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RESEARCH ARTICLE

PRODUCTION OF *OREOCHROMIS NILOTICUS* WITH A FEED MADE FROM BREWER'S SPENT GRAINSIN GABON

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ABSTRACT

The objective of this study is to contribute to the improvement of knowledge on the feeding of *Oreochromis niloticus*. The trial required 2262 monosex *O. niloticus*juveniles with average weights comprised between 21.10±1.04 and 39.70±1.27 g, distributed in 4 groups with two repetitions per feed in 2.5 and 3 Ares concrete basins. The juveniles were fed a control ration (Asmag) and the ration made from a mixture of 40% of dried brewer's spent grains and 60% of fine wheat bran (Afab) during 180 days. The average live weight (ALW), the absolute weight gain (AWG), the daily individual growth (DIG), the specific growth rate (SGR), the feed conversion index (FCI), the protein efficiency coefficient (PEC), the total length (TLg), the standard length (SLg), the condition factor (K), the survival rate (SR), the quantity of feed distributed and the manufacturing costs of akg of feed were evaluated. It emerges from these results that, except the DIG, FCI, SGR, PEC, K and SR that showed no significant difference ($p>0.05$) at the level of the feeds, the ALW, AWG, TLg andSLg of the fish fed the ration Asmag were significantly ($p<0.05$) higher than those recorded in fish submitted to the ration Afab. For Asmag and Afab, it was obtained respectively an ALW of 148.01gvs 90.48 g; anAWGof 16.52 g vs 10.44 g;aTLg of 19.64 cm vs 16.50 cm and aSLg of15.50 cmvs 13.10 cm. Moreover, the cost price of Afab (61,040.88 FCFA) was lower than that of Asmag (308,368 CFA).In view of growth performance and production costs of feed recorded, the feed locally made (Afab) could be recommended to farmers producing *O. niloticus*.

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INTRODUCTION

Fish farming, which has existed in Gabon since the 1950s, has not been successful, despite numerous projects initiated by the Gabonese State and international organizations (Ekouala, 2013). In Gabon, the national fish production as in many developing countries, constitutes the main source of proteins, a real local resource that meat cannot replace because of its high selling price. It's a source of proteins and essential microelements, very valuable for nutritional balance and health, representing about 40% of protein intake of animal origin and 9.5% of total needs of the population (Medale *et al.,* 2003). A great interest is carried today in aquaculture mainly because of the decline in natural fish reserves, caused by excessive and uncontrolled fishing (Naylor *et al.,* 2000; Pauly *et al.,* 2002). There is also the need to produce 40 million tons of additional fish by 2030 given the stagnation of fishing landings, the increase in the population in the world and the transformation of 50% of fishery products into oil and meal used as animal feed including farmed fish (Morin, 2006; Subasinghe, 2006). In this context, aquaculture appears to be the main alternative that can meet this strong demand of fish for human consumption (Chan *et al.,* 2019).

Unfortunately, the traditional animal feed remains difficult to balance due to the insufficiency of ingredients and particularly the lack of protein rations (Hardouin *et al.,* 2000), the high price of animal feeds (Mpoame *et al.,* 2004), the competition between humans and animals over basic ingredients (maize, soy, fish, meat, etc.) (Malekani, 2002) and the high cost of dietary proteins. In addition, animal feed representing 70% of the production costs (Gourène *et al.,* 2002) is an obstacle to the development of livestock in inter-tropical zone. Faced with this situation, it is urgent to invest in the search for other alternative sources of proteins accessible and cheap and whose use does not compete with humans. Brewer's spent grain is a by-product obtained after the manufacture of beer. It is of high nutritional value (Tang *et al.,* 2009), contains cellulose, hemicelluloses, lignin and high protein content. It also contains vitamins, minerals and essential amino acids (Essien and Udotong, 2008). The main objective of the present study is to contribute in the improvement of knowledge on the feeding of the species *Oreochromis niloticus*.

