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Effect of Replacement of Fishmeal With Lima Bean Meal on the Zootechnical Performances of African Catfish (Clarias Gariepinus) in the Batié Sub-Division, West Region of Cameroun

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Abstract

This study was conducted to evaluate the effect of the substitution of fishmeal by Lima bean flouron the growth performance, survival rate and feed cost of *Clarias gariepinus* between March and May 2018 within the AIO ICG of the Batié District. It also aimed to contribute to the development of alternative sources of animal protein on a global scale. For this purpose, 300 fry of *Clarias gariepinus* with an average weight of 3 ± 1.41g were divided into five batches and fed three times a day with rations corresponding to 5% of their ichthyobiomass. The rations R_0, R_{25} R_{50}, R_{75} and R_{100} respectively corresponded to the substitution rates of 0, 25, 50, 75 and 100% of fish meal by that of Lima bean. The physic-chemical characteristics of the water (pH, temperature, dissolved oxygen, nitrites and nitrates) were measured daily. The following results were obtained: The highest weight gains were obtained with the rations R_{25} (20.56 ± 0.40 g), R_{50} (20.64 ± 0.32 g), R_{75} (20.98 ± 0.46 g) and the lowest with the rations of R_{100} (16.21 ± 0.28 g). The highest average daily gain were 0.36 ± 0.02 g; 0.37 ± 0.01 g ; 0.38 ± 0.01 g respectively for the R_0, R_{50} and R_{75} rations and the lowest with R_{100} (0.29 ± 0.01 g). The highest value of the specific growth rate (2.47 ± 0.07%) was obtained with the ration R_0 and the lowest (1.61%) with the ration R_{100}. The consumption index reached its highest and lowest values with the rations R_{100} (4.74 ± 0.42) and R_{50} (3.57 ± 0.43) respectively, compared to the value of the ration R_0 (3.31 ± 0.37) for this parameter. Concerning the condition factor K, the highest value was recorded with the R_{50} diet (1.11 ± 0.49) while the lowest value was obtained with the R_{75} diet (0.95 ± 0.45). The cost of producing one kilogram of food was higher with the R_{25} ration (504.59 FCFA) and lower with the R_{100} ration (443.20 FCFA). Our results revealed that incorporating 75% Lima bean flour into the feed increases the growth performance of *Clarias gariepinus* fry and reduces the cost of food production.

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Introduction

Global fish production and demand are steadily increasing and have increased fivefold in less than 10 years (FAO, 2017)[11]. Production increased from 39 million tons in 2010 to 174.1 million tons in 2016 (FAO, 2017)[11]. In addition, its global *per capita* consumption per year has increased from an average of 9.9kg in the 1960s to over 20kg in 2016 (FAO, 2016)[10]. In sub-Saharan Africa, fish products contribute an average of 50% of GDP in protein intake of animal origin but are still insufficient (FAO, 2012)[9]. In Cameroon, the high protein demand linked to the impetus of the demographic growth of the population is generating interest in fish farming, which represents an alternative that can promote the self-sufficiency of rural populations and food security (Marquet, 1985)[20]. However, fish farming faces many constraints, the main ones being the lack of fry and quality feed, the unavailability of by-products and the high costs of imported food (Hishamunda and Ridler, 2003, Moehl et *al.*, 2006)[14,23]. Because of the high costs of imported feeds and the unavailability of certain ingredients, the protein component mainly made of fishmeal, remains the most expensive (Alphonsus et *al.,* 2009)[5] and it is urgent to find alternative sources available and less expensive. Thus, several studies have been conducted on the substitution of fishmeal by other protein sources, whether of plant or animal origin (Pouomogne, 1994; Olaniyi and Salau, 2013) [25,26,28]. Hence, this has led to the initiation or the attempt to replace total or partial fish meal with that of Lima bean (*Phaseolus lunatus*). The species *Phaseolus lunatus* is one of the least used legumes in Cameroon. This bean has an amino acid profile similar to that of common beans (Ologhobo, 1980, Aletor and Aladetimi, 1989) [27,4] but because of the ignorance of its nutritional potential, its culture is neglected. Thus, in order to get breeders to take an interest in this alternative source of protein, this research work has been initiated with the global objective of contributing to the development of alternative sources of protein in the diet of fish. More specifically, it was undertaken to evaluate the effect of Lima bean flour on the survival rate, growth performance and finally on the economic cost of producing *Clarias gariepinus*.

