Journal of Aquaculture Feed Science and Nutrition 11 (2): 6-14, 2019
ISSN: 2070-1667

Potential of Some Locally Available Feedstuffs for the Rearing of African Catfish *Clarias gariepinus* Fingerlings in Cote d'Ivoire: Effects on Growth, Feed Utilization and Fish Carcass Composition

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Abstract: African catfish *Clarias gariepinus* culture remains undeveloped in Cote d'Ivoire due to the lack of locally quality feed, fingerlings and the high cost of imported feeds. Because of the importance of feed in the aquaculture development, three different isoproteiques 40% feeds SG1, SG2 and G were formulated with locally available feedstuffs in three fish farming agroecological area for *Clarias gariepinus* fingerlings growth. *C. gariepinus* fingerlings average weight 6.76±0.23 g were fed with these three feeds in three replicate groups, three times a day (09:00, 13:00 and 17:00 h) at 10% of total biomass during 60 day in outdoor hapas in earthen ponds. During the trial, water quality parameters recorded in the ponds were within suitable range for *Clarias gariepinus* culture. At the end of feeding trial, average daily growth (0.25-0.36 g/d), specific growth rate (1.89-2.39%/d) and survival rate (96.84-98.73%) values recorded show the good quality of the simple three composed 40% protein feeds formulated for *C. gariepinus* fingerlings. However, feed G formulated with the accessible feedstuffs for Guinean area recorded the best response of growth, feed utilization and survival. Protein content of the carcass of the three groups of fish fed ranged between 17.12±1.73 (SG2) and 18.34±0.04% (SG1) and did not differ significantly. Highest significantly values of fish carcass crude lipid level were recorded from fish fed feed SG1 (4.83±0.05%) and SG2 (4.71±0.56%) when fish fed feed G presented the lowest value (3.91±0.19%). The availability of feedstuffs used in feed production, the affordable prices of these three feeds produced, their good nutritional quality and the good growth and survival recorded with them could promote their use to improve *Clarias gariepinus* fingerlings culture in Cote d'Ivoire.

Key words: *Clarias gariepinus*, fingerlings, feeds, locally available feedstuff, utilization, growth

INTRODUCTION

African catfish *Clarias gariepinus* reared in many countries is ideal specie of aquaculture in the world (Musa *et al*., 2012). It has become a popular species for aquaculture in sub-Saharan Africa particularly in Nigeria where it represents the most aquaculture fish produced (Ducarme and Micha, 2003; Nyina-Wamwiza *et al*., 2007; Anonymous, 2012). So, culture of African catfish has considered of great promise for fish farming in Africa because of its high growth rate, resistance and possibility of rearing in restricted environments, capacity to withstand adverse environemental conditions, high fecundity, air-breathing ability and ability to accept a wide variety of diets giving a high production (Oteme *et al*., 1996).

However, *Clarias gariepinus* culture remains undeveloped in Cote d'Ivoire, although, this fish was selected for the development of fish farming in Cote d'Ivoire (Koumi *et al*., 2015, Anonymous, 2016). In fact, in this country, it was reported that production of *Clarias gariepinus* and some catfish generally faces lack of capital, high cost of imported quality feed, lack of locally quality feed, little presence of hatcheries producing high quality seed, predation and cannibalism of larvae and unavailability of fingerlings (Hetch *et al*., 1997; Anonymous, 2016; Koumi *et al*., 2016). Among these problems, fish feeds alone accounts at least 60-70% of the total cost of fish production that optimizes the yield, so, the availability of quality feeds is the major contraint of productivity and sustainability of farming fish production (Hetch *et al*., 1997; Lazard, 2014). Hence, the increasing of

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Clarias gariepinus production in Cote d'Ivoire requires a particular attention in locally fish feeds and good practices of feeding (Koumi *et al*., 2015).

