}	3.62±0.01 ^{a}	0.00
K	1.10±0.08 ^{b}	1.05±0.08 ^{a}	1.05±0.09 ^{a}	1.07±0.08 ^{ab}	1.04±0.04 ^{a}	0.00
PER	1.10±0.03 ^{d}	1.42±0.01 ^{c}	1.52±0.07 ^{b}	1.60±0.02 ^{a}	1.59±0.09 ^{a}	0.00
PFC (Fcfa)	126.55±26.81 ^{a}	102.72±9.24 ^{b}	95.12±10.80 ^{b}	100.02±12.46 ^{b}	99.91±10.79 ^{b}	0.00

a, b and c: the means with the same letters on the same line are not significantly different (P> 0.05).

FC = Food consumption, LW = live weight, TL = total length, WG = weight gain, ADG = average daily gain, SGR = Specific growth rate, CI = Consumption index, K = Condition factor, PER = protein efficiency rate, PFC = food production cost; p = probability and R_0-R_5: Rations containing respectively 0; 3.5; 4; 4.5 and 5% of *Allium sativum*

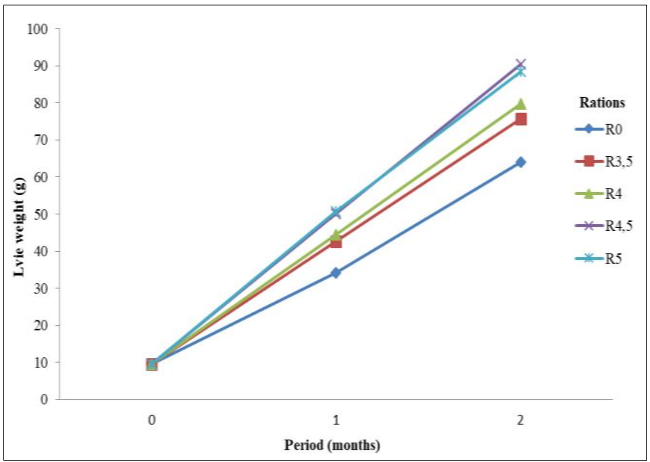
Food consumption

The mean food consumption (Table 2) was significantly higher with the $R_{4.5}$ ration (111.98 ± 0.13g) followed by that of the 5% food *A. sativum* (110.01 ± 0.08g) then the 0% ration of A. sativum (R_0) (108.37 ± 1.08g) and the lowest food consumption value (102.20 ± 0.02g) was obtained with R_4.

Live weight

It appears from Table 2 that the juveniles of *C. gariepinus* that received $R_{4.5}$ ration and R_5 had live weights (90.43 ± 4.30g and 88.40 ± 5.56g) significantly comparable and superior to those of the fish having received the other rations. However, the subjects given the ration containing no additive had a significantly lower body weight (63.93 ± 5.43g).

The curve of the monthly change in live weight (Figure 2) had the same profile, the same pace and the same trend. However, from the start to the end of the test, the weights of the animals fed with feed supplemented with 4.5 and 5% *A. sativum* powder were above that of all other groups of animals. ; followed by that of fish fed with feed supplemented with 4% phyto-additive and the lowest curve was recorded in individuals fed with 0% *A. sativum* in the food.



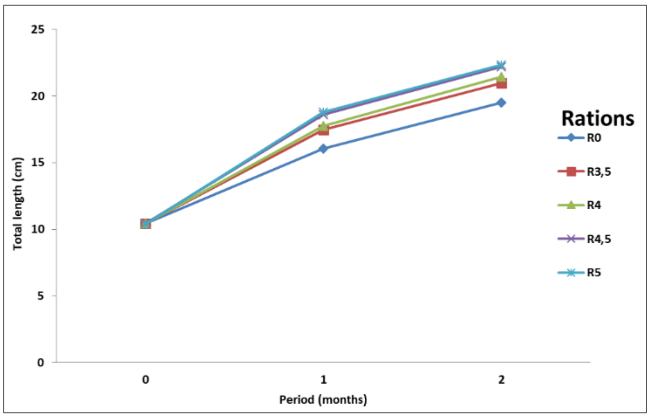
R_0-R_5: Rations containing respectively 0; 3.5; 4; 4.5 and 5% of *Allium sativum*