Materials and Methods

Study Zone

The study took place within the Joint Initiative Group of Integrated Western Aquaculture (ICG AIO), located between 5 ° 17'0 " - 5 ° 18'53 " of latitude North and 10 ° 17'0 " - 10 ° 19'31 " east longitude and at an altitude of 1700 m in the West Region of Cameroon, Haut-Plateau Division, specifically in the Batié Sub-division. The climate is the Sudano-Guinean type and includes a rainy season (mid-March to mid-November) and a dry season (mid-November to mid-March). The temperature and average rainfall are respectively 23 °C and 1621 mm / year.

Biological Material

Three hundred (300) *Clarias gariepinus* fry with a mean weight of 3 ± 1.41 g and a mean total length of 7 ± 1.45 cm were used. These fry were divided into five (5) batches according to the different diets tested. The loading of these fry, resulting from an artificial reproduction made within the GIC, was 20 fry per basin. Lima bean (*Phaseolus lunatus*) and agricultural byproducts were purchased from the Bafoussam city market.

Production of Lima Bean Flour

Fourteen (14) kilograms of beans were boiled 100°c for 2 hours and then dried under the sun to constant weight. It was then crushed and mixed with other agricultural by-products according to the food rations formulated.

Experimentation and Data Collection

Fifteen (15) circular basins of 1m3 each, filled with drilling water were used. The volume of water in each basin was 900 liters and the water was renewed to two-thirds (2/3) every day. To this, three hundred (300) *Clarias gariepinus* fry with comparable size and weight were randomly divided into five lots with three replicates per batch. Each batch was randomly assigned to one of the R0, R25, R50, R75 and R100 experimental diets formulated. The compositions and the bromatological characteristics are given in Table 1. The feed was distributed three times a day (7am, 12h and 18h) at 5% of ichthyobiomass (Tomedi et *al.*, 2008, Ani et *al.*,

Table 1. Food Composition, Bromatological Characteristics and Cost of Different Rations

feeds/Ingrédients in %	**R_0**	**R_{25}**	**R_{50}**	**R_{75}**	**R_{100}**
Fish meal	18.6	13.9	9.3	4.7	0
Bean flour	0	4.7	9.3	13.9	18.6
Cotonseed cakes	18.6	20.2	18	18	24.9
Soybean meal	18.5	20.2	22	23	24.9
Peanut cake	18.6	20.2	17	23	24.9
Remoulding wheat	7.8	5.4	3.2	3	0.00
Rice flour	7.8	5.4	3.2	4	0.00
CMAV	5	5	5	4	5
Palm oil	3.8	3.8	5	3	4
Cassava	1.5	1.5	1	2	1
Total	100	100	100	100	100
Bromatological characteristics					
Crude protein (% DM)	39.80	40.14	40.07	39.90	39.93
Metabolizable energy kcal / g	2714.86	2701.85	2752.10	2619.04	2797.20
Calcium g/kg	1.70	1.43	1.24	0.94	0.74
Phosphorus g / kg	1.15	1.00	0.86	0.70	0.58
Ca/P	1.49	1.43	1.42	1.35	1.27
Price of one kg of feed	522.19	504.59	487.09	469.48	443.20

Ca = calcium; P = phosphorus.

2013)[32,6] for 56 days during the experiment, and the quantity was readjusted after each control fishery.

Every two weeks, a control fishery was conducted and 25% of the fish in each treatment were individually weighed using an electronic scale of 0.1 gram precision and measured with a 0.1mm precision icthyometer. This made it possible to evaluate the growth characteristics of the fish and readjust the quantity of food to be distributed during the two following weeks.

In parallel with the data collection, the physical and chemical parameters of the water were obtained *in situ* between 06:00 and 07:00 in each basin: it consisted of taking the temperature, the pH, the ammonia, the nitrites, nitrates and dissolved oxygen from the water respectively using a HANNA mini-maxi thermometer, a Waterproof pH meter, a Tera nitrite chemical kit, and an EUTECH instrument or meter instrument. At the end of the test, all the fish were counted, weighed and measured.

Survival Rate and Growth Parameters

- The survival rate is the ratio (in percentage) between the number of fish at the end of the observation and the initial number of fish.

Loss of survival (%) = (Final number of fish / Initial number of fish) x100

- Weight gain: It evaluates the growth (weight) of fish at a given time.

Weight gain (g) = Final average weight -

Initial average weight

- **Average daily gain** gives informations on the daily growth rate of fry during the experimental period.

Average daily gain (g / d) = Weight gain / time (number of days).