MATERIALS AND METHODS

Experimental site: The present trial was conducted at the Peyrie fish station in Libreville (Gabon). This station is situated in the Estuary Province, at 0°24'30.8'' latitude North and 9°27'40.2'' longitude East (FDNS, 2004). The climate is of monsoon tropical type, and characterized by a short rainy season from October to December ending, a long rainy season from March to May ending, a short dry season from January to February, a long dry season from June to September ending ; the amount of rainfall in the driest month goes over 60 mm. The mean rainfall is 2883 mm/year and the mean annual temperature is 26.2°C (FDNS, 2004). The vegetation found there is of ombrophilic equatorial type.

Biological material: The study used 2262 monosex *Oreochromis niloticus* juveniles from a dam pond that were stocked and reared for a period of 180 days. These juveniles were obtained from the artificial reproduction of parent stocks at the Peyrie fish station in Libreville (Gabon). Thus, 2262 fish with average weights comprised between 21.10±1.04 and 39.70±1.27 g, were distributed in 4 groups.

Technical material: The distribution of *Oreochromis niloticus* juveniles and the predators *Hemichromis fasciatus* in the basins according to the surface area is recorded in the Table 1.

Experimental designs: For this trial, the control ration (Asmag) and the manufactured ration (Afab) were used. Asmag is the feed produced with imported ingredients by the Gabonese Poultry Milling Company (SMAG). As far as the feed Afab is concerned, it was obtained from a mixture of 40% of dried brewer's spent grains (BSG) and 60% of fine wheat bran. The BSG was obtained from the Gabon Brewery Company (SOBRAGA) and the wheat bran was purchased from resellers of agricultural by-products in the city of Libreville. The quantities of each ingredient were weighed with the help of an electronic balance of OHAUS type (capacity 3 kg and accuracy 0.01 g). The mixture of all the ingredients was done manually and water was added gradually. The mixture so obtained was processed into a granulated form and then dried. After drying, the granules were crushed and reduced into fines particles. After crushing, the product was stocked in bags for its subsequent use.

The feeds were then distributed to fry in a powder form. The chemical composition of the 2 rations/feeds are presented in the Table 2. Fish from the ponds B2 and B4 were fed manufactured feed (Afab) and those from B1 and B3 were submitted to the feed SMAG (Asmag). The quantity of feed distributed according to the mean weights of fish stocked in the different ponds is recorded in the Table 3. From the Table 3, it appears that the nourishing rate is the same for all the fish in ponds. Ponds were positioned in a completely randomized block design. Rations were distributed trice a day after 3 hours (9 am, 12 am and 3 pm) during the trial. Physicochemical parameters of water such as temperature, pH and oxygen level were measured twice a day during the trial; in the morning at 7 am before the distribution of feed and between 2 and 5 pm. An electronic pH-meter of pH 10A brand mark was used to measure pH and temperature values. To determine oxygen level in water, the oxymeter of WTW OXI 330 type was used. Each morning of the fifteenth day, control fisheries were carried out in the 4 ponds in order to count and weigh fish according to experimental rations. The day of the control fishing, fish were fed only once (6 pm). The trial lasted for 180 days and a total of 12 control fisheries were carried out. Control fishing begins with the capture of fish with the help of a seine net. Once the fish captured, they were put in large recipients filled with water and weighed consecutively. After weighing, twenty fish randomly selected were put in another recipient containing water as well and they will be used to collect subsequent data, while the rest of fish was put back in the pond immediately after weighing. A third recipient containing water received the eventual fry from the reproduction of females introduced in the pond by sexing error. The predators were spontaneously put back in water after their capture. Fry contained in the third recipient were immediately transferred in the pre-grow-out ponds. For weighing and measurements, 125 fish were randomly chosen in the ponds B1 and B2 and 162 fish in the ponds B3 and B4. So, the mean weights were determined with the help of an electronic scale of OHAUS type (capacity 3 kg and accuracy 0.01 g). Standard and total lengths were measured with the help of an ichtyometer. The chemical composition of the 2 rations distributed to fish was determined in laboratories of the University of Dschang in Cameroon. The analyzed parameters were: the dry matter (DM) content (%), the crude protein (CP) content (%), the crude cellulose (CC) content (%), the fats content (%), the NNE content (%) and ash content (%). Three repetitions per sample were necessary for the determination of the mean value of each of these components. The DM and the ash contents were determined using the AOAC method (1990), the CP and NNE contents were determined using the Bradford/Sedmak method, the fats content was determined using the extraction method under reflux with the help of the Soxhlet design. The determination of the CC content was realized by the modified Sheerer method.

