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Total Replacement of Fish Oil by *Balanites aegyptiaca* and *Adansonia digitata* Seed Oils in Diets of *Clarias anguillaris* Fry

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Abstract

Clarias anguillaris fries were fed with three isoproteic (30.25%) and isoenergetic (1.42 MJ/Kg) diets to evaluate the effects of plant seed oil on the growth performance, feed efficiency and survival rate. The test was carried out on *Clarias anguillaris* with an initial average weight of 0.07 g distributed in 6 plastic tanks with a stocking density of 15 fries each. The treatments were in duplicate for 45 days. The results of this experiment showed that the fish fed diet B containing *Adansonia digitata* seed oil as a source of lipid has the best total average weight gain (AWGa) (0.15g) compared to those fed with P and S diets containing fish oil and the *Balanites aegyptiaca* seed oil respectively. Similar results were obtained with the specific growth rate, which showed a significant difference between the fish fed with B diet and those fed with S and P diets that do not differ significantly between them. The best feed conversion rate (FCR) was obtained with the fish fed with B diet, which showed a significant difference with the fish fed with P and S. The best survival rate (SR) of 80% was obtained with the fish fed with diet B, followed by 73% in fish fed with diet S, and finally the lowest value 67% was contained in the fish fed with the control diet P. The best protein efficiency ratio (PER) was obtained with the fish fed with diet B (1.16) followed by the fish fed with diet S (0.80) compared with the fish fed with the control diet P (0.74). From the results of this study, we can say the replacement of fish oil with *Balanites aegyptiaca* seed oil and *Adansonia digitata* seed oil has no negative impact on the growth of *Clarias anguillaris* fries. In conclusion, diet B containing *Adansonia digitata* seed oil appears to be more suitable for *Clarias anguillaris* fry growth.

Keywords: *Balanites aegyptiaca*, *Adansonia digitata*, Seed oil, Growth performance, feed efficiency, survival, *Clarias anguillaris*

1. Introduction

One of the significant issues in fish nutrition is the reduction in the use of raw materials of marine origin (fishmeal and fish oil) to preserve natural resources while allowing a sustainable development of aquaculture. For this, it is necessary to diversify the raw materials incorporated in fish feed, in particular by using vegetable proteins and oils, available in larger quantities and with more regularity. However, the nature of lipids incorporated in fish feed conditions the fatty acid composition of the flesh.

In Senegal, fish represents 30 to 40% of animal proteins (FAO, 2010). The fisheries sector has been in crisis for years due in part to the existence, overexploitation of major stocks, the weakness of the resource tracking system and fisheries monitoring. Between 2000 and 2010, fish production increased from 390,300 tons to 407,029 tons, of which 30% is for export. During this decade, landings were around 400,000 tons representing Senegal's annual production potential (ANSD, 2011). In fact, for the same year, ANSD reports that fishing landings decreased by 8.1% between 2009 and 2010. This decline is attributable to the decrease in landings of industrial (-11.1%) and artisanal (-7.8%) fisheries.

To cover this protein deficit, the development of fish farming brings great hope. However, what species should be raised to compensate for this imbalance quickly? One answer to this question is the fish farming of species with high growth potential such as *Clarias anguillaris*.

In Senegal, the breeding of this species is quite recent because of the difficulties of production of juveniles in captivity. However, currently, artificial reproduction techniques described by Viveen et al. (1985) have facilitated the supply of fry and consequently revived the production of this species. However, the availability of adequate and locally available food is a limiting factor for the development of this activity.

Due to the many benefits associated with the production of this species, several studies related to its diet with the use of several local by-products as a source of protein in a controlled environment and vegetable oils have been realized (Okoye and Eyo, 2002; Ng et al., 2003; Babalola and Apata, 2012).

However, unlike fish oil, vegetable oils are cheaper and do not accumulate persistent organic pollutants (POPs). Also, production costs can be reduced in vegetable oil-based diets, as well as exposure to contaminants for fish and consumers.

This study aimed to substitute fish oil with vegetable oils such as *Adansonia digitata* and *Balanites aegyptiaca* oils in *Clarias anguillaris* fry diets

2. Material and Method

2.1 Feed Manufacturing

Three isoproteins 30.25% per kilogram of experimental diets are formulated with Diet formulator software. These diets differ from the nature of the oils used.

Part of the total feed protein was from fishmeal, and the rest came from different ratios of wheat bran, *Moringa oleifera* meal (Table I).

For each diet, the ingredients are reduced to powder, sieved, weighed and mixed to get a homogeneous powder. Minerals and vitamins are added.