- Specific growth rate: it helps to evaluate the weight gained by the fish every day from it live weight.

Specific growth rate (%) = [(final average weight) - (initial average weight)] * 100 / time; ln = natural logarithm

- condition factor K: it gives the overweight of fish during the experiment.

Condition factor K (%) = (W / LT3) x100 with W = weight in g, L = total length

- Consumption index: it is a coefficient which is often used by zootechnicians to characterize the efficiency of feed.

Consumption index = quantity of food served / weight gain

Financial Evaluation

The financial evaluation of the ration was made on the basis of the prices of the different ingredients on the market and on the basis of the cost of production of the kilogram of Lima beans.

- **Cost of Feed Consumption** = Cost of Kg of Feed x Feed Consumption

- **Production Feed Cost** = Feed Consumption Cost x Consumption Index

Statistical Analyzes

The growth and biochemical parameters were expressed on mean standard deviation and in percentages. One-way analysis of variance (ANOVA) was used to test the effects of treatment and the Ducan test (at 5% threshold) to separate the means when there was a significant difference. SPSS 20.0 software was used for analysis.

Results and Discussion

Results

Effect of the Substitution of Fishmeal by Lima Bean Meal in the Feed on the Survival Rate of Clarias Gariepinus

The effect of fish meal replacement by Lima bean flour on the survival rate of *Clarias gariepinus* is shown in Figure 1. It shows that the highest survival rate (98.4 ± 2.3%) was obtained with the R_{50} ration followed by R_{75} and R_{100} (97.6 ± 2.5%). The lowest value (96.5 ± 2.5%) was recorded with the R_{25} diet, although no significant difference was observed between the diets (R_0, R_{25}, R_{50}, R_{75} and R_{100}).

Effect of Fishmeal Substitution by Lima Bean Flour on the Growth Characteristics of Clarias Gariepinus

The effect of the substitution of fishmeal by Lima bean flour on growth characteristics is summarized in Table 2 and illustrated in Figures 2 to 6. It is generally apparent that all characteristics were significantly affected. From Table 2, it appears that the R_{100} diet gave the significantly ($p < 0.05$) lowest weight gains (GP). On the other hand, no significant ($p > 0, 05$) difference ($p > 0, 05$) was observed between the other treatments. Regarding average daily earnings (ADG), the lowest significant ($p < 0.05$) value was obtained with the R_{100} ration. The latter was comparable ($p > 0, 05$) to rations R_{25}. The R_{75} diet gave the highest value but comparable ($p > 0, 05$) to that of the R_0 and R_{50} values.

With respect to the specific growth rate, the values were comparable ($p > 0, 05$) with the R_0 to R_{75} diets and significantly low with the R_{100} diet. With regard to the condition factor K, it recorded the values significantly ($p < 0.05$) higher with the ration R_{50}, R_{25} and R_0 and significantly ($p < 0.05$) lower with the R_{75} and R_{100}. The opposite trend was observed with the consumption index with R_{100} having the significantly ($p < 0.05$) higher index value.

Effect of Fish Meal Substitution by Lima Bean Meal on Clarias Gariepinus Weight Gain

The effect of fish meal replacement by Lima bean flour on the weight gain of *Clarias gariepinus* fry, as shown in Figure 2, shows that the weight gain generally increased over time regardless of the food ration experienced. However, weight gains were significantly greater with the R_{75} (20.98 ± 0.46g), R_{50} (20.64 ± 0.32g), R_0 (20.25 ± 0.44g) and R_{25} (18.56 ± 0.40 g) in contrast to the R_{100} diet which was the lowest value (16.21 ± 0.28 g).