The following zootechnical parameters were determined:

- **Absolute Weight Gain (AWG) (g) =** Final weight (g) – Initial weight (g);
- **DIG (g)** = (Final weight (g) – Initial weight (g)) / Number days of follow up ;
- **Specific Growth Rate (SGR) (%/day)** = (Ln (Final weight (g)) – Ln (Initial weight (g)) / Number of days of follow up) x 100 ;
- **PEC =** Weight gain / Quantity of proteins consumed;

- **Apparent Feed Conversion Index (FCI) =** Quantity of feed distributed (g) / Weight gain (g) ;
- **Total Length (cm)** = From the apex of the mouth till the tip of caudal fin;
- **Standard Length (cm)** = From the apex of the mouth till the base of the caudal fin;
- **Survival Rate (SR) (%)** = 100 x Final number of fish / Initial number of fish,
- **Condition Factor (K)** = 100 x Final weight (g) / (standard length (cm))^3 ;

Statistical analyses: Data on temperature, pH, average oxygen level, SGR, PEC, K and the SR were submitted to one-way (ration) analysis of variance and data on ALW, AWG, DIG, FCI, TLg and SLg were submitted to two-way (ration and age) analysis of variance with the help of the SPSS 20.0 software. In case of significant differences among treatments, the separation of means was done by the Duncan test at 5% significant level.

RESULTS

The Table 4 presents the temperature, pH and average oxygen level in water according to basins. From the Table 4, it appears that temperatures recorded in basins B3 and B4 were comparable ($p>0.05$) and significantly ($p<0.05$) higher than those obtained in basins B1 and B2. Temperatures recorded in basins B1, B2, B3 and B4 were 27.12±0.74; 27.00±0.90; 29.05±0.51 and 28.64±0.84 respectively.

Table 1. Distribution of *Oreochromisniloticus* juveniles and predators *Hemichromisfasciatus* in the basins according to surface area

Basins	Surface area (a)	Number of juveniles at the beginning of the trial	Number of predators
B1	2.50	490	20
B2	2.50	494	20
B3	3.00	630	20
B4	3.00	648	20
Totals	11	2262	80

As far as pH is concerned, statistical analysis has revealed that the pH values obtained in the basins B1 and B4 were comparable ($p>0.05$) and significantly ($p<0.05$) higher than those recorded in the basins B2 and B3 that were comparable ($p>0.05$) among them. The dissolved oxygen in the basins showed no significant difference ($p>0.05$), they were 8.30±0.58 mg/l, 7.65±0.58 mg/l; 8.85±0.83 mg/l and 7.60±0.50 mg/l respectively in the basins B1, B2, B3 and B4. The Table 5 presents some growth performance of *Oreochromis niloticus* according to the periods during the trial. It appears from the Table 5 that feeds have influenced the parameters during the study. In fact, except the DIG, the other parameters presented a significant difference ($p<0.05$) at the level of rations during the weeks. No matter the weeks, the ALW of fish fed the Asmag were significantly ($p<0.05$) higher than those recorded in fish submitted to the feed Afab. The ALW obtained in fish fed the ration Asmag were comprised between 55.29 g and 232.00 g and those recorded in fish submitted to the ration Afab were comprised between 35.86 g and 143.43 g. Furthermore, it equally appears that the ALW has increased markedly from the 1st week to the 12th week.

