Effects of cowpea (*Vigna unguiculata* (L.) Walp.) as a fishmeal replacer in diet on growth performance of catfish *Clarias gariepinus* (Burchell, 1822) reared in tanks

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Abstract: The aim of this study was to test the substitution of fish meal by cowpea meal *Vigna unguiculata* in order to improving access for local fish farms to a high-performance feed at low cost. The experimental system consisted of two tanks, each containing 30 *Clarias gariepinus* individuals. In tank T1, the fish were fed with imported fishmeal feed, while in tank T2, they were fed with feed made locally from cowpea meal. During the three-week experiment, mean temperature in the tanks varied between 25±.27 and 26±19, and pH between 7±10 and 8±.09. These values were close to the optimum growth conditions for *C. gariepinus* fry. Growth data were obtained by evaluating various growth parameters. Data on average length and weight gains showed that the T1 feed had the best results with an increase of 5.83cm and 13.69g, compared with 2.58 cm and 7.02 g for the T2 diet. In terms of feed conversion ratio, the fishmeal-based feed had the lowest value (1.4 compared with 2.32 for local food), which also means that it's the diet most likely to promote weight gain in fish. Similarly, the T1 diet also showed the best Specific Growth Rate (1.61% / day) compared with the T2 diet (0.76% / day). These results suggested that cowpea meal could be used as a feed component in clarias farming, but appears less efficient when used to replace fishmeal entirely.

Keywords: imported feed; local feed; cowpea meal, *Clarias gariepinus*, growth

1. Introduction

The consumption and demand for fish as a cheap source of animal protein has increased in Africa. Aquaculture can therefore be seen as a good way of supplementing capture fisheries (Mbaye, 2005), whose landings are constantly declining.

In Senegal, the aquaculture sector is one of the priority sectors for economic growth. It is a viable alternative fish production system, capable of adequately meeting the demand for animal protein. However, the development of this sub-sector faces a major obstacle, specifically the cost of feed, which accounts for some 75-80% of total production costs (Kébé, 2008). In fact, fishmeal is generally the essential component of aquaculture feed (Ndione, 2022). Its high purchase price and irregular quality have prompted research into alternative protein sources that are not directly usable for human consumption. Research has therefore turned to other protein sources, to replace fishmeal, in particular with other animal raw materials, while seeking to preserve the organoleptic nutritional qualities of aquaculture fish. To add value to agricultural by-products such as millet bran, rice bran, peanut cake and corn meal (grown in Senegal and other African countries), these have been combined with fish meal to produce a feed for aquaculture fish.

However, the development of aquaculture in developing countries will be possible on condition that local agro-industrial by-products are valorized. Indeed, access to fishmeal traditionally used in the production of high value-added fish is not always possible, and represents an excessive expense that small local producers cannot easily afford.

It is within this context that this study has been carried out to evaluate the effects of cowpea meal *Vigna unguiculata* in substitution for fish meal on the growth performance of *Clarias gariepinus*. Cowpeas are widely grown in Senegal, with a growing impact on the nutritional quality of food products (Tienebo, 2009). Catfish of the *Clarias* genus is a species with high growth potential (Sagne, 2019; Ducarme and Micha, 2003). Popularizing catfish farming could help meet the animal protein and essential nutrient requirements of significant populations in Senegal.

2. Material and Methods

Study Area

The experiments were carried out on the fish farm of the Centre National de Formation des Techniciens des Pêches et de l'Aquaculture (CNFTPA) located in Dakar, Senegal (14°44'20" N, 17°23'47" W). This institution is under the authority of the « Ministère de la Formation professionnelle, de l'Apprentissage et de l'Artisanat ». The biological material consists of 60 individuals of *Clarias gariepinus*. Two plastic tanks with a dimension of 0.76 x 0.44 x 30 m were used for the experiment.

Methodology

1. Food formulation and chemical composition of fish feed

Table 1 shows the proportions of the various ingredients present in each feed for 20 kg of feed. The imported feed containing a high proportion of fish meal is devoid of cowpea, while in the local feed, fishmeal has been replaced by cowpea meal.

Table 1 feed formula for both imported and local feeds

Components	Imported feed		Local feed	
	For 20 kg	%	For 20 kg	%
Fish meal	6	30%	0	0%
Peanut meal	4.6	23%	4.6	23
Corn flour	4.4	22%	4	20%
Rice bran	4	20%	5.4	27%
Mineral premix	0.2	1%	0.2	1%
Vitamin premix	0.2	1%	0.2	1%
Aqua binder	0.2	1%	0.2	1%
Fish oil	0.4	2%	0.4	2%
Cowpea	0	0%	4	20%
TOTAL	20kg	100%	20kg	100%

The chemical composition of the two types of feed used (imported vs. local feed) is shown in Table 2.