Effect of Fish Meal Substitution with Lima Bean Meal on

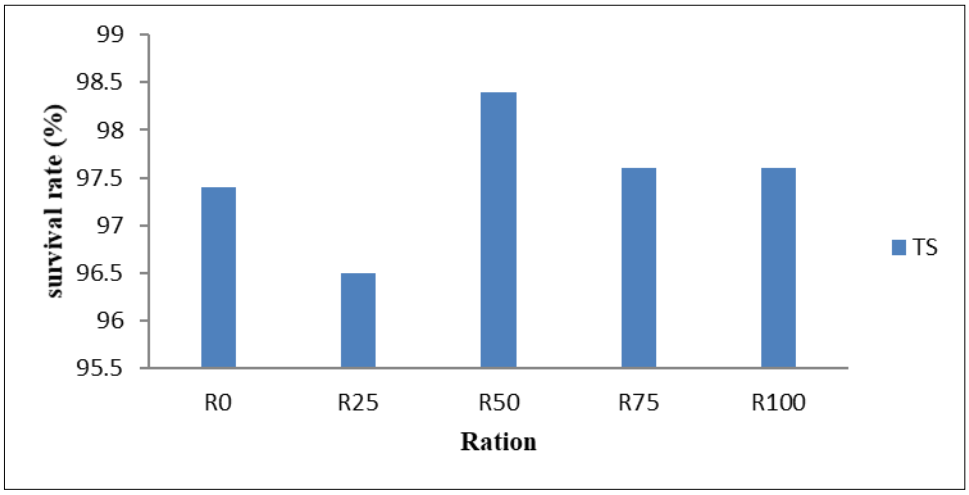

Figure 1. Effect of fishmeal substitution by Lima bean meal on the survival rate of *Clarias gariepinus*

R0-R100: Rations containing respectively 0%, 25%, 50%, 75% and 100% Lima bean flour; TS: survival rate

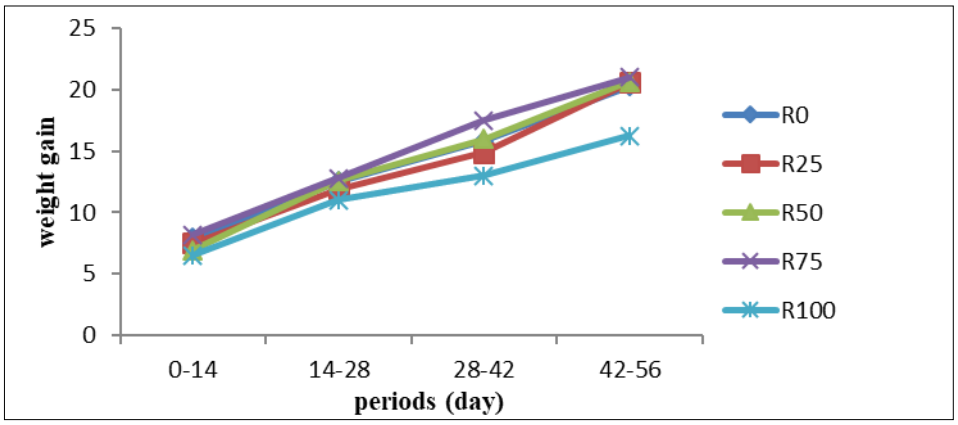

Figure 2. Effect of the substitution of fishmeal by Lima bean meal on the weight gain of *Clarias*

R0-R100: Rations containing respectively 0%, 25%, 50%, 75% and 100% Lima bean flour

Table 2. Values of zoo technical characteristics according to the substitution rate of fishmeal by Lima bean flour

Parameters	**R_0**	**R_{25}**	**R_{50}**	**R_{75}**	**R_{100}**
In	60±0	60±0	60±0	60±0	60±0
Fn	57.5±1.50	58±1.00	56±1.50	58±0.50	59±0.50
Wg (g)	20.25 ± 0.44^b	18.56 ± 0.4^b	20.64 ± 0.32^b	20.98 ± 0.46^b	16.21 ± 0.28^a
ADG (g)	0.36 ± 0.02^b	0.33 ± 0.01^a	0.37 ± 0.01^b	0.38 ± 0.01^b	0.29 ± 0.01^a
SGR (%)	2.33 ± 0.07^b	2.20 ± 0.05^b	2.47 ± 0.1^b	2.51 ± 0.45^b	1.61 ± 0.04^a
K	0.99 ± 0.38^a	1.01 ± 0.43^a	1.11 ± 0.49^a	0.96 ± 0.38^b	0.95 ± 0.45^b
CI	3.31 ± 0.37^b	3.63 ± 0.52^b	3.47 ± 0.43^b	3.68 ± 0.28^b	4.74 ± 0.42^a

In: initial number of fish, **Fn**: final number of fish, **Wg**: weight gain; **ADG**: average daily gain; **SGR**: specific growth rate; **CI:** consumption index**, K:** condition factor. **R0-R100**: Rations containing respectively 0%, 25%, 50%, 75% and 100% of Lima bean flour.

(**a, b, c)** averages with the same letters for the same line are not significantly different (p>0,05).