As far as the AWG is concerned, except the AWG from the 11th to the 12th week which presented no significant difference ($p>0.05$), the AWG of fish fed the ration Asmag at the 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 9th and 10th weeks were significantly ($p<0.05$) higher than those recorded in fish submitted to the ration Afab but that recorded in fish fed the ration Asmag at the 8th week was significantly ($p<0.05$) lower than that obtained in fish submitted to the ration Afab. The AWG obtained in animals fed the ration Asmag were comprised between 5.71 g and 26.29 g and those recorded in animals submitted to the ration Afab were comprised between 5.14 g and 14.29 g.

The DIG of fish presented no significant difference ($p>0.05$) between feeds at the level of weeks. The DIG recorded in fish fed the ration Asmag were comprised between 0.47 and 2 g/day and those obtained in fish fed the ration Afab were comprised between 0.57 and 1 g/day. Except the FCI of fish at the 7th, 9th and 10th weeks which presented a significant difference ($p<0.05$) between feeds, those of the other weeks presented no significant difference ($p>0.05$). FCI obtained in animals submitted to the ration Asmag were comprised between 1.00 and 3.14 and those recorded in fish fed the ration Afab were comprised between 1.00 and 5.71. Except the TLg of the 2nd week which presented no significant difference ($p>0.05$), the TLg of fish fed the ration Asmag at the 1st, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th and 12th weeks were significantly ($p<0.05$) higher than those recorded in the fish fed the ration Afab. The TLg obtained in fish submitted to the ration Asmag were comprised between 14.00 and 22.71 cm and those obtained in fish submitted to the ration Afab were comprised between 12.43 and 20.43 cm. Concerning the SLg of fish, except the SLg of the 2nd, 3rd and 9th weeks which presented no significant difference ($p>0.05$), the SLg of the fish fed the ration Asmag at the 1st, 4th, 5th, 6th, 7th, 8th, 10th, 11th and 12th weeks were significantly ($p<0.05$) higher than those recorded in fish fed the ration Afab. The SLg obtained in fish submitted to the ration Asmag were comprised between 11.00 and 20.14 cm and those recorded in fish submitted to the ration Afab were comprised between 9.71 and 16.00 cm. The Table 6 presents the growth performance of *Oreochromis niloticus* at the end of the trial.

From the Table 6, it emerges that feeds have influenced the growth parameters in course of the study. In fact, except the DIG, FCI, SGR, PEC, K and SR which presented no significant difference ($p>0.05$) at the level of feeds, the mW, AWG, TLg and the SLg of fish fed the ration Asmag were significantly ($p<0.05$) higher than those recorded in fish submitted to the ration Afab. For the feeds Asmag and Afab, it was obtained respectively an mW of 148.01 g vs 90.48 g; an AWG of 16.52 g vs 10.44 g; a TLg of 19.64 cm vs 16.50 cm and a SLg of 15.50 cm vs 13.10 cm. The Table 7 presents the quantity and cost of ingredients entering in feeds' formulation. From the analysis of the Table 4, it emerges that fish fed the ration Asmag have received a quantity of feed higher than that received by fish fed the ration Afab. Moreover, the cost price of the ration Afab (61,040.88 FCFA) was lower than that of the ration Asmag (308,368 CFA). Mindful of the quantity of fish produced with the utilization of the ration Afab (163.73 kg) and the ration Asmag (259.04 kg), it appears that the production cost of a kilogram of fish recorded with the ration Afab was lower (372.81 FCFA) than that recorded with the ration Asmag (1,190.43 FCFA).

Table 2. Chemical composition of experimental feeds

Feeds	Evaluation of components	Dry matter (%)	Crude proteins (%DM)	Fats (%DM)	Crude cellulose (%DM)	Hemi-cellulose (%DM)	Lignin (%DM)	Ash (%DM)	NNE (%DM)	Phosphorus (%DM)
Afab	Laboratory	89.65	18.32	6.02	9.65	29.80	7.20	6.33	49.33	0.45
	Theoretical	89.6	21.56	4.48	14.38	-	-	6.06	53.52	0.944
Asmag	Laboratory	89.92	31.15	6.25	5.36	31.29	-	8.13	31.29	0.57
	Commercial label	-	26	5	5	-	-	6	-	-

NNA: Non-nitrogenous extractives; Afab: Manufactured feed; Asmag: SMAG feed (control feed).

