Fish Feeds Used in Côte d'Ivoire: Nature, Quality, Use and Productivity

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ABSTRACT---- ***This study was conducted at the Oceanology Research Centre of Abidjan, Côte d'Ivoire to determine fish feeds nature and quality, factors affected their use, their impacts on fish growth parameters and fish farms production. Data were collected from 301 fish farms distributed in the 16 principal fish production regions, between May and November 2013. The majority of fish farmers (71.10%) used agro-industrial byproducts to feed fish, 27.57% used commercial feeds, 22.26% used non conventional feed and 17.94% mix their own feed. These different types of feeds were used alone or in combination to feed farmed fish depending on the growth stage. Agro-industrial byproducts and non conventional feed have low nutritional quality. Quality of feeds formulated by farmers varied greatly and not always met the requirement of fish cultured. Only high cost imported commercial feeds met well the nutritional requirement of fish depending of species and size. Agro-industrial byproducts and non conventional feed were most used by farmers localized in the rural area in the extensive and semi-intensive systems contrary to commercial feeds and farmers feeds produced were used by economic operators and salaried in urban and periurban areas in semi-intensive and intensive systems in majority. Agro-industrial byproducts associated or not to non conventional feed were most used to feed tilapia (59.10%), Heterotis niloticus (78.36%), catfish (45.45%) and African carp (100%). Commercial feeds are frequently using (33.33%) to feed bagrid catfish and parachana (33.33%). Highest growth, economic and production values were recorded with commercial feeds in semi-intensive and intensive farming systems. These results express the need to make available for local farmers, quality and cheap fish feeds made with the good processing methods which take into account the requirements of different species and stages of farmed fish.***

Keywords--- Fish farming, fish feeds, chemical composition, availability, use, fish production

1. INTRODUCTION

The fundamental challenge facing the aquaculture is to improve protein sources provide for human. In the year 2010, the wold aquaculture production contributed to 47% to world food fish production for human consumption [1]. The Africa aquaculture production is insignificant compare to the rest of the world, the entire continent contribute only to 2.2% to the world aquaculture production in the 2010[1]. In sub-Saharan Africa, aquaculture fish production remains insignificant to meet there own needs despite many years of practical. It's the case of Côte d'Ivoire where annual national fish consumption is estimated between 250 000 and 300 000 tons when the inland production is 75 611 tons [2]. The contribution of the aquaculture sector was estimated of 3720 tons in 2012 [2]. According to Brechbühl [3], the majority of the fish farms not running very well. This author reported the low growth rate with the long length of fish production cycle. The major problems of Ivorian aquaculture are the lack of locally produced high-quality fish feed, high costs of available feeds, absence of technical assistance, and the insufficient knowledge [4, 5, 3]. Otherwise, fish requires high quality nutritionally balanced diet for growth and attainment of market size within the shortest possible time [6, 7]. Feeds are one of the major inputs in aquaculture production and play very vital role in aquaculture growth and expansion. The availability of quality and quantity fish feeds is the most important factors that determine the sustainability and profitability of aquaculture [8, 9]. The objectives of this study were to identify the different fish feeds used in the Ivorian

aquaculture to determine fish feeds nature and quality, factors affected their use, their impacts on fish growth parameters and fish farms productions and the problems associated to feeding fish in Côte d'Ivoire.

2. MATERIALS AND METHODS

2.1 Data collection

The survey was carried out in sixteen (16) regions of Côte d'Ivoire, West Africa. These regions were identified by national fish producer organization and the Ivorian fisheries ministry such as principal fish production regions of the country. Data were collected between May and November 2013. Fish farmers were identified in each region with data and guidance given by local fish farmer's organizations and the regional technical assistances of Ivorian state agriculture and fisheries ministries. Because of irregular distribution of fish farmers by region, all accessible commercial fish farmers which effectively produce fish per area were selected. Each of the respondent via a personal interview, questions about fish feeding, fish species produced, type of farming systems, socio-economic characteristics of fish farmers, and production data. In addition, fish feed was sample on each fish farm to chemical composition determination. The sample consists to 301 fish farms localized in 16 regions, 33 Departments, and 58 cities distributed through the country (Figure 1).

Figure 1: Map of Areas Visited

2.2 Chemical analysis of feeds

The approximate composition of fish feeds was analyzed using standard methods of the Association of Official Analytical Chemists [10]. Moisture content of each sample was determined through a hot-air oven (MEMMERT Drying Oven, GE-174, Memmert GmbH, Heilbronn, Germany) set at 105°C for 24 h. Ash was determined by incineration at 550°C in a muffle furnace (Thermo Fisher Scientific Heraeus M 110 Muffle Furnace, Waltham, MA, USA) for 24 h. Crude protein (nitrogen x 6.25) was determined using micro-Kjeldahl method, N% x 6.25 (Kjeltech autoanalyzer, Model 1030, Tecator, Höganäs, Sweden), crude fat was extracted (hexane extraction) by using the Soxhlet method (Soxtec System HT6, Tecator) and crude fibre was quantified by acid digestion followed by ashing the dry residue at 550°C in muffle furnace for 4 h. The gross energy of samples was determined using the gross energy values for the macronutrients [7]. Sample calcium and phosphorus composition was analyzed using microwave digestion and atomic absorption spectrophotometer (Varian SAA 110) air- acetylene flame [11]. All the samples were analyzed in triplicate.