The diets are supplemented with 30% oil composed of 100% fish oil (diet P), 100% *Adansonia* seed oil (diet B) and 100% *Balanite s*seed oil (diet S). They are then dried under the sun for two days, then packed in jars and kept until use.

Table I. Composition of diets

Ingredients	**Diets (g/kg)**		
	P	**B**	**S**
Fishmeal	360	360	360
Wheat Bran	320	320	320
Moringa oleifera meal	250	250	250
Binder	20	20	20
Vit mix[a]	10	10	10
Min mix[b]	10	10	10
Fish oil	30	....	….
***Adansonia* seed oil**	….	30	….
***Balanites* seed oil**	….	….	30
Total (g)	1000	1000	1000

a=vit A 250000 UI; vit D3 250000UI; vit E 5000mg; vit B1 100mg; vit B2 400mg; vit B3(pp) 1000mg; vit B5 pantode Ca2000mg; vit B6 300mg; vit K3 1000g; vit C 5000mg; H biotin

15mg; choline 100g; anti-oxydant (BHT), crushed and calcined attapulgite qs 1000mg;

b= phosphorus 7%; calcium 17%; sodium 1,5%; potassium 4,6%; magnesium 7,5%; manganese 738mg; zinc 3000mg; iron 4000mg; copper 750mg; iodine 5mg; cobalt 208mg; calcined and ground attapulgite qs 1000g; fluorine 1.5% (approximately),

Table II shows the biochemical composition of the different diets tested.

Table II. Biochemical composition of the diets

Parameters	**Diets (g/kg)**		
	P	**B**	**S**
DM (%)	**90.79**	**90.79**	**90.79**
Ash(%)	**4.18**	**4.18**	**4.18**
Gross energy (MJ/kg)	**1.42**	**1.42**	**1.42**
Digestible Energy (MJ/kg)	**1.31**	**1.31**	**1.31**
Protein(%)	**30.25**	**30.25**	**30.25**
Protein digestible (%)	**0.14**	**0.14**	**0.14**
Lipids(%)	**9.04**	**9.04**	**9.04**
Fiber(%)	**5.27**	**5.27**	**5.27**

2.2 Breeding Conditions

The three diets were fed to fry of *Clarias anguillaris* with an initial average weight of 0.07 g distributed in six plastic tanks with a stocking density of 15 fries each. The treatments were in duplicate for 45 days. The fish were fed manually every day in the morning at 9 am and in the afternoon at 5 pm. Fish were fed 10% of their biomass at the beginning of the experiment. Before feeding, tanks were cleaned by siphoning to remove waste, and leftover food with an airhose and the water in the tanks was renewed by half. Thus, every 15 days, control of the growth was done by weighing the fish of each tank individually to evaluate the biomass. The feeding rate was readjusted according to the weighings.

2.3 Physicochemical Parameters

During the experiment, some physicochemical parameters were measured to monitor the water quality of the tanks. Thus, twice daily, the pH, the temperature and the dissolved oxygen (DO) were measured using a multiparameter device YSI Model 58 oxygen meter (Yellow Springs Instrument, Yellow Springs, OH, USA). All these parameters were taken before feeding, and the observed values were recorded in cards.

2.4 Growth Parameters

The growth parameters were described as in the following formulae:

Absolute Average Weight gain (AWGa, (g/ fish)) = final mean body weight - initial mean body weight;

Specific growth rate (SGR, (% /day)) = ((In Wt- In Wi) /T) x 100, where Wt is the weight of fish at time t, Wi is the weight of fish at time 0, and T is the rearing period in days;

Feed conversion rate (FCR) = total dry feed fed (g/ fish) / total wet weight gain g/ fish.

Survival rate (%) = 100*(number of fish which survived/initial number of fish).

Protein efficiency ratio (PER) = wet weight gain (g)/ total protein intake (g)

2.5 Statistical Analysis

The data collected was written in Microsoft Excel and then analyzed with Statistical Analysis System (SAS-PC) software (Joyner, 1985) subjected to analysis of variance (ANOVA). The Duncan test was used to compare significant differences between treatments. The effect of diets is significant at $P < 0.05$.

3. Results and Discussion

3.1 Results

3.1.1 Physicochemical Parameters

Temperature, pH and dissolved oxygen were measured during the experiment to monitor water quality. The average values obtained during the experiment were recorded (Table III).