Table 3. Quantity of feed distributed according to mean weights (mW) of fish stocked in ponds

Basins	mW (g)	Rationing rate (%)	Theoreticalration (g)	Practicalration (g)	Frequency of distribution
B1	25.5	5	208.25	250	3
B2	33.9	5	279.11	300	3
B3	39.7	5	416.85	450	3
B4	21.1	5	227.88	250	3

Table 4. Physicochemical parameters during the trial

Parameters	B1	B2	B3	B4
Temperature (°C)	27.12 ± 0.74^{a}	27.00 ± 0.90^{a}	29.05 ± 0.51^{b}	28.64 ± 0.84^{b}
pH	7.68 ± 0.60^{b}	6.28 ± 1.32^{a}	6.54 ± 0.72^{a}	7.48 ± 0.36^{b}
Dissolved oxygen (mg/l)	8.30 ± 0.58^{a}	7.65 ± 0.58^{a}	8.85 ± 0.83^{a}	7.60 ± 0.50^{a}

Table 5. Some growth performance of *Oreochromisniloticus* according to the periods during the trial

Parameters		Periods of collection (days)											
		15	30	45	60	75	90	105	120	135	150	165	180
ALW	Afab	35.86^{a}	48.29^{a}	58.86^{a}	67.14^{a}	77.86^{a}	89.00^{a}	93.57^{a}	101.86^{a}	109.57^{a}	124.43^{a}	135.86^{a}	143.43^{a}
	Asmag	55.29^{b}	73.29^{b}	85.57^{b}	101.43^{b}	122.71^{b}	138.57^{b}	164.71^{b}	171.71^{b}	189.43^{b}	214.86^{b}	226.57^{b}	232.00^{b}
	SEM	2.87	3.67	3.98	5.12	6.48	6.97	9.99	9.76	11.11	12.62	12.84	12.85
	Prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AWG	Afab	12.14^{a}	14.29^{a}	9.71^{a}	8.14^{a}	10.00^{a}	12.00^{a}	5.14^{a}	8.71^{b}	9.71^{a}	14.00^{a}	13.43^{a}	8.00^{a}
	Asmag	19.14^{b}	18.14^{b}	13.29^{b}	15.71^{b}	21.71^{b}	16.00^{b}	26.00^{b}	6.00^{a}	18.57^{b}	26.29^{b}	11.71^{a}	5.71^{a}
	SEM	1.08	0.71	0.56	1.13	1.63	0.85	2.91	0.51	1.27	1.91	1.32	0.76
	Prob.	0.000	0.002	0.000	0.000	0.000	0.012	0.000	0.003	0.000	0.000	0.539	0.139
DIG	Afab	1.00^{a}	1.00^{a}	1.00^{a}	0.57^{a}	1.00^{a}	1.00^{a}	1.00^{a}	0.71^{a}	0.86^{a}	1.00^{a}	0.86^{a}	0.57^{a}
	Asmag	1.00^{a}	1.00^{a}	1.00^{a}	1.00^{a}	1.00^{a}	1.00^{a}	2.00^{a}	0.54^{a}	1.00^{a}	2.00^{a}	1.00^{a}	0.47^{a}
	SEM	1.57	0.33	0.21	0.11	0.99	0.72	0.28	0.13	0.07	0.14	0.07	0.13
	Prob.	0.337	0.055	0.785	0.055	0.274	0.276	0.164	0.055	0.337	0.785	0.337	0.129
FCI	Afab	1.00^{a}	1.00^{a}	2.00^{a}	2.71^{a}	2.71^{a}	3.00^{a}	5.71^{b}	2.57^{a}	3.00^{b}	2.43^{b}	3.14^{a}	3.29^{a}
	Asmag	1.14^{a}	1.43^{a}	2.00^{a}	2.00^{a}	2.00^{a}	3.14^{a}	1.00^{a}	3.00^{b}	1.00^{a}	1.00^{a}	3.00^{a}	3.14^{a}
	SEM	0.07	0.11	0.76	0.13	0.13	0.28	0.66	0.11	0.31	0.22	0.22	0.63
	Prob.	0.267	0.055	0.675	0.385	0.276	0.814	0.000	0.002	0.000	0.000	0.761	0.915
TLg	Afab	12.43^{a}	14.00^{a}	14.71^{a}	14.71^{a}	15.43^{a}	16.00^{a}	17.29^{a}	17.43^{a}	20.43^{a}	18.43^{a}	18.71^{a}	18.43^{a}
	Asmag	14.00^{b}	15.00^{a}	15.71^{b}	17.57^{b}	18.00^{b}	21.43^{b}	21.71^{b}	21.57^{b}	22.00^{b}	22.71^{b}	22.29^{b}	23.71^{b}
	SEM	0.24	0.14	0.19	0.42	0.37	0.77	0.63	0.60	0.30	0.61	0.54	0.76
	Prob.	0.000	0.540	0.002	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000
SLg	Afab	9.71^{a}	11.00^{a}	12.00^{a}	12.29^{a}	12.00^{a}	12.86^{a}	13.43^{a}	13.71^{a}	16.00^{a}	14.43^{a}	14.57^{a}	15.14^{a}
	Asmag	11.00^{b}	12.00^{a}	12.71^{a}	14.00^{b}	15.00^{b}	16.43^{b}	16.29^{b}	16.00^{b}	16.43^{a}	18.00^{b}	18.00^{b}	20.14^{b}
	SEM	0.20	0.27	0.25	0.29	0.44	0.56	0.43	0.33	0.28	0.52	0.49	0.77
	Prob.	0.000	0.063	0.158	0.000	0.000	0.000	0.000	0.000	0.468	0.000	0.000	0.000