Table 2 chemical composition of the two feed types, imported and local

Analyses	Imported feed	Local feed
Crude protein	29.00%	20.81%
Crude fat	8.00%	4.69%

Crude cellulose	4.20%	10.20%
Crude ash	7.70%	0%
Calcium	0.94%	0.66%
Humidity	0%	11.22%
Total phosphorus	0.95%	0%
Sodium	0.15%	0.57%

2. Physicochemical parameters

Water quality was observed on each culture system during the study. Data were collected from each culture system. Environmental parameters such as temperature and pH where daily measured using a pH/temperature sensor HI12963.

3. Breeding technique

The experiment was carried out on 60 *Clarias gariepinus* individuals, divided into two tanks with 30 fish in each rearing system. In tank 1, fish individuals (with an average weight of 4.67 g) were fed imported feed, and in tank 2 (with an average weight of 4.58 g) they were fed local feed manufactured at the CNFTPA. The clarias were acclimatized for 7 days before the commencement of the experiment. They were fed twice a day and weighed every 7 days. Individual weights and lengths were measured using 0.01g precision electronic scales and calipers respectively.

4. Growth parameters

Results are obtained by evaluating the following growth parameters:
Average length and weight gain: these parameters were used to evaluate fish length and weight growth over a given period of time. In the present study, absolute length gain (ALG) and absolute weight gain (AWG) were used.

$$ALG\ (cm) = Average\ final\ length - Average\ initial\ length$$

$$AWG\ (g) = Average\ final\ weight - Average\ initial\ weight$$

The food conversion rate (FCR) : this coefficient is used to characterize feed utilization efficiency.

$$FCR = \frac{Amount\ of\ feed\ distributed\ per\ fish}{Weight\ gain}$$

The specific growth rate (SGR) : This coefficient measures the weight gained by each fish each day, as a percentage of its live weight.

$$SGR\ \left(\%\frac{g}{day}\right) = \frac{Q(\ln(Final\ average\ weight) - \ln(Initial\ average\ weight))}{duration\ of\ experiment\ per\ day} \times 100$$

3. Résults

Physicochemical parameters

The physicochemical variables obtained in this study (Table 3) showed that temperature varied between 25±27°C and 26±19°C in both *Clarias gariepinus* growth environments. PH ranged from 7±10 to 8±.09.

Table 3 mean and standard error (SE) of environmental parameters recorded in tank 1 and tank 2

Tank number	Parameters	Experimental weeks		
		Week 1	Week 2	Week 3
Tank 1	**Temperature (°C)**	26±17	26±19	25±28
	pH	7±10	7±29	7±44
Tank 2	**Temperature (°C)**	25±,76	26±16	25±,27
	pH	8±,09	7±76	7±51

Growth parameters

1. Average length and weight gains

Fish in tanks T1 and T2 were measured and weighed after 21 days of experimentation. The difference in length between the beginning and end of the experimental period is greater for the imported feed (Figure 1A). There was an increase of 5.83 cm in tank T1, while in tank T2, containing the local feed, there was an increase of only 2.58 cm. The values of the average weight gain showed that the T1 feed had the best results (Figure 1B), with an AWG of 13.69 g obtained after three weeks of rearing. In contrast, fish reared in tank T2 showed a lower average weight gain (7.02 g).