Fig 2: Monthly evolution of the live weight of juveniles of *C. gariepinus* with respect to the incorporation rate of *Allium sativum* in the feed

Total length

The highest mean total length (22.35 ± 0.51cm) was observed in fish fed with the R_5 ration followed by that fed with $R_{4.5}$ (22.19 ± 0.64 cm). The shortest length (19.49 ± 0.73 cm) was obtained with the subjects of R_0 (Table 2). The evolution of the length gain of juveniles of *C. gariepinus* fed at different rations with respect to the level of supplementation of *A. sativum* (Figure 3) shows that, whatever the treatment, the gain in length has not only increased over time, but also presented the same profile, same look and same trend. However, the linear growth of the fish was almost identical in all treatments until the end of the experiment. However, from the 1st to the last day of the study, the length curves of juveniles fed with feed containing 4.5 and 5% of *A. sativum* powder showed comparable growth and remained above the curves of others treatments.

On the other hand, the lowest curve was recorded with the subjects fed the ration without additive (R_0).



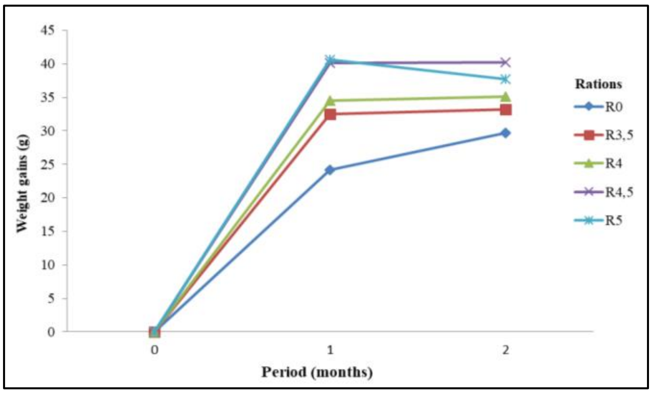
R_0-R_5: Rations containing respectively 0; 3.5; 4; 4.5 and 5% of *Allium sativum*

Fig 3: Monthly evolution of the total length of juveniles of *C. gariepinus* fed with different rations according to the level of supplementation of *A. sativum*

Weight gain and average daily gain

The weight gain and the mean daily gain as presented in Table 2 show that the highest values (80.36 ± 4.31g and 1.34 ± 0.07g) for these characteristics were recorded with the feed containing 4.5% of the phyto-additive followed by those (78.32 ± 5.53g and 1.31 ± 0.09g) of the R_5 treatment; which were otherwise significantly comparable. The lowest values of weight gain and mean daily gain (53.84 ± 5.41g and 0.90 ± 0.09g) were obtained with fish fed with the powder-free ration of *A. sativum* (R_0).

The shape of the evolution curves of fish weight gain between 0 and 2 months as illustrated in Figure 4 was identical regardless of the ration considered. However, the weight gain curves of individuals fed with the $R_{4.5}$ and R_5 rations evolved faster than those of other treatments throughout the study. However, from the start to end of the 1st month of the study, the weight gain curves of subjects fed with $R_{4.5}$ and R_5 were comparable to each other. On the other hand, during the 2nd month, the curve of the weight gain of the fish of the $R_{4.5}$ treatment (40.12 g) evolved more quickly than that of the R_5 ration which moreover regressed (37.73 g). The curve of individuals fed 0% *A. sativum* in the food showed the smallest change throughout the study period.