a and b: means bearing the same lowercase superscript letters on the same column of each parameter are statistically identical; SEM: Standard Error on the Mean; Prob.: Probability. Afab: Manufactured feed; Asmag: SMAG feed (control); 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165 and 180:Periods of data collections.

Table 6. Growth performance of *Oreochromisniloticus* at the end of the trial

Parameters	ALW (g)	AWG (g)	DIG (g/day)	FCI	TLg (cm)	SLg (cm)	SGR (%)	PEC	K	SR (%)
Afab	90.48^{a}	10.44^{a}	0.80^{a}	2.71^{a}	16.50^{a}	13.10^{a}	1.01^{a}	2.51^{a}	2.31^{a}	99.59^{a}
Asmag	148.01^{b}	16.52^{b}	1.02^{a}	2.07^{a}	19.64^{b}	15.50^{b}	1.03^{a}	1.83^{a}	1.78^{a}	99.74^{a}
SEM	4.33	0.48	0.04	0.15	0.25	0.20	0.96	0.21	0.31	0.26
Prob.	0.000	0.000	0.147	0.085	0.000	0.000	0.241	0.168	0.075	0.162

a and b: means bearing the same lowercase superscript letters on the same column of each parameters are statistically identical; SEM: Standard Error on the Mean; Prob.: Probability.Afab: Manufactured feed; Asmag: SMAG feed (control).