Development of fish feeding research is motivates for use of cheap and locally available agro-industrial by products in fish feeding to reducing the cost of production without compromising feed quality (Gabriel *et al*., 2007). So, formulation of least-cost feeds with locally available feedstuffs for *Clarias gariepinus* rearing in Cote d'Ivoire resides in the knowledge of locally available feedstuffs costs and nutritional values in the different fish farming regions. In Cote d'Ivoire, a wide range of agro-industrial byproducts used in fish feeds was reported by Bamba *et al*. (2008) and Koumi *et al*. (2015). Moreover, the nutritional requirements of *Clarias gariepinus* fingerlings is very well documented, so, to achieve good growth of fingerlings, 40% protein level, 8-10% ash level, less of 10% lipids and crude fibre levels are recommended for good growth (New, 1987; Hecht *et al*., 1997; Guillaume *et al*., 1999, Lazard, 2007). Also, the successful use of local feedstuffs in formulation of quality competitive fish feeds particularly for African catfish *Clarias gariepinus* has been reported by several researchers (Gabriel *et al*., 2007; Nyina-Wamwiza *et al*., 2007, Hecht *et al*., 1997). However, the availability and cost of raw materials reported vary by region and area and in Cote d'Ivoire, Guinean zone, Sudano-Guinean zone 1 and Sudano-Guinean zone 2 were reported as the three agro-ecological areas which recorded the highest concentration of fish farmers (Yao *et al*., 2017).

The purpose of this study was to formulate locally low cost quality feeds for *Clarias gariepinus* fingerlings with the different feedstuffs available by area in the three fish farming agro-ecological areas to increase availability of good feeds for *Clarias gariepinus* rearing in Cote d'Ivoire.

MATERIALS AND METHODS

Feeds ingredients: Fish meal (55% protein content), soybean meal, cashew nut oil cake, cotton seed oil cake, white rice bran and wheat bran were feedstuffs used to formulate feeds in this study. There were chosen according to the preliminary survey realized on available raw materials usable in fish feeds in three agro-ecological areas by Oceanology Research Centre of Abidjan, Cote d'Ivoire in year 2016. Fish meal (55% protein content) and soybean meal were used as main protein source in the three diets. Cotton seed oil cake was used as complementary protein source to achieve dietary protein requirement because of his high content of crude fibre. Cashew nut oil cake was used as raw material rich in dietary lipid. The white rice bran was used as carbohydrates sources. Wheat bran was an additional ingredient, used at low level to adjust some nutrients content. The choice of feedstuffs for each agro-ecological area feed formulation was oriented by it's nutritional value, cost and availability. The different proximate compositions of feedstuffs used were presented in Table 1. The cost of these feed ingredients varied between 1.04-1.21 USD/kg for fish meal, 0.64 and 0.73 USD/kg for soybean meal, 0.35 and 0.61 USD/kg for cashew nut oil cake, 0.36 and 0.48 USD/kg for cotton seed oil cake, 0.20 and 0.23 USD/kg for wheat bran and between 0.095 and 0.12 USD/kg for white rice bran. Cashew nut oil cake was not available in Sudano-Guinean zone 1 area, white rice bran recorded low availability in the Sudano-Guinean zone 2 area and presented the highest cost in this area in contrast in the Sudano-Guinean zone where is well available and sold at the lowest price. Feeds ingredients used by agro-ecological area were presented in Table 2.

Feeds formulation: Based on the nutrient composition of the feedstuffs chose (Table 1) and macronutrient requirements of *C. gariepinus* fingerlings rearing recorded by New (1987), Guillaume *et al*. (1999) and Lazard (2007), three isoproteic feeds were formulated. All feeds were formulated using linear programming method as described by Koumi (2010). For each formulation, dry feed ingredients were weighed, ground in fine flour and mixed. The different mixes were produced in the monthly frequency in the sufficient quantities to cover the needs of feeding trial.

Table 1: Proximate/mineral composition (Dry matter (g/100 g)) of different feedstuffs used in feeds formulation

Parameters	Fish meal (55)	Soybean meal	Cashew nut oil cake	White rice bran	Wheat bran	Cotton seed oil cake
Moisture (%)	11.23±0.21	11.89±0.50	06.14±0.51	09.88±0.22	10.84±0.32	09.66±0.51
Crude protein (%)	55.30±0.12	44.56±2.29	19.87±1.74	11.95±1.77	15.97±0.93	35.71±0.73
Crude fibre (%)	02.39±0.61	04.67±0.40	06.08±0.32	10.37±0.28	20.32±0.35	24.58±0,25
Crude lipid (%)	09.05±0.71	01.74±0.51	38.90±0.36	14.27±1.76	04.64±0.03	03.01±0.10
Ash (%)	21.15±0.98	06.09±0.16	03.21±0.18	08.75±1.05	05.12±0.02	05.93±1.46
NFE[1] (%)	00.99±0.46	31.32±3.27	26.73±1.23	44.68±2.67	43.27±1.61	21.10±1.79
*Energy (kJ/g)	17.26±0.10	17.44±0.25	25.48±0.01	17.93±0.42	16.53±0.01	17.52±0.40
Calcium (mg/g)	57.90	03.48	00.17	00.97	01.74	01.10
Phosphorus (mg/g)	26.00	03.14	01.53	07.78	02.98	04.88