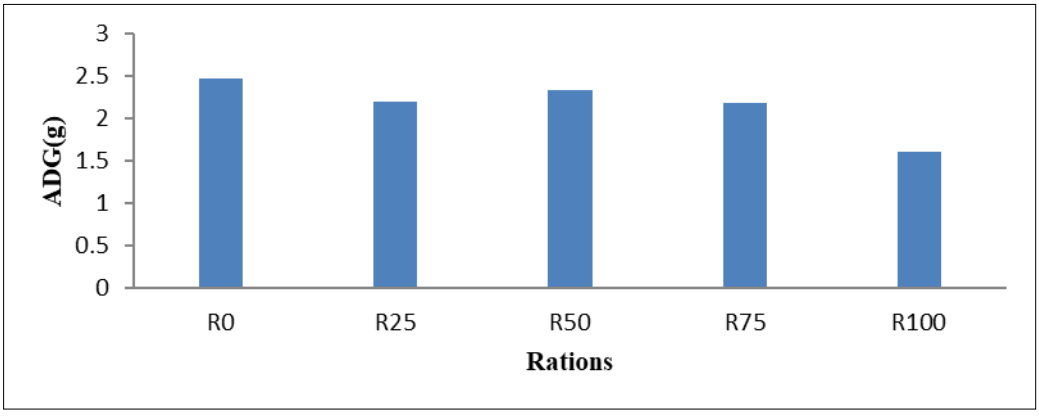

Figure 3. Effect of the substitution of fish meal by bean flour on the average daily gain of *Clarias gariepinus*

R0-R100: Rations containing respectively 0%, 25%, 50%, 75% and 100% Lima bean flour

Average Daily Gain of Clarias Gariepinus Fry

Figure 3 illustrates the effect of fish meal replacement by Lima bean flour on average daily gain in *Clarias gariepinus* fry. Generally, it appears that the average daily gain increased throughout the study period regardless of the treatment. However, it was significantly ($p<0.05$) higher with the R_0 (0.36 ± 0.02g), R_{50} (0.37 ± 0.01g) and R_{75} (0.38 ± 0.01g) rations, while the most less values 0.33 ± 0.01 g and 0.29 ± 0.01 g were obtained with R_{25} and R_{100} respectively.

Effect of Fish Meal Replacement by Lima Bean Meal on the Specific Growth Rate of Clarias Gariepinus

The effect of fish meal replacement by lima bean meal on the specific growth rate of *Clarias gariepinus* (Figure 4) shows that R_0 (2.47 ± 0.07%), R_{25} (2.2 ± 0.05%), R_{50} (2.33 ± 0.1%) and R_{75} (2.18 ± 0.45%) were significantly ($p<0.05$) higher than the R100 diet (1.61 ± 0.04%) which recorded the lowest value.

Effect of Fishmeal Substitution by Lima Bean Meal on the Condition Factor of Clarias Gariepinus

The effect of the substitution of fishmeal by Lima bean flour on the condition factor K is shown in Figure 5. It is apparent that the overall trend, profile and the pace are comparable between treatments. However, the rations R_{50} (1.11 ± 0.49), R_{25} (1.01 ± 0.43) and R_0 (0.99 ± 0.38) recorded the significantly ($p<0.05$) highest values, unlike the 0.96± 0.38 and 0.95 ± 0.45 values of R_{75} and R_{100} respectively.

Effect of Fishmeal Substitution by Lima Bean Meal on the Consumption Index of Clarias Gariepinus

The consumption index of *Clarias gariepinus*, as illustrated in Figure 6, was significantly ($p<0.05$) affected by the substitution of fishmeal with Lima bean flour. Thus, the lowest index value (3.31 ± 0.37) was recorded in the lots that received the R_0 ration followed by R_{50} (3.47 ± 0.43) and the highest (4.74 ± 0.42) was obtained with R_{100}. This characteristic tends to increase with the level of substitution.

Correlation between the growth Characteristics of Clarias gariepinus and the Physicochemical Parameters of Water

In general, the growth characteristics were not influenced by the physical and chemical parameters of the water, with the exception of the consumption indices of the R_0 and R_{50} diets, which significantly ($p<0.05$) were affected by the temperature of the water and the rate of nitrite; and mean daily gain (ADG) that was significantly influenced ($p<0.05$) by pH and dissolved oxygen. (Table 3)

Financial Evaluation

The economic evaluation of the different rations is summarized in Table 4. It appears that the R100 ration had the lowest production price (443.2 FCFA), followed by R_{75} (469.48 FCFA) and R_{50} (487.09FCFA). However, the best value for money was obtained with R_{75}. (Table 4)

Discussion

The results show that survival rates were not significantly affected by the different percentages of fish meal substitution by Lima bean flour. This rate varied from 96.5 ± 2.50 to 98.4 ± 2.30%. These results are similar to those obtained by Pouomogne (2013)[30] who recorded a maximum survival rate of 96.66% and those of Keremah et *al.* (2014)[18] who obtained a survival rate ranging from 76.7 to 96.7%. They are also similar to those obtained by Lacroix (2004)[19] who registered a survival rate ranging from 98 to 100% in *Clarias gariepinus* in breeding fish ponds. The lack of difference reflects the fact that Lima beans can substitute fishmeal without affecting the survival of fish.