DISCUSSION

Temperature, pH and dissolved oxygen in water according to breeding basins: The temperatures recorded for water in the basins during this study varied between 27±0.90 and 29.05±0.51°C; these values are similar to those reported by Ué *et al.,* (2019) (29.16±0.03 - 29.38±0.46°C) and by Kreman *et al.,* (2020) (27.1±1.2 – 27.5±2.4°C). They corroborate those advised by Lazard (2009) and Amoussou *et al.,* (2016) that

Table 7. Quantity and cost of ingredients entering in feeds' formulation

Ingredients	Quantity of ingredients used (kg)	Price of the kg of ingredient (FCFA/kg)	Price of quantities used (FCFA)		
Wheat bran	60	160	96		
Brewer's spent grains	40	15	6		
Total	100	/	102		
Treatments	Quantities of feeds distributed during the trial (kg)	Purchase price of a kg of feed (FCFA/kg)	Cost price of feeds distributed (FCFA)		
Afab	598.44	102	61,040.88		
Asmag	770.92	400	308,368		
	Quantity of fish produced (kg)	Price of a kg of fish (FCFA)	Selling price (FCFA)	Profit (FCFA)	Production cost of a kg of fish (FCFA)
Afab	163.73	2000	327,460	266,419.12	372.81
Asmag	259.04	2000	518,080	209,712	1,190.43

Afab: Manufactured feed; Asmag: SMAG feed (control).

explain that, in livestock, the ideal temperature for the growth of fish should be comprised between 24 and 32°C and by Makori *et al.,* (2017) (27 - 30°C). This will lead to say that the temperature values during this trial are within the breeding standards for a better growth of this species of fish. The lowest average pH value recorded during this study is 6.28±1.32. This value is lower than those obtained by Ué *et al.,* (2019) (7.16±0.03 - 7.38±0.46), but close to that reported by Obame Mba (2020) (6.76) in the ponds of the species *Clarias gariepinus* and by Kreman *et al.,* (2020) (6.8±0.1 – 7.1±0.4). It is in conformity with those recommended for the good growth (6.5 - 9) of fish (Uzoka *et al.,* 2015). Moreover, it is in the limit of tolerance (5<pH<11) recommended by Lawson and Anetekhai (2011). Thus, this parameter will not have negatively influenced the production of fish. Concerning the dissolved oxygen recorded during the present study, it has varied from 7.60±0.50 – 8.85±0.83 mg/L. These values are comparable to those reported by Ram *et al.,* (2001) (7.7 mg/L) but higher than those recorded by Ué *et al.,* (2019) (4.17±0.03 – 4.38±0.46 mg/L), by Kreman *et al.,* (2020) (5.5±2.7 – 6.4±2.1 mg/L) and by Amon *et al.,* (2020) (4.10 – 4.21 mg/L). These values are above the growth threshold value (2.3 mg/L) reported by Ross (2000). The values of dissolved oxygen higher or equal to 3 mg/L are acceptable for a good production of fish (Ué *et al.,* 2019). On the other hand, Tilapias do not required much dissolved oxygen (Ross, 2000).

Growth parameters of *Oreochromis niloticus* at the end of the trial: During the present study, the lowest mW (90.48 g) was obtained with fish fed the ration Afab. This value is close to that reported by Iga Iga (2008) (95.7 g) and by Ram *et al.,* (2001) (91±1–93±2 g), but higher than those recorded by Obame Mba (2020) (48.1±5.51 g and 27.11±9.23 g), by Bamba *et al.,* (2008) (37.31–54.69 g). They mention that, ingredients could seem to be excellent sources of nutrients, but of low nutritive value, due to the variability of their coefficient of digestibility and coefficient of absorption and the availability of nutrients (amino acids, minerals). The highest AWG (16.52 g) recorded during the present study was obtained with fish fed the ration Asmag. This value is lower than that recorded by Obame Mba (2020) (27.11±9.23-48.1±5.51 g) and by Kreman *et al.,* (2020) (75.10±7.4 g). It appears from the present study that there is no significant difference (p>0.05) between DIG and SGR of fish at the level of the feeds. The values vary from 0.80 to 1.02 g/day and from 1.01 to 1.03% for DIG and SGR respectively. These values are close to those recorded with the same species, by Amon *et al.,* (2020), which are 1.22±0.01 g/day for DIG and 0.78±0.17% for SGR and by Kreman *et al.,* (2020), which vary between 0.67±0.04 and 1.09±0.07 for DIG g/day and between 0.97±0.02 to 1.29±0.04% for SGR. Moreover, the DIG recorded during this study are equally comparable to those reported by Iga Iga (2008), by Bamba *et al.,* (2007) and by Dibala *et al.,* (2018), respectively 1.12, 1.20, 1.77 and 1.36 g/day in the same species. The SGR are lower than those recorded by Imorou *et al.,* (2007) in *Oreochromis niloticus* which vary from 3.56 to 4.17% g/day and by Rossato *et al.,* (2018) which vary from 3.62±0.08 to 3.99±0.13% g/day. Concerning the FCI and the PEC, no significant difference (p>0.05) has been observed at the level of the feeds consumed by the fish. The values vary between 2.07 and 2.71 and between 1.83 and 2.51 for FCI and PEC respectively. These values of FCI are similar to that recorded by Amon (2020) (1.90±0.30), by Kreman *et al.,* (2020) (2.52±0.11-3.04±0.15) for the same species. The PEC are comparable to those reported by Bahnasawy (2009) (1.36-2.43) in *O. niloticus*.