[1]Nitrogen free extract = 100-(moisture+crude protein+crude lipid+crude fibre+ash). *Gross energy was calculated on the basis of 23.7 kJ g protein, 39.5 kJ g lipids and 17.2 kJ g carbohydrates

Table 2: Formulation and composition (kg/100 kg of dry matter) of feeds produced for *Clarias gariepinus* fingerlings rearing by agro-ecological area (Sudano-Guinean zone 1 = SG1; Sudano-Guinean zone 2 = SG2; G = Guinean zone)

	Fish feeds produced		
Ingredients	SG1	SG2	G
Fish meal (55)	50	30	30
Soybean meal	20	30	30
Cashew nut oil cake	-	10	10
White rice bran	30	-	10
Wheat bran	-	10	-
Cotton seed oil cake	-	20	20

Experimental fish and feeding trial: African catfish *Clarias gariepinus* fingerlings used for feeding trial came from of artificial reproduction and larvae rearing realized at hatchery of Centre de Recherches Oceanologiques (CRO), Cote d'Ivoire. Fish with initial average weight of 6.76±0.23 g were randomly distributed at density of 13 fish/m^2 in three replicate hapas (4×3×0, 75 m) per dietary treatment installed inside the earthen ponds. The feeding trial was done during 60 days at the experimental fish farming located near of Azaguie town at 40 km at the West part of Abidjan, Cote d'Ivoire (Latitude 5-6° North; Longitude 4-5° West). Pond was regularly supplied in fresh water by a dam. All fish were hand-fed three times daily (09:00, 13:00 and 17:00 h) at 10% of total biomass with the three feeds produced during 60 days. Fish died in the hapas were removed daily. The water quality parameters (temperature, pH, salinity, conductivity, dissolved oxygen, dissolved percentage and total dissolved solids) were monitored weekly in pond using the multi-parameters Hanna. Every 2 weeks, samples of 30 fish in each hapas were individually weighed using a sensitive electronic balance, EKS balance LE 5000 g to the nearest 0.01 g and measured with a rule to the nearest 0.01 cm, respectively. Subsequently, the total fish biomass was calculated by hapas based on the fish new mean weight and the feed rations were adjusted. At the end of the rearing, 10 fish were sampled from each hapas and frozen (-20°C) for carcass analyses.

Feed performance evaluation: The growth and nutrient utilization parameters were calculated for each treatment as follows: Mean Weight Gain (MWG) (g) = Final body weight-Initial body weight; Daily Weight Gain (DWG) (g/day) = (Final body weight-Initial body weight)/Number of day; Specific Growth Rate (SGR) (%/day) = [Ln (final body weight)-ln (initial body weight)]×100/Number of day; Feed Conversion Ratio (FCR) = Total weight of feed consumed/Wet biomass gain; Protein Efficiency Ratio (PER) = Biomass gain/Dietary protein intake; Survival Rate (SR) (%) = (Final number of fish/Initial number of fish)×100.

Chemical analysis of feedstuffs, fish feeds and fish: The proximate composition of feedstuffs, fish feeds and fish at the end of the trial was determined using AOAC. (1990) methods. Dry Matter (DM) was determined after oven drying at 105°C for 24 h, until constant weight; crude protein (% N°6.25) was determined using Kjeldahl method, crude lipid by Soxhlet extraction with hexane as solvent; ash was measured by incineration at 550°C in a muffle furnace for 24 h, crude fibre were measured by acid digestion following by ashing the dry residue at 550°C in a muffle furnace for 4 h while Nitrogen-Free Extract (NFE) was calculated by difference. The gross energy contents of the diets were calculated on the basis of their crude proteins, lipid and carbohydrate contents using the energy equivalents of 23.7, 39.5 and 17.2 kJ/g, respectively. Mineral composition was determined by atomic absorption spectrophotometer (AOAC., 2003). All analyses were made in triplicate for each sample.