2.3 Fish growth and farm production parameters

Fish growth and farm production parameters were calculated for each farm as follows:
Average Growth Rate (g/d) = Fish final body weight / Length of a cycle; Feed Intensity (kg/ha/d) = Total weight of feed used/ Water productive surface/ Length of a cycle; Fish Production Cost (FCFA/kg) = Total weight of fish produced/ Total cost of feed used; Yield (kg/ha/year) = Annual weight of fish produced/ water productive surface.

2.4 Statistical Analysis

Survey data were analyzed using Sphinx version 4.5 software packages and fish growth and farm production parameters were analyzed by using one way analysis of variance (ANOVA) using Statistica version 7.1. Tukey's multiple range test was used to compare the differences among the individual means. The effects of treatment were considered to be significant at $p < 0.05$.

3. RESULTS

3.1 Fish feeds

The survey revealed four different types of fish feeds used in Côte d'Ivoire which are commercial feeds, feeds produced by fish farmers themselves, agro-industrial byproducts and non conventional feed.

A ratio of 27.57% of fish farmers used the commercial feeds, among them 48.19 % used only commercial feeds and the other 51.81% associates commercial feeds with other types of fish feed. Three categories of commercial feeds were available on fish farms: feed sellers commercial feeds, national industrial commercial feeds and imported industrial commercial feeds. Feed sellers commercial feeds were formulated with the regular feed stuffs by the local feed sellers, the national Oceanology Research Center (CRO) station and the local wheat bran provender (GMA). Six different feed sellers commercial feed are met on fish farms. Four department feed sellers commercial feeds presented in the form of meal, the CRO station feed presented in pellets (2mm) and crushed pellets forms and the GMA feed presented in the large size pellets (6mm). These feeds were regularly and locally available. National industrial commercial feeds are delivered by IVOGRAIN and FACI, two animal industrial feed providers in Côte d'Ivoire. These industries produce two types of tilapia-feed that are juveniles tilapia feed presented in the meal form and grower pellet (2mm) tilapia feed. The imported industrial commercial feeds met in the fish farm were produced by SKRETTING (Holland) and RAANAN fish feed (Israel) marketed by two different local large fish farms. These feeds were catfish and tilapia starter, juveniles and grower extruded feeds presented in the crumble, and floated pellets form at the different size (0.5 mm, 0.7mm, 1.0 mm, 1.8 mm, 2.5 mm, 4.5 mm).

A total of 17.94 % of fish farmers mixed their own feed by using primary materials which were usually agro industrial by-products. Many of these materials are cheap and available in quantity. Majority of them (53.7%) used only their feed produced and 46.29 % associated their feed produced with the other types of fish feed. The survey revealed that the majority of fish farmers who mix their own feed used fish meal (77.59%), coconut cake (50%), white rice bran (41.40%), wheat bran (46,55%), cotton seed meal (34.5%), corn bran (29.31%), soya bean meal (20.7%), shell (19%), rice bran (18.97%), corn meal (10.34%) when 8.6% used salt, 6.9% vitamin and mineral premix, 6.9% biacalcium, 6.9%, palm oil 3.45% soya oil and 1.7% fish oil. All of feeds produced by fish farmers themselves were presented in meal form.

The Agro-industrial byproducts from vegetal origin such are rice bran, corn bran, white rice bran and wheat bran were regularly used to directly feed fish. They are cheap, locally produced and available in very large quantity. These agro-industrial byproducts are used alone or in combination to other fish feed. Majority of the fish farmers (71.10%) used agro-industrial byproducts. Among them, 53.74% used only agro-industrial byproducts and the other (46.26%) associated agro-industrial byproducts with the other types of fish feed. Rice bran (48.59%) is the most used followed by the combination of rice bran and corn bran (22.9%), white rice bran (8.88%), corn bran (8.88%) wheat bran (3,74%) and the other combinations of agro-industrial byproducts are few used by fish farmers.

About 22.26% of fish farmers used non conventional feed. Therefore, these fish farmers associated non conventional feed to agro-industrial byproducts. These feed stuffs come from several sources and are not consumed by human in most cases. There are locally available feed stuffs that are not standardized. The non conventional feed met in fish farms are kitchen and pig wastes, household waste, cassava and potato leaves and remains of human food.