Table III. Mean values of physicochemical parameters

Treatments	T (℃)	pH	DO (mg/l)
P	27.7	7.01	8.33
B	27.15	7.01	8.39
S	27.12	7.01	8.38

For physicochemical parameters, there is no significant difference between treatments.

The mean temperature ranged from 27.7 to 27.15 ℃. There is no significant difference between the different diets.

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The average values of dissolved oxygen varied between 8.33 and 8.39 mg/L. There is no significant difference noted between the mean values of the different treatments.

The average pH values found are not different. They are equal to 7.01 for all treatments.

3.1.2. Parameters of Growth, Feed Efficiency and Survival

Data on total mean weight gain (MWGa), relative mean weight gain (MWGr), individual daily growth (IDG), specific growth rate (SGR), feed conversion rate (FCR) and survival rates (SR) are presented in Table IV below.

Table IV. Growth performance, feed efficiency and survival rate

Treatments	IMW (g)	FMW (g)	MWGa (g)	MWGr (%)	SGR (%/d)	FCR	SR (%)	PER
P	0.07	0.16^b	0.09^b	128.57^b	1.79^b	0.33^a	67	0.74^b
B	0.07	0.22^a	0.15^a	214.29^a	2.58^a	0.21^a	80	1.16a
S	0.07	0.18^b	0.11^b	157.14^b	2.07^b	0.33^a	73	0.80^b

Values with the same letter in the same column are not significantly different (P <0.05)

The fish fed diet B containing *Adansonia digitata* seed oil as a source of lipid has the best average absolute weight gain (0.15g) compared to those fed with P and S diets containing fish oil and the *Balanites aegyptiaca* seed oil respectively. The values obtained vary between 0.09g for the fish fed P diet and 0.11g for that of feeding with diet S. These results do not show any significant difference between the S and the control diet P.

The trend of the relative mean weight gain was similar to those of the absolute mean weight gain. The values varied between 214.29% for the B diet, 157.14% for the S diet and 128.57% for the control diet P.

Similar results were obtained with the specific growth rate, which showed a significant difference between the fish fed with B diet and the fish fed with S and P diets that are not differ significantly between each other. The best feed conversion rate (FCR) is obtained with the fish fed with B diet, which showed a significant difference with the fish fed with P and S. These two diets did not have any significant difference between each other and are equal to a value of 0.33 compared to 0.21 for the diet B.

For the duration of the experiment, the survival rate varied between 67 to 80%. The best survival rate of 80% was obtained with the fish fed with diet B, followed by 73% in fish fed with diet S, and finally, the lowest value 67% in the fish fed with the control diet P.

The best protein efficiency ratio was obtained with the fish fed with diet B (1.16) followed by the fish fed with diet S (0.80) compared with the fish fed with the control diet P (0.74), which has the lowest value. There is no significant difference between the fish fed with diet S and those fed with the control diet P. However, the fish fed with diet B showed significant difference with the fish fed with diet S and the control diet P.

3.2 Discussion

3.2.1 Water Quality Parameters

The parameters used to monitor water quality during the experiment were temperature, pH and dissolved oxygen. They were generally within the optimum range of values recommended. The mean temperature during the experiment varied between 27.7 and 27.15 ℃. These values are comparable to those indicated (26 and 30 ℃) for proper growth of Catfish (Baras and Jobling, 2002).

The mean dissolved oxygen values recorded between 8.33 and 8.39 mg/L during the tests are greater than 3 mg / L reported by Viveen et al. (1985) who revealed that this DO is favorable for the growth of *Clarias gariepinus* and is the optimum DO for proper growth of *C. gariepinus* fingerling. However, *C. gariepinus*is provided with morphological adaptations enabling it to withstand extremely low or even zero dissolved oxygen levels (Mélard, 1999) in the adult stage.

The mean pH obtained was 7.01 for all treatments, and this value is in the neutral range as recommended by Balarin and Hatton (1979), and Boyd (1982).

3.2.2 Growth Performance, Feed Efficiency and Survival Rate

For fish growth performance, the best daily weight gain and the best specific growth rate are obtained with fish fed diets B and S in which the fish oil has been entirely substituted with *Adansonia* and *Balanites* oils respectively. This could be attributed to the fact that *Adansonia* seed oil and *Balanites* seed oil are rich in linoleic acid (n-6) (20.6-32.1% and 37.0% respectively). Similarly, it has been reported that vegetable oils rich in 18: 2 n-6, such as soybean oil, corn oil, sunflower oil, canola/rapeseed oil, and palm oil are also good sources of lipids (Lim et al., 2009). It is in this sense that some researchers encourage the use of plant-derived lipid sources to promote sustainable development of the aquaculture industry (Sotolu, 2010). Recent studies have shown that the substantial use of vegetable oils as a source of energy in fish feed has given positive responses to the growth of high fish (Babalola and Adebayo, 2007). Also, Aderolu and Akinremi (2009) have shown that the use of coconut oil and groundnut oil in diets for catfish does not pose a problem of palatability and that their use is adequate. Sotolu (2010) reported similar results when he fed *Clarias gariepinus* fry with diets containing benni seed oil, peanut oil, soybean oil, and palm oil.