Statistical analysis: Data collected were analysed using Statistica 7.1 Software. Data were presented as mean±Standard Deviation (SD). Data resulting were subjected to one-way Analysis of Variance (ANOVA). The Tukey's multiple range tests was used to compare differences among means. Differences among treatments means were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Nutritional quality of feeds produced: The proximate and mineral compositions of three feeds produced are shown in Table 3. Results showed significant difference between the three formulated isoproteic 40% feeds in crude fibre, lipid, ash, NFE, gross energy and P/E ratio. Significant highest ($p<0.05$) values of crude fibre (7.15±0.04%), ash (11.75±0.08%) and P/E (22.04±0.01 mg/kJ) were recorded with feeds SG1 when SG2 presented the highest ($p<0.05$) value of NFE (32.83±0.24%). The feed G presented the highest values of crude lipid (8.40±0.08%) and gross energy (19.03±0.04 kJ/g). All feeds follow the *Clarias gariepinus* fingerlings feeds biochemistry composition requirement presented in Table 3 with cost ranged between 0.66 and 0.69 USD/kg. Calcium, phosphorus, magnesium, manganese, potassium, sodium and iron content of three feeds produced were well above of recommended requirements of *Clarias gariepinus* fingerlings feeds (Table 3).

Water quality parameters: Water quality data recorded in earthen ponds used for feeding trial were presented in Table 4. Water temperature ranged between 27.83-29.32°C with an average of 28.71°C. Water pH ranged from

Table 3: Proximate and mineral compositions (Dry matter (g/100 g)) and cost (USD/kg) of feeds produced for the rearing of *Clarias gariepinus* fingerlings by fish farming agroecological area

	Fish feeds produced			
Proximate composition	SG 1	SG 2	G	[1, 2]Requirement
Moisture (%)	7.40±0.08[a]	8.00±0.61[a]	7.50±0.41[a]	<10
Crude protein (%)	40.25±0.07[a]	40.35±0.06[a]	40.78±0.82[a]	40
Crude fibre (%)	7.15±0.04[b]	5.65±0.04[a]	5.05±0.76[a]	<10
Crude lipid (%)	7.82±0.01[b]	6.82±0.08[a]	8.40±0.08[c]	10
Ash (%)	11.75±0.08[c]	6.36±0.08[a]	8.17±0.14[b]	8-10
NFE[1] (%)	25.64±0.02[a]	32.83±0.24[c]	30.11±1.63[b]	25
Gross energy (kJ/g)*	18.27±0.08[a]	18.87±0.41[b]	19.03±0.04[b]	18-19
P/E (mg/kJ)	22.04±0.01[b]	21.38±0.32[a]	21.43±0.21[a]	≤20
Cost of feed (USD/kg)	0.69	0.67	0.66	-
Mineral composition (mg/g)				
Calcium	9.63	6.35	7.98	4.5 mg/g
Phosphorus	10.36	6.15	7.31	3.0-4.5 mg/g
Magnesium	5.64	0.99	4.43	0.2-0.4 mg/g
Manganese	0.35	0.04	0.23	2.4 mg/g
Potassium	10.37	11.86	16.69	2.6 mg/g
Sodium	9.55	1.06	6.30	ND
Iron	6.15	0.21	2.85	20-30 ppm

Means values in the same row having the different superscript letter are significantly different ($p>0.05$). *Gross energy was calculated on the basis of 23.7 kJ $g_{protein}^{-1}$, 39.5 kJ g_{lipid}^{-1}, 17.2 kJ $g_{carbohydrate}^{-1}$. [1](New, 1987; Guillaume *et al*., 1999; Lazard, 2007). [2]Guillaume *et al.* (1999)

Table 4: Water quality paremeters in the hapas during the feeding trial

Parameters	Ranges	Means	SE
Temperature (°C)	27.83-29.32	28.71	0.64
pH	08.26-9.53	09.11	1.00
Dissolved oxygen (mg/L)	07.77-9.90	08.59	0.91
Dissolved oxygen percentage	98.20-124.20	105.85	10.96
Total dissolved solute (TDS) (mg/L)	13.00-16.00	14.75	1.26
Salinity (‰)	00.00-0.01	00.00	0.01
Conductivity (µS/cm)	26.00-32.00	29.75	2.63
ORP	30.00-106.30	65.55	47.52

8.26-10.53 with an average of 9.11. Dissolved oxygen and dissolved oxygen percentage ranged between 7.77-9.9 and 98.20-124.20, respectively. The total dissolved soluble of water (TDS) ranged between 13.00-16.00 mg/L with the mean of 14.75 mg/L. Conductivity values varied between 26.00-32.00 µS/cm with an average of 29.75 µS/cm when ORP values were changed between 30-106.30.