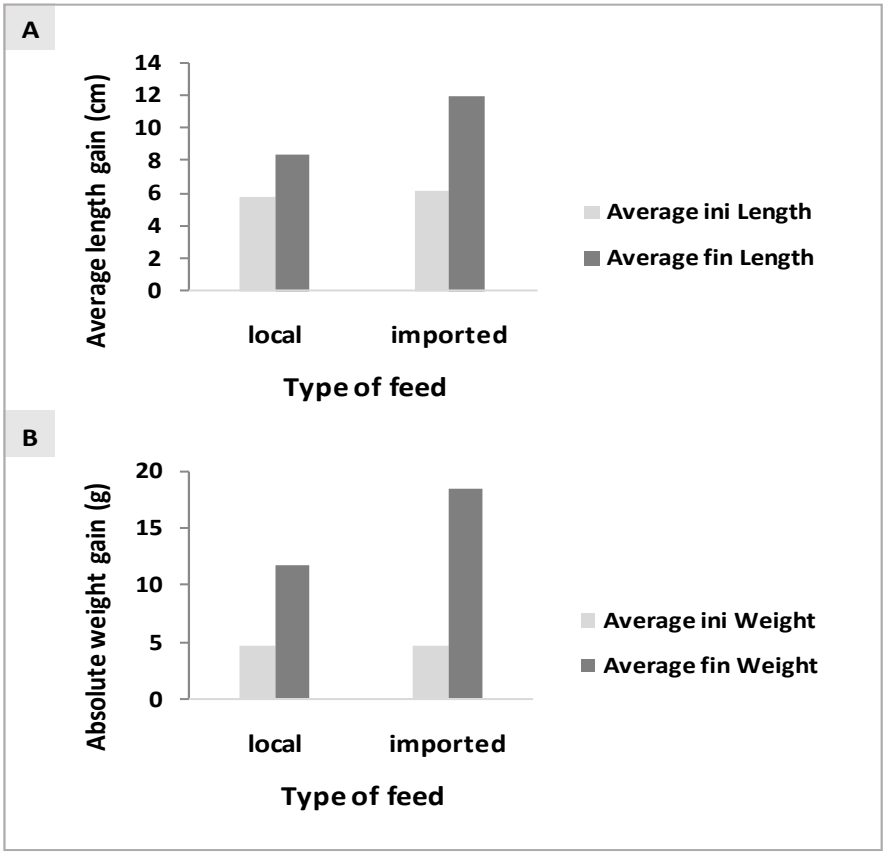

Figure 1 average length (A) and weight (B) gain of fish fed with imported and local feed. ini = initial; fin = final.

2. Feed conversion rate (FCR)

The most effective diet is the one with the lowest FCR. Results shown in Table 3 indicated that diet T1, corresponding to the fishmeal-based diet, is the most effective diet, as it has the lowest FCR of 1.4. The T2 diet, containing a high proportion of cowpea, is considered the least effective diet during the present study, with a feed conversion ratio of 2.32.

3. Specific Growth Rate (SGR)

The SGR has shown the same trends as the previous growth parameters (Table 3). The T1 diet also presented the best Specific Growth Rate (1.61% / day) compared with the T2 diets, which had a value of 0.76% / day.

Table 3 growth parameters for imported and local feed. SGR = Specific Growth Rate; FCR = Feed conversion rate

Parameters	T1 diet	T2 diet
FCR	1.4	2.32
SGR (%)	1.61	0.76

4. Discussion

During the three-week experiment, the average temperature was 27.1°C. This value is close to the optimal temperature for the growth of *Clarias gariepinus* fry, which according to Bara and Jobling (2002) is around 26°C. The pH was almost neutral throughout the experiment, varying between 7±10 and 8±.09. These values ranged from 6.7 and 7.5, which is the recommended pH range for breeding this species (Marimuthu et al., 2019).

The use of cowpea meal-based feed (*Vigna unguiculata*) as a substitute for fish meal in the formulation of *Clarias guariepinus* feed would have a positive influence on its growth performance (Diop, 2018). However, in the present study, the imported feed appears to be more conducive to clarias growth than the local feed manufactured with a substitution of cowpea for fishmeal. Indeed, in terms of total biomass at the end of the experiment, fish fed diet T1 (imported feed) showed the best weight gain compared with diet T2 (local feed). These results are superior to those obtained by Orire and Ozoadibe (2015), who obtained an absolute mean weight gain equal to 1.37 in the diet containing 100% soy waste in juvenile *C. gariepinus*. In contrast, this values for absolute weight gain (15.3 for feed T1 and 2.65 for feed B2) are lower than those (5.24 g) reported by Soumaïla, et al. (2016) on the study of the effect of substituting fish meal with *Achatina fulica* (African giant snail) meal on the growth of *C. gariepinus* fry. The use of cowpea meal as a substitute for fish meal in the feed formulation of *C. guariepinus* would have a positive influence on its growth performance (Diop, 2018).

Concerning the feed conversion ratio (FCR), which measures an animal's ability to convert feed mass into essential requirements, the T1 diet seemed to perform better, as it had the lowest FCR of 0.37. The local feed in the T2 tank had a higher FCR (1.4), and therefore appeared to be less rich. The local feed distributed in T2 had a higher FCR (1.4), and therefore appeared to be less rich than the imported feed. This value is in line with that of Nandakumar et al. (2017), who found conversion rates (1.73) in *Lates calcarifer* (barramundi) fry fed on vegetable by-product feed.

In terms of specific growth rate, the best result was obtained in diet T1 with 1.61%/day. These values are also higher than those obtained by Amisah et al. (2009), who obtained a specific growth rate of 0.31 in *Clarias gariepinus* juveniles fed the diet containing 20% *Leucana leucocephala*, a Mimosa species in the Fabaceae family. This result is also lower than that obtained by Djissou et al. (2016), with *Oreochromis niloticus* fed on the diet containing 8% *Dialium guineense* (tamarind) and 10% *Azolla filiculoide* (water fern), which is equal to 1.33, or those reported by Ernesta et al. (2016) (4.98%/d) obtained in tilapia fed on the control diet during trials replacing fish meal with oyster meat meal.

5. Conclusion

The aim of this study was to replace fish meal with cowpea meal (*Vigna unguiculata*), in an attempt to solve the problem posed by the lack of high-performance fish feeds accessible to average fish farmers and thus contributes to the development of this activity. The test between the two types of diet showed that the imported food containing a high proportion of fish meal was more performant than the one where fish is replaced by cowpea. Thus, results of this study suggested that cowpea meal could be used as a feed component in clarias farming, but appears less efficient when used to replace fishmeal entirely.

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