Results on growth characteristics indicated that the weight gain, average daily gain, and specific growth rate of fish fed with the feed containing different levels of Lima bean meal were significantly comparable to those receiving the control diet, with the exception of fish fed with the R100 diet. These results are in accordance with the work of Adeparusi and Olute (2000)[2] who evaluated the influence of a food-based diet of Lima bean (80%) in *Oreochromis niloticus* and found that the diet containing approximately 20% of fish meal gave the best results.They are also similar to those obtained by Ekoué et *al.,* (2013)[8] who observed that feed with similar composition gave the best results with substitution rates of 30 and 60% of fish meal by lima bean meal on juveniles of *Clarias gariepinus*. These similar results may be due to the fact that proteins and other nutritive substances in the lima bean were assimilated by the fry of *Clarias gariepinus*. However, these results are in contrast with those of Abel et *al.,*[1]

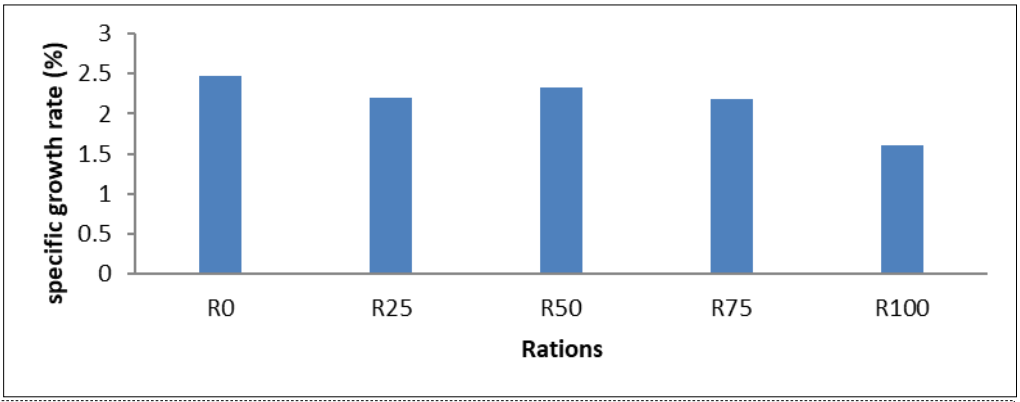

Figure 4. Effect of the substitution of fishmeal by Lima bean flour on the specific growth rate of *Clarias gariepinus*

R0-R100: Rations containing respectively 0%, 25%, 50%, 75% and 100% Lima bean flour

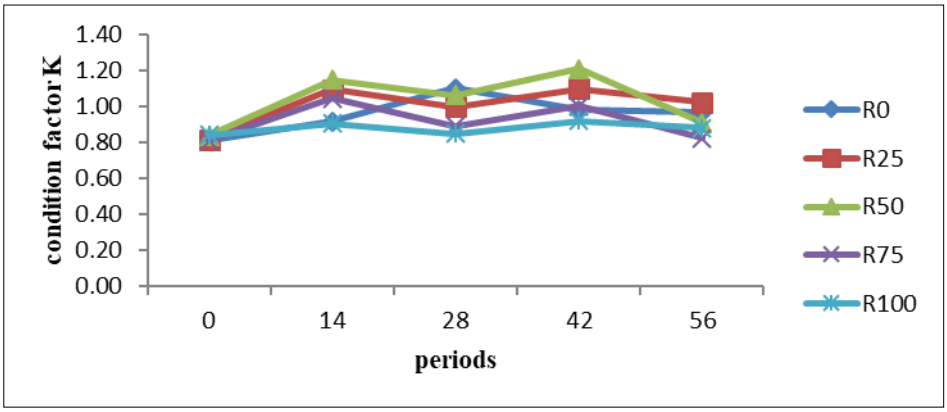

Figure 5. Effect of the substitution of fishmeal by Lima bean meal on the overweight of *Clarias gariepinus*