Growth and nutrient utilization: During the 60 days of feeding, fish fed with the different feeds had the same growth evolution tendencies, however, fish fed feeds G presented the best growth following to those of fish fed feeds SG2 and SG1 which showed significant similar growth rate (Fig. 1). At the end of feeding trial, growth performance, feed utilization and survival parameters values recorded with fish were presented at Table 5. All weight parameters values calculated were presented significant difference ($p<0.05$) between the feeds treatments contrary to the length parameters values which are similar in all treatments. Fish fed feed G had the significantly highest final body weight (28.5±3.57 g), weight gain (21.74±3.57 g), average daily growth (0.36±0.02g/d), specific growth rate (2.39±0.21%/d), final

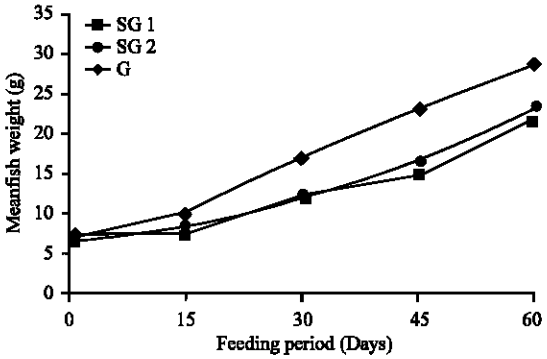

Fig. 1: Growth of *C. gariepinus* fingerlings fed with feeds produced by fish farming agroecological area SG1, SG2 and G during 60 days

biomass (4417.5±53.35 g) and biomass gain (3356.18±53.35 g) following by fish fed feeds SG2 when those of fish fed with feed SG1 presented the lowest values of these parameters. The significantly ($p<0.05$) best values of feed conversion ratio and protein efficiency ration were recorded from fish fed feeds G (2.63±0.19; 0.95±0.14) and SG2 (2.96±0.02; 0.84±0.01) compared to fish fed feed SG1 (3.63±0.05; 0.73±0.22). Fish fed feed G recorded also significantly best value of survival rate (98.73±0.90%).

Proximate composition of *Clarias gariepinus* after 60 days of feeding: Table 6 presents the proximate composition of fish at the end of the experiment. Moisture, crude protein and ash contents and gross energy were similar ($p>0.05$) in all treatments. Moisture levels ranged between 74.38±1.24 and 77.29±2.52%, crude protein level of fish varied from 17.12±1.73 and

Table 5: Growth performance, feed utilization and survival of *C. gariepinus* fed with the feeds produced by fish farming agroecological area SG1, SG2 and G during 60 days

	Fish feeds produced		
Parameters	SG1	SG2	G
Weight			
Initial body weight (g)	6.98±0.37^{a}	6.53±0.14^{a}	6.76±0.27^{a}
Final body weight (g)	21.90±2.06^{a}	23.07±2.45^{a}	28.5±3.57^{b}
Weight gain (g)	14.92±2.06^{a}	16.54±2.45^{ab}	21.74±3.57^{b}
Average daily growth (g/d)	0.25±0,01^{a}	0.28±0.03^{b}	0.36±0.02^{c}
Specific Growth Rate (SGR) (%/d)	1.86±0.08^{a}	2.07±0.14^{a}	2.39±0.21^{b}
Initial biomass (g)	1102.84±20.10^{a}	1031.74±13.08^{a}	1061.32±23.45^{a}
Final biomass (g)	3350.70±27.18^{a}	3529.71±33.85^{b}	4417.5±53.35^{c}
Biomass gain (g)	2247.86±27.18^{a}	2497.97±33.85^{b}	3356.18±53.35^{c}
Lenght			
Initial length (cm)	8.67±0,76^{a}	8.8±0,72^{a}	8.63±0.32^{a}
Final length (cm)	14.03±2.07^{a}	14.29±2.05^{a}	14.99±1.37^{a}
Length gain (cm)	5.36±2.82^{a}	5.49±1.36^{a}	6.36±1.08^{a}
Average daily length (cm/d)	0.09±0.05^{a}	0.09±0.02^{a}	0.11±0.02^{a}
Feed efficiency			
Feed Conversion Ratio (FCR)	3.63±0.05^{b}	2.96±0.02^{a}	2.63±0.19^{a}
Protein Efficient Ratio (PER)	0.73±0.22^{a}	0.84±0.01^{b}	0.95±0.14^{b}
Survival			
Survival rate (%)	96.84±2.00^{a}	96.84±1.2^{a}	98.73±0.90^{b}