The results indicate that *Clarias anguillaris* fries prefer the diets containing vegetable oils in their food. Indeed, the two treatments in which fish oil was substituted by *Adansonia* seed oil (HB) and *Balanites* seed oil (HS) showed the best growth performance. The lipid source constituted by the seeds of *Adansonia* and *Balanites* could be a solution for the substitution of fish oil in the diet of *C. anguillaris*.

Experimental diets with a substitution rate of (100% of fish oil) were correctly consumed by the *Clarias* fry and showed no signs of stress during the whole period of the experiment. This shows that there is no problem of palatability and that the feed has been used adequately. This is similar to the work of Ng et al. (2000) who also reported that up to 90% of fish oil could be replaced with vegetable oils without compromising the growth and/or efficient use of the tropical catfishes.

The most effective diet is the one with the lowest value of FCR. In this study, the best FCR was obtained with the fish fed diet B based on *Adansonia digitata* seed oil compared to those fed with the control diet P. These results are consistent with those of Sagne et al. (2013), who obtained a better FCR with the diet containing peanut oil and soybean oil in equal proportion with respect to the control diet 100% of fish oil in the tilapia fry.

The protein efficiency ratio varied from 0.74 to 1.16 in the treatments. These values are higher than those of Sotolou et al. 2010 (0.75-0.82) on the total replacement of fish oil by vegetable oils on African catfish fry (*Clarias gariepinus*) diets. An increase in PER could probably be that the lipid level saved the conversion of dietary protein into energy (Chou and Shiau, 1996, Regost et al., 2001). Lim et al. (2001) explained that there is the definitive influence of a non-protein energy source (lipids or carbohydrates) on nitrogen retention and that dietary lipids can also influence growth performance and protein utilization.

It should also be noted that the mortality observed during the experimental phase could be generated by manipulations (catches and weighing) relative to the system of rearing and storage of relatively small fish. However, it is more critical in fish fed on diet P containing fish oil with the survival of 66.67% against 80% in those fed with the diet containing *Adansonia* seed oil and 73% for those fed with *Balanites* seed oil. Okonji and Okafor (2013) also observed similar mortalities with 64-80% survival in their studies of lipid-like effects on the growth performance of *Clarias gariepinus*. In the same line, Piedecausa et al. (2007) obtained an 85% survival rate in a study with soybean oil in the diet for sea bream sar with a pointed snout.

4. Conclusion and Perspectives

The establishment of diets based on local by-products seems to be a significant priority to boost the development of aquaculture in the world in general and in Senegal in particular. Aquaculture is undoubtedly one of the solutions to the problem of capture fisheries. Its development involves taking into account the food needs of farmed fish while relying on its dependence on fish oil from industrial fishing whose supply cannot be guaranteed with the current situation of fish resources in the world. Thus reducing the use of fishery products in the diet of farmed fish by substitutions meeting the criteria of sustainable development is one of the significant challenges for the future of aquaculture in the world.

Thus, the objective of this study was to evaluate the effects of total substitution of fish oil by vegetable oils in the feed for *Clarias anguillaris* fry on growth performance and survival. The results obtained showed the importance of the use of vegetable oil in aquaculture.

Fish fed with the diet containing 100% vegetable oils had the best growth performance compared to the fish fed with the control diet containing 100% fish oil. As a result, we can say that the replacement of fish oil with *Balanites aegyptiaca* seed oil and *Adansonia digitata* seed oil has no negative impact on the growth of *Clarias anguillaris* fry. Moreover, to completely get rid of raw materials (fishmeal and fish oil) in the diet formulation, the current challenge in aquaculture is to study the possibilities of a joint replacement of fishmeal and fish oil by accessible plant by-products to reduce the dependence of the aquaculture industry on halieutic species. It would be interesting first of all to study the effects of the substitution of fish oil by mixing these two vegetable oils and also to determine the optimal inclusion rate of these oils in African catfish feed.

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