During the present study, it emerges that there is no significant difference (p>0.05) between the TLg and the SLg of fish at the level of the feeds. The values vary from 16.50 to 19.64 cm and from 13.10 to 15.50 for TLg and SLg respectively. These values are lower than those reported by Minoungou *et al.,* (2020) (26.70 cm); by Kreman *et al.,* (2020) (20.84±0.34 cm), and by Abba *et al*., (2010) (23 cm). It has been observed in this study that, there was no significant difference (p>0.05) between the K of fish at the level of feeds. The values of K vary between 1.78 and 2.31. Regardless the feed used, all the fish obtained in this trial are of fat type because K>1 (Mensah *et al.,* 2014). These values are lower than that reported by Minoungou *et al.,* (2020) (11.73±2.64) but similar to those reported by Kreman *et al.,* (2020) which vary between 1.67±0.02 and 1.90±0.07, by Ué *et al.,* (2019) which vary from 1.61±0.04 to 1.76±0.01, by Abba *et al.,* (2010) (1.25–1.71), by Da *et al*., (2018) (2.37) and by Rossato *et al.,* (2018) (1.03±0.02-1.06±0.04). Concerning the survival rate, no significant difference (p>0.05) has been observed at the level of the feeds consumed by the fish. These rates vary between 99.59 and 99.74%. They are higher than those recorded by Amon *et al.,* (2020) (83.33%) and by par Kreman *et al.,* (2020) (80.33±7.57 - 89.09±2.00%) in the same species. These differences recorded at the level of the growth parameters in *Oreochromis niloticus* during the present study could be justified by the ingredients used, the chemical composition of the feed and the breeding density (Bamba *et al.,* 2008). In fact, the digestibility of a feed depends on the nature of the ingredients used (Burel *et al.,* 2000; Köprücü and Özdemir, 2005). Moreover, these values could also be justified by the physiological status, the strain and the origin of fish (Mensah *et al.,* 2014).

Manufacture costs of a Kg of feed and feeds distributed: As far as the price of the kg of feeds is concerned, the ration Asmag has a cost higher (400 FCFA/kg) than the treatment T (102 FCFA/kg). So the cost price of feeds distributed (FCFA) is 61,040.88 FCFA and 308,368 FCFA for Afab and Asmag respectively. The profit (in FCFA) made from the production of fish was 266,419.12 (Afab) and 209,712 (Asmag). Based on the production costs of feeds recorded, the ration Afab could be recommended with regards to the feed Asmag to feed *Oreochromis niloticus* in controlled environment.

CONCLUSION

At the end of this study bearing on the effects of a feed basically made of brewer's spent grains on growth performance of *Oreochromis niloticus* in controlled environment, it emerges that the locally manufactured feed (Afab) has influenced the growth performance of fish. Moreover, regarding the growth performance recorded and production costs of feeds, the feed Afab could be recommended to farmers producing *Oreochromis niloticus* in Gabon.

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