Means values in the same row having the different superscript letter are significantly different (p>0.05)

Table 6: Proximate composition (Wet weight (%)) of *Clarias gariepinus* carcass fed with the feeds produced by fish farming agroecological area SG1, SG2 and G during 60 days

	Fish feeds produced		
Carcass composition	SG1	SG2	G
Moisture	74.38±1.24^{a}	77.29±2.52^{a}	76.61±1.47^{a}
Crude protein	18.34±0.04^{a}	17.12±1.73^{a}	18.32±0.01^{a}
Crude lipid	4.83±0.05^{b}	4.71±0.56^{b}	3.91±0.19^{a}
Ash	2.46±0.16^{a}	2.40±0.01^{a}	2.17±0.28^{a}
Gross energy (kJ/g)	6.25±0.03^{a}	5.91± 0.47^{a}	5.88±0.08^{a}

Means values in the same row having the different superscript letter are significantly different (p>0.05)

18.34±0.04% and the ash content from 2.17±0.28 and 2.46±0.16% while gross energy ranged between 5.88± 0.08 and 6.25±0.03 kJ/g. Only fish carcass lipid content showed a significant difference (p>0.05) between feeding treatment. Highest significantly (p<0.05) values of fish crude lipid level were recorded from fish fed feed SG1 (4.83±0.05%) and SG2 (4.71±0.56%) compared to those of fish fed feed G (3.91±0.19%) which were presented the lowest values.

Raw material and feeds produced: Total of six different raw materials were used in *Clarias gariepinus* fingerlings feed formulation and production. Fish meal (55) was rich in ash (21.15±0.98%) when cashew nut oil cake was rich in crude lipid (38.90±0.36%), wheat bran (20.32±0.35%) and cotton seed oil cake (24.58±0.25%) were rich in crude fibre and white rice bran (44.68±2.67%) and wheat bran (43.27±1.61%) were rich in carbohydrate. The proximate composition and the using of fish meal (55), soybean meal, cashew nut oil cake, white rice bran, wheat bran and cotton seed oil cake in fish feeds formulation were well know and documented by several researchers (Guillaume *et al*., 1999; Koumi *et al*., 2015, Kimou *et al*., 2016). But using of cashew nut oil cake in fish feed formulation is recent. In fact, it is now available in Cote d'Ivoire Sudano-Guinean 2 and Guinean areas for animal nutrition because of the installation of large cashew nut processing and import units in Abidjan (Guinean area) and Bouake (Sudano-Guinean 2 area), since, the last years. So, activities of traditional extraction of cashew nut oil are being grown near these units with the non-compliant nuts. So, the high lipid level (38.90±0.36%) in the low cost cashew nut oil cake using in this study was due to the traditional extraction of cashew nut oil. In fact, cashew nut contains 46.4-64.0% of total fat and traditional extraction removes little level of lipid (Nandi, 1998; Ros, 2010).

Otherwise, depending of the price, nutritional value and availabilities by area of raw materials and nutritional requirements of *Clarias gariepinus* fingerlings feeds (40% protein level, 8-10% ash level, less of 10% lipids and crude fibre the three feeds were formulated at 40% protein with different levels of selected raw materials by area (New, 1987; Hetch *et al*., 1997; Guillaume *et al*., 1999; Lazard, 2007). However, in spite of the same protein level of the three feeds produced, the nutritional value of each raw materials used in feeds formulations was affected feeds proximate and mineral composition. The highest level of ash (11.75±0.08%) in feed SG1 could be due to the 50% level of incorporation of fish meal (55) in this feed, also the high level of crude fibre (7.15±0.04%) in this same feed must be due to the 30% incorporated of white rice bran which is rich in the crude fibre (10.37±0.28%).

Guillaume *et al.* (1999) also reported that the high level of ash in fish meal (55) influences the feed ash and mineral level. However, the excess of minerals and ash (11.75±0.08%) in feed SG1 compared to requirement value (<10) in this feed could be well released into the water by fish and should not affect the use of nutrient feed as reported by Pouomogne *et al.* (1997) and Guillaume *et al.* (1999). Consequently, feed SG recorded lowest value of gross energy with the highest value of protein/energy of the three feeds formulated.