R0-R100: Rations containing respectively 0%, 25%, 50%, 75% and 100% Lima bean flour

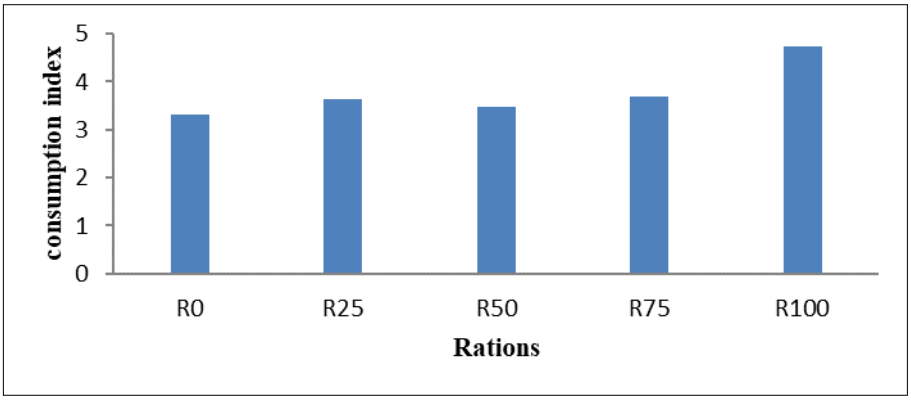

Figure 6. Effect of fishmeal substitution by Lima bean meal on the consumption index of *Clarias gariepinus*

R0-R100: Rations containing respectively 0%, 25%, 50%, 75% and 100% Lima bean flour

Table 3. Correlation between the growth characteristics of *Clarias gariepinus* and the physicochemical parameters of water

Rations	**Growth characteristics**	**Correlation**				
		T(°C)	pH	NO_2^-(mg/l)	NO_3(mg/l)	Oxygen
R_0	K	0.351	0.163	0.773	-0.026	-0.903
	CI	0.999*	-0.889	0.840	-0.959	-0.686
	ADG	0.639	-0.169	0.938	-0.353	-0.994
	weights	0.371	0.143	0.785	-0.047	-0.911
R_{25}	K	-0.087	-0.574	0.423	0.423	-0.201
	IC	-0.437	-0.828	0.071	0.071	-0.537
	ADG	0.765	0.985	0.341	0.341	0.834
	weights	0.292	-0.225	0.731	0.731	0.181
R_{50}	K	-0.941	0.988	-0.848	-0.779	0.628
	CI	-0.637	0.771	-1.000*	-0.349	0.937
	ADG	0.357	0.174	0.513	-0.643	-0.766
	weights	0.995	-0.996	0.693	0.908	-0.419
R_{75}	K	-0.995	-0.894	-0.893	-0.056	-0.138
	CI	-0.614	-0.941	-0.289	0.685	0.622
	ADG	0.165	0.667	-0.201	-0.949	-0.919
	weights	-0.941	-0.976	-0.756	0.189	0.108
R_{100}	K	0.520	-0.024	0.854	-0.155	-0.024
	CI	0.989	-0.931	-0.150	-0.971	-0.931
	ADG	0.866	-1.000**	-0.499	-0.991	-1.000**
	weights	-0.971	0.961	0.241	0.989	0.961

*. Correlation is significant at 0.05 (bilateral)

**. Correlation is significant at 0.01 (bilateral).

Table 4. Evaluation of the cost of different rations

Experimental rations	R_0	R_{25}	R_{50}	R_{75}	R_{100}
Price of a kg of feed	522.195^b	504.59^b	487.09^b	469.48^a	443.20^a
Feeding cost of a kg of fish	1044.39	787.16	774.47	1065.72	899.69

R_0-R_{100}: Rations containing respectively 0%, 25%, 50%, 75% and 100% of Lima bean flour.
Prices with the same letters for the same line are not significantly different (p>0, 05).

(1984) who observed that the feed of mirror carp containing 50% of soy bean meal treated with heat replacing half of the fish meal reaches 60 to 65% of growth with feed made from fishmeal.