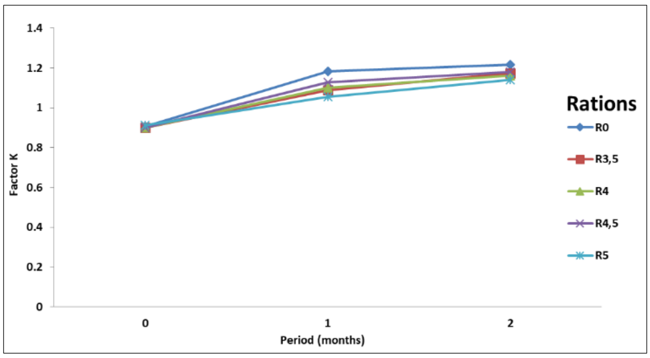


R_0-R_5: Rations containing respectively 0; 3.5; 4; 4.5 and 5% *Allium sativum*

Fig 4: Monthly evolution of the weight gain of juveniles of *C. gariepinus* during pre-fattening with respect to the supplementation rate of *A. sativum* in the feed

Condition factor K

The condition factor K of fish tended to decrease significantly ($p<0.05$) with the rate of supplementation of the phyto-additive *A. sativum* (Table 1). Thus, the highest value (1.10 ± 0.08) was recorded with the food containing 0% of this phyto-additive, followed by that (1.07 ± 0.08) at 4.5% of *A. sativum* and otherwise significantly comparable ($p<0.05$). The most reliable value (1.04 ± 0.04) was observed with the R_5 ration. The curve of the monthly evolution of the factor k as a function of the level of supplementation of *A. sativum* in the ration shows a continuous and almost comparable growth between the treatments whatever the period of the trial except that of the treatment fed the R_0 ration that was above the curves of all of the other rations (Figure 5).



R_0-R_5: Rations containing respectively 0; 3.5; 4; 4.5 and 5% *Allium sativum*

Fig 5: Monthly evolution of the k factor witn respect to the level of *A. sativum* in the feed during pre-fattening of *Clarias gariepinus*.

Consumption index (CI)

The consumption index decreased significantly with the increasing rate of supplementation of the phyto-additive in the food. Thus, it was lower (1.39 ± 0.01 and 1.40 ± 0.08) with the rations containing respectively 4.5 and 5% of *A. sativum*, which moreover comparable significantly between them. Then, followed by that (1.47 ± 0.07) of ration R_4. However, the highest index value (2.02 ± 0.06) was obtained with the feed without R0 additive.

Specific growth rate

The specific growth rate tends to increase with the percentage of incorporation of *A. sativum* in the feed (Table 2). Thus, it was higher (3.66 ± 0.08% g / d) with the individuals of the $R_{4.5}$ treatment followed by the value (3.62 ± 0.01% g / d) obtained with those of the ration R_5, However, there was no significant difference ($p>0.05$) between them. However, the lowest value (3.07 ± 0.15% g / d) was observed in subjects fed with feed containing no additive.

Protein efficiency coefficient

The protein efficiency coefficient increased significantly with the increasing rate of phyto-additive supplementation in the feed (Table 2). The highest values (1.60 ± 0.02 and 1.59 ± 0.09) were significantly obtained with the rations $R_{4.5}$ and R_5 respectively. Followed by that (1.52 ± 0.07) of the R_4 treatment, the lowest (1.10 ± 0.03) being recorded with individuals fed with feed containing 0% *A. sativum* powder.

Food cost of production (FCP)

The economic evaluation of the different rations according to the supplementation rate of *A. sativum* is summarized in Table 2. It appears that the price per kilogram of food increased with the increasing rate of supplementation of A. sativum. The lowest price (578.50 FCFA / kg) was recorded with the R_0 ration. However, the R_4 ration obtained the lowest food cost of production (95.12 FCFA), followed by the R_5 (99.91 FCFA) and $R_{4.5}$ (100.02 FCFA) rations and the highest was recorded with the ration containing no additive (R_0). However, the best value for money was obtained with the $R_{4.5}$ ration.