Without the high level of ash to the feed SG1, all feeds formulated follow the recommended requirement of feeds for *C. gariepinus* fingerlings rearing. This feeds can be well use by *Clarias gariepinus* fingerlings for growth. These three feeds were rich in protein than those of feeds sellers commercial feeds (16.2-24.9% of protein), national industrial feeds (28.00-30.15% of protein) and fish farmers feeds (10.92-35.90% protein) reported used to fed fish on Cote d'Ivoire fish farms by Koumi *et al.* (2015). However, protein level of feeds produced in this study were within in the 30-57% protein level of high quality imported industrial commercial feeds (Koumi *et al.*, 2015, 2016). Also feeds produced SG1, SG2 and G cost varied between 0.66 and 0.69 USD/kg which were affordable for fish farmers than those of 1.04-2.18 USD/kg reported for recommended imported industrial commercial feeds (Koumi *et al.*, 2015). In add, feeds used in this growth trial were the simple mixing of local feedstuffs identified in the different agro-ecological fish farming areas of Cote d'Ivoire and there will be easily reproduce and made by farmers to produce low cost available local *Clarias gariepinus* fingerlings feeds.

Water quality: All water parameters recorded in the ponds during the feeding trial were within the recommended range value for *Clarias gariepinus* rearing. Melard (1999), Baras and Jobling (2002) reported that catfish *Clarias gariepinus* had an optimal growth at temperature varied between 26 and 30°C. So, temperature values recorded ranged between 27.83-29.32°C in the ponds water during growth trial were within in the recommended range for maximum growth of catfish. The recorded water pH values (8.6-9.53) were within in the recommended pH values for pond culture varied between 5.5 and 10 (Stone and Thomforde, 2004). Also, the average value of pH (9.11±1.00) recorded in ponds was conform to the superior limit of pH according to Kanangire (2001). Dissolved oxygen as an indicator of water quality, so, it is the most important water quality parameter in aquaculture. According to the guidelines for the management of fish water quality, a minimum concentration of 5 mg/L is required for pond culture (Boyd, 1990). The mean value of ponds water dissolved oxygen (8.59 mg/L) recorded was conform to this value. This indicates relatively good oxygenated water for *C. gariepinus* rearing. Also, water conductivity values recorded (26.00-32.00 µS/cm) in all ponds water influenced by levels of TSD (13.00-16.00 mg/L) were within the natural waters conductivity ranged between 20-1500 µS/cm (Abowei, 2010).

Pond water was fresh nature and the analysis of the average values of the most important physico-chemical parameters (temperature, pH and dissolved oxygen) recorded, indicate that the ecological conditions of rearing were favorable to an optimal growth of *C. gariepinus* fingerlings.

Fish growth and survival: At the end of growth trial, daily growth rate recorded with the fish fed with the three produced feeds varied between 0.25±0.01 and 0.36±0.02 g/d were higher than 0.07 and 0.22 g/d reported by De Graaf (1994) in pond under the same rearing conditions with *C. gariepinus* fingerlings of 5 g. Daily growth rate values were also higher than 0.07 g/d obtained by Sotolu (2010) from the same specie fingerlings fed at 20% of body weight ratio with 40% crude protein feed formulated with Nigeria local byproducts enriched with vitamins and minerals premix. These results show that the three feeds used were well accepted by fish and confirm the ability of *C. gariepinus* to use efficiently a simple composed feeds (Nahar *et al.*, 2000; Nyina-Wamwiza *et al.*, 1997; Elegbe *et al.*, 2015). Results were similar to Nahar *et al.* (2000), who reported suitable growth performance with a simple mixing of agro-industrial byproducts without supplementation in amino acids. This simple formulated feeds can well made by fish farmers to improve *Clarias gariepinus* fingerlings growth. However, average daily weight 0.46-0.75 g/d and 0.47-0.76 g/d recorded, respectively by Richir (2004) and Nyina-Wamwiza *et al.* (2010) with *C. gariepinus* fngerlings initial weight 6-7 g fed apparent satiation twice daily in Rwanda could show a possibility to improve *C. gariepinus* fingerlings growth with increasing of feeding ratio beyond 10% recommended in this growth stage (New, 1987; Ducarme and Micha, 2003).