Moreover, the individual average daily gain registered in the present study (0.35g/day) is higher than that obtained by Gandaho (2007)[12,13] with moringa leaves (0.19g/day) but remains inferior to 0.47g/j as reported by Mouori (2007)[24] and to 0,45g/day obtained by Ekoué (2013)[8] who substituted fish meal by soy bean meal in juveniles of *Clarias gariepinus.* This average daily gain is equally ten times inferior to 3g/day obtained by Micha (1974) and Lacroix (2004)[19,21] in juveniles of *Clarias gariepinus* fed with feed grading 40 and 30% protein respectively and raised to 30°C. These results can justified by the environmental conditions of these studies specifically the average temperature which is around 23.01°C.It is the same with the values of the specific growth rate (1.61% to 2.51%) which are greater than 0.04 to 0.18%/day obtained by Pouomogne (1995)[29] and to 0.78% reported by Keremah et *al*., (2014)[18]. However, they are inferior 2.90 %/day; 3.4 %/ day and 4.14 to 5.80 %/day obtained respectively by Lacroix (2004); Hoffman *et al.,* (1997) and Toko (2007)[15,16,19] in *Clarias gariepinus.* The values of the specific growth rate are also inferior3.60%/day as presented (Ekoué, 2013)[8] in juveniles of the same species and to the values obtained by Kanangire (2001)[17]in the same species. The values obtained by Kanangire (2001)[17] are aound 4.26; 4.05 and 3.85 %/j gotten respectively for feed in Azolla (0%, 30%, and 50%). These low performances may be due to the experimental conditions. In facts, the average temperatures (23.01°C) of our experiment were lower than 27.4°C of Keremah et *al,* (2014)[18]. The thermal interval favourable to a better growth of Clarias is around 26 and 30°C (Baras and Jobling, 2002)[7]. The difference observed can be due to the genetic material used and to the feed quality because is an omnivorous species with a carnivorous tendency.

The condition factor K which gives the overweight of fish varies with the treatment (rations) and was greater than 1 for the R_{25} and R_{50}reflecting a good weight according to Fulton (1902) who reported that when K>1 it means that the fish has a good weight.In fact, the condition factor K obtained in *C. gariepinus* in this study was between 0.95 et 1.11. These values are comparable (P> 0,05) to those (0,62 à 1,86) reported by Mlewa et *al*., (2004)[22] in *Protopterus aethiopicus* and superior to those obtained by par Rukera et *al.,*[31] (2005) (0,79 à 0,83%) in *C. gariepinus* raised at many density and fed with complete feed or to those reported by Ekoué (2013)[8] (0,06 à 0,74). The difference between these values might be due to an optimal use of plant resources in livestock breeding.

Regarding dietary parameters, the consumption index was significantly comparable between the different diets (R_0, R_{25}, R_{50} and R_{75}). However, the consumption index values recorded during the study (3.31 ± 0.37 to 4.74 ± 0.42) are far superior to the values of 1.3 and 1.7 found by Lacroix (2004)[19] by feeding fish in floating cages using feed that has 30% crude protein at a density of 100 individuals/m^3. Similarly, this index was also higher than that reported by Yakubu et *al*. (2013)[33] at a density of 95 individuals/m^3 and at 1.46 registered by Olayini and Salau (2013)[25,26] in *Clarias gariepinus* fed with feed containing maggots meal. In this study, the incorporation of Lima bean flour generally increased ingestion in *Clarias gariepinus* fry relative to the control diet (R_0). This observation makes it possible to assume that the feeds tested were more appreciated by the *Clarias gariepinus* fry than the R_0 control feed though their assimilation has been variable.

The R_{75} diet represents the best value for money (469.48 FCFA per kg of food purchased and 1065 FCFA obtained per kg of fish sold) and is therefore the most efficient bio economically. This result is in accordance with the works of Ajani et *al.* (2004)[3] which show that the substitution of fish meal by maggots meal at 50 and 100% helps to reduce the production cost of a kilogram of fish at about 18 to 28% due to the low cost of ingredients.

Conclusion

At the end of this study on the effect of the replacement of fishmeal with Lima bean flour, aimed at contributing to the development of alternative sources of animal protein the following conclusions were drawn:

- The survival rate of *Clarias gariepinus* fry was not significantly affected by the substitution rate.

Ø However, the highest survival rate was recorded with

the lot fed with the R_{50} ration; all growth characteristics were significantly affected by the substitution rate.

Ø However, it should be noted that the best characteristics were obtained with the R_{50} ration while the feed containing 75% Lima bean flour is the most bio economically efficient.

In view of the above, the use of the ration substituted by 75% Lima bean increases the growth performance of *Clarias gariepinus* fry and reduces the cost of food production. However, the influence of Lima bean flour on reproductive parameters and the technological and organoleptic qualities of fish flesh should be examined.

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