Discussion

The physico-chemical characteristics of water remained within the recommended standards for the survival and growth rates of *C. gariepinus* in culture, which are 17 - 35 ° C for temperature and 6.5 - 9 for pH, same as nitrogen compounds NO^{2-} and NO^{3-} respectively for <0.3 mg / l and <25 mg / l. these values remained within the range of values prescribed by Géoffroy *et al*. (2019) [14].

At the end of the experiment, the survival rate was significantly higher in the treatments supplemented with *Allium sativum* powder compared to the control group. However, it was significantly higher with the $R_{4.5}$ treatment compared to the other batches. Carrying Mesalhy *et al.* (2008) [21] concluded that feeding fish at higher doses of garlic for long periods of time would give better results. In the present study, this rate varied from 96.00 ± 1.66% to 99.97 ± 0.04% consistent with that (96 to 99%) of Labrador *et al.* (2016). These authors worked on the marine shrimp *Litopenaeus vannamei* fed with feed supplemented with the same additive (2 to 6%). Likewise, Abbasi *et al.* (2017) [1] also obtained similar results in carp fed with commercial feed added 2% ginger powder. The high values of the survival rate may be due to the enhancement of the immune response resulting from the increase in the number of monocytes and also thanks to the antioxidant properties present in the additive as the stimulating effect of garlic on the immune system correlation with improved fry survival (Mesalhy *et al.*, 2008) [21]. This high rate is also justified by the presence of sulfur compounds in garlic because recent chemical characterizations of the sulfur contained in garlic have shown active ingredients against microbes (Rose *et al.*, 2005) [30]. This result is greater than the 50.77 to 72.71% found by Agbebi *et al.* (2013) [4] in *C. gariepinus* fed with food supplemented with 1 to 3% of *A. sativum*. This could be attributed to cannibalism which thus contributes in reducing survival rate and it might also be due to the low dose of the phyto-additive in the feed.

The results obtained show that all the growth characteristics and the food cost of production were significantly affected with the increasing rate of *A. sativum* in the food. This result is in accordance to that of Khalil *et al.* (2001) [18] who explained that the supplementation of garlic in food provides other nutrients such as allicin and sulfur compounds, which were well assimilated by the fry of *C. gariepinus* and promoted the performance of the intestinal flora, thereby improving digestion and improving the utilization of proteins and energy, which leads to improved growth. Food consumption tended to increase with increasing level of *A. sativum* supplementation. This increase is similar to that observed by Agbebi *et al.* (2013) [4] in *C. gariepinus* for 8 weeks and fed with a feed incorporated at 3% of the same additive. This is because during their work, consumption had increased with the increasing rate of the phyto-additive in the food. During this study the total length significantly improved in the $R_{4.5}$ and R_5 treatments and the lowest with the R_0 treatment which corresponds to the diet not supplemented with garlic. The results of this study corroborate those obtained by Nwabueze (2012) [25] where an increase in the total length of fry of *C. gariepinus* was observed with a diet supplemented with 3% garlic compared to fish in the diet not supplemented with garlic over 8 weeks. The weight gain increased throughout the period of the experiment regardless of the treatment. However, the highest values were obtained with the highest levels (4.5 and 5%) of *A. sativum* in the food, which is contrary to that obtained by Ndong and Fall (2011) who reported that a garlic supplemented diet resulted in decreased weight gain in juvenile hybrid tilapia (*Oreochromis niloticus* x *Oreochromis aureus*) fed with 0.5 g garlic / kg feed over 4 weeks. This difference could not only be due to the difference in species but also to the levels of dosage of the additive, the different intestinal morphology, the intestinal microbiota and the stages of life (Hoseinifar *et al.*, 2010) [17]. In contrast, a decrease in the specific growth rate was observed in all treatments throughout the period of the trial. This trend confirms the model obtained by Gnikpo *et al.* (2014) [15], who reported that the specific growth rate decreases as muscle mass increases. However, the value obtained in the R_0 treatment is lower than that obtained by Stanley *et al.* (2018) (3.22% g / d) over a period of 70 days with *C. gariepinus* fry fed with a ration incorporated with 2% ginger. The results indicate that there is a significant increase ($p<0.05$) in growth with different supplementation rates of *A. sativum* compared to the batch without additive. This therefore indicates that the use of garlic in the feed of *C. gariepinus* fry would improve nutrient utilization.