However, survival rates recorded in the trial ranged between 96.84-98.73% were much better. According to Umaru *et al.* (2016), high survival rates could be attributed to the favorable Physic-chemical water quality, good health condition of the fish stocked, quality and quantity of the feeds used and also the feeds acceptance by fish. In addition, survival rates values were higher than 87.78±9.62% obtained with fish raised in hapas in the same rearing conditions with an imported feed (Skretting) at 45% protein (Elegbe *et al.*, 2015).

However, the best growth, feeds efficiency and survival rate recorded with 40% protein feeds G could be due to his higher level of crude lipid (8.40±0.08%) and gross energy (19.03±0.04 kJ/g) than the two other feeds

used. Results were similar of Nahar *et al.* (2000) who reported from juveniles *Clarias gariepinus*, highest growth with the feed which contain highest lipid level. Ahmad (2008) also reported the similar trend with the same specie when Babalola and Apata (2006) reported from catfish *H. longifilis* an increasement of growth with increasing of lipid and gross energy contents with isoproteic feeds. Ahmad (2008) and Jantrarotai *et al.* (1998) reported improvement feed efficiency up to 35% dietary protein level with the increasing lipid contain of the feed. In fact, high lipid and energy content of the diet improve digestion and absorption of the others nutriments of feed (Dupree *et al.*, 1979). So with the same dietary protein content, the increasing of lipid led to an improvement in growth performance and feed efficiency from catfish *H. longifilis*, *C. gariepinus* and some of their hybrid (Babalola and Apata, 2006; Ahmad, 2008). In this case, dietary proteins were used for growth rather than for energy and dietary lipid and energy used by fish to spares protein (Tibaldi *et al.*, 1996; Calduch *et al.*, 1999).

The best specific growth rates (2.39±0.21%/d) obtained from fish fed feed G is almost comparable to 2.78-2.94%/d recorded with *C. gariepinus* fingerlings (Initial weight 6 g) fed commercial feeds with 42% proteins and 2.69%/d reported with an enriched formulated 40% protein feed (Agokei *et al.*, 2011; Nahar *et al.*, 2000). These results show the best quality of the simple composed 40% protein feed G formulated for Cote d'Ivoire Guinean area fish farmers.

Fish carcass proximate composition: Several studies on African catfish have shown that the amount of protein in the diet influences the amount of fish carcass protein (Hoffman *et al.*, 1997). In this trial, feeds were isoproteic (40%), similarly, the protein content of the fish did not differ significantly ($p>0.05$). Protein contents of the fish (17.12-18.34%) at the end of feeding trial were comparable to those found in the literature. In fact, Fagbenro (2004) recorded 16.8-17.5% protein content from *C. gariepinus*. Nyina-Wamwiza *et al.* (2007) obtained protein levels of *C. gariepinus* carcass varying between 15-17% with feeds based on Ruwanda local byproducts enriched with mineral premixes and vitamins. However, the lowest significant carcass lipid contain of fish fed feed G confirms the use of dietary lipid and energy in this feed for fish growth need and the spare of protein for fish growth reported by Tibaldi *et al.* (1996) and Calduch *et al.* (1999). Also, lowest accumulation of lipid in fish fed with the highest dietary lipid contain is similar to that observed from catfish *C. gariepinus* and *H. longifilis* fed high level of lipid in feed (Goda *et al.*, 2007; Koumi *et al.*, 2011). The good biochemical composition of fish fed carcass revealed the good quality of feeds formulated.

CONCLUSION

Growth performance, feed utilization and survival rate obtained in this experiment revealed the well acceptance of the three experimental feeds at 40% protein proposed for *Clarias gariepinus* fingerlings. However, growth and feed efficiency results showed that feed G was the better followed by SG2 and SG1. The availability of raw materials used and the affordable prices of feeds formulated for these three areas which record the high concentrations of fish farmers represent an opportunity to use low-cost competitive local feeds adapted to the raising of *C. gariepinus* fingerlings in Cote d'Ivoire.

ACKNOWLEDGEMENTS

This research was conducted in the framework of the PAFARCI (Project to Support the Recovery of Agricultural Sectors in Cote d'Ivoire) project funded by the FIRCA (National Inter-professional Fund for Research and Agricultural Council). The research are grateful to FIRCA and also thank feed sellers feeds and fish farmers for their help in this research.

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