These results are therefore in agreement with many previous studies which reported that garlic powder as an additive improves growth (Dias *et al.*, 2002 ; Shalaby *et al.*, 2006; Metwally, 2009; Nwabueze, 2012 ; Charjan *et al.*, Kulkarni, 2013; Lee *et al.*, 2014 ; Saleh *et al.*, 2015) [9, 33, 22, 25, 7, 20, 15]. These results are also similar to those of Abraham *et al.* (2014) [2] who reported significant effects following supplementation at the rate of 10 g of garlic / kg of food in juvenile *C. gariepinus*. According to the same author, supplementing garlic at a rate of 10 g / kg of food significantly improves the rate of food conversion. The consumption index decreased significantly ($p<0.05$) with the increasing level of supplement (phyto-additive) in the food. Thus, it was lower (1.39 ± 0.01) with the ration added to 4.5% of *A. sativum* ($R_{4.5}$) and followed by that of the ration R_5. This result is different from 1.6 to 1.62 reported by Gnikpo *et al.* (2014) [15] after 8 weeks of rearing with feed formulated with a local ingredient in fry of *C. gariepinus*. This difference could be explained by the intake of *A. sativum* in fish food in the present study.

The condition factor K which expresses the overweight of the fish was variable with the treatments and was greater than 1 for all the treatments, thus reflecting a good overweight according to Fulton (1902) who reports that K> 1 reflects a good overweight Fish. In fact, the K factor obtained in *C. gariepinus* was between 1.04 and 1.10. These values were higher than those (0.79 to 0.83) reported by Rukera *et al.* (2005) [31] in the same species reared at several densities and fed with a complete feed without additives or to those reported by Ekoué (2013) [11] (0.06 to 0.74). The difference between these values would be linked to non-compliance with the physico-chemical quality of the breeding water.

The protein efficiency coefficient of juveniles of *C. gariepinus* at pre-fattening increased significantly with the high level of *A. sativum* in the feed. This same trend has been observed by Agbebi *et al.* (2013) [4] with the same species. This result is also in agreement with that of Nya and Austin (2009) [26] in rainbow trout which recorded a significant increase in feed conversion and protein efficiency following feeding supplemented with 0.5 and to 1 g of garlic per 100 g of food.

The food cost of production decreased with the increasing rate in the feed, the lowest value was recorded with the ration R_4 and the highest with R_0. However, feed $R_{4.5}$ represents the best value for money for the production of *Clarias gariepinus* post-juveniles in an intensive system.

Conclusion

At the end of this study on the effect of feed supplemented with *Allium sativum* on the survival rate, growth rate and food cost of production of post-juveniles of *C. gariepinus* during pre-fattening, it emerges that survival rate, growth and food cost of production had a significantly positive impact with the increasing level of the additive in the feed. However, the supplementation level of 4.5% provided the best performance for growth, survival and food cost of production.

Recommendation and perspective

On the basis of the results obtained, for a clear improvement in the production of post-juveniles of *Clarias gariepinus*, we practically recommend that producers should incorporate the powder of *Allium sativum* in the feed at a rate of 4.5% for better improvement of growth performance.

Further studies should be carried out to determine the effect of the use of garlic on the growth and survival performance of juveniles of *Clarias gariepinus* in the full cycle in an aboveground tank.

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Conflict of interest

The authors declare no conflict of interest.

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