3.2 Chemical composition of fish feeds

Results of the proximate analysis of the fish feed are shown in Table 1 and Table 2. The proximate composition of commercial feeds produced by feed sellers was 16.2 and 24.9% crude protein, 4.30 and 9.42% crude fat, 5.47 and 10.84% crude ash, 9.74 and 43.21% crude fibre, 15.74 and 17.57 kJg-1 energy, 9.52 and 14.61 mgkg-1 protein/energy ratio and 1.19 and 3.75 for calcium/phosphor ratio. The price of feeds produced by feed sellers ranged between 110 and 300 FCFA kg^{-1}. National industrial commercial feeds crude protein ranged between 28.00 and 30.15%, crude fat between 4 and 7%, crude ash between 10.76 and 11.53%, crude fibre between 6.52 and 8.21%, energy between 16.53 and 17.01 kJ g^{-1}, protein energy ratio between 16.46 and 18.07 mg kJ^{-1} and the calcium/phosphor ratio between 0.8 and 1.8. The price of the national industrial commercial feeds varied between 240 and 295 FCFAkg^{-1}. Imported industrial commercial feeds crude protein varied between 30.00 and 57.00%, crude lipid between 5.00 and 15.00%, crude ash between 8 and 11%, crude fibre between 0.1 and 4.0 %, energy between 17.34 and 20.81 KJ g^{-1}, protein/energy ratio between 17.3 and 27.39 mgKJ^{-1} and calcium/phosphor ratio between 0.86 and 0.96. The price of imported industrial commercial feeds varied between 600 and 1250 FCFAkg^{-1} (Table 1). Feeds produced by fish farmers themselves contained 10.92 and 35.90 % of crude protein. Lipid content of these feeds varied between 1.83 and 17.86, Ash between 4.7 and 16.97%, fibre between 4.7 and 56.33, energy between 14.44 and 21.99 kJ g, protein/energy ratio between 6.40 and 18.81 (mg kg^{-1}) and the calcium/phosphor ratio between 0.09 and 1.53. The price of the feeds produced by fish farmers themselves varied between 25 and 270 FCFAkg^{-1}. Agro-industrial byproducts recorded the low values of crude protein (9.45-16.20%), protein/energy ratio (5.92-9.84%), calcium (0.89-3.41 mg g^{-1}) with the high values of crude fibre (8.88-51.54%) while energy values varied between 15.97 and 18.44 kJ $g^{-1}$and the phosphor between 2.92 and 15.07 mg^{-1}. Among them, the highest crude protein (16.20 ± 0.37 %) was observed with wheat bran, rice bran (14.54 ± 1.23 %) and white rice bran (9.65 ± 0.80 %) presented the highest crude fat. Rice bran (25.85 ± 0.81%), corn bran (51.54 ± 7.75 %), and wheat bran (40.79 ± 2.59%) recorded the highest crude fibre when white rice bran recorded the lowest crude fibre (8.88 ± 0.55%) and the corn bran the lowest lipid (0.93 ± 0.21%) and phosphor (2.92 ± 1.65%). The prices of these agro-industrial byproducts were low and varied between 20 and 105 FCFA. However, wheat bran (105 FCFA kg^{-1}) recorded highest price (Table 2).

Among these feeds, imported industrial commercial feeds recorded the highest average crude protein, protein/energy ratio, and price followed by national industrial commercial feeds while the lowest values were obtained with feed sellers commercial feeds and feeds produced by fish farmers themselves. Contrary, the highest average values of crude fibre were observed with feeds produced by fish farmers themselves followed by sellers feed commercial feed and National industrial commercial feed, the lowest values are observed in imported industrial commercial feeds. Otherwise, non conventional feed are generally free and have low protein content, amino acide imbalance and contains antinutritional factors [12, 13, 14].

3.3 Fish feed utilization

Localization of fish farms: Figure 2 shows the distribution of fish farms in urban and periurbain or rural areas according to fish feed type used. The results show that the majority of fish farms using agro-industrial byproducts (67.29%), non conventional feed (65.67%) and commercial feeds (62.65%) were localized in the rural areas. Contrary, fish farm where fish were fed with feeds produced by fish farmers themselves were localized in majority (59.26%) in the urban and periurban areas.

Principal function of fish farmers: The principal function of fish farmers depending of type of fish feed as shown in Figure 3. Survey showed that the majority of famers used agro-industrial byproducts (155) and non conventional feed (50). Only 20 and 29 farmers produced feeds and used commercial feeds respectively. Most of salaried used agro-industrial by products (29) and commercial feeds (27) to feed cultured fish while, few number of these fish farmers category produced feed (14) and used non conventional feed (8). Economic operators (22) used commercial feeds and agro-industrial byproducts (17) in majority, 12 of them produced their feed, and 5 used non conventional feed. Fish famers used in majority agro-industrial byproducts (13) compared to non conventional feed (4), feeds produced by fish farmers themselves (8) and commercial feeds (5).

Fish farming system: The survey showed difference in the fish feed utilization among the fish farming systems (Figure 4). Non conventional feed is used in rice fish farming (4) and extensive system (63). Agro-industrial byproducts are used in rice fish farming (12), extensive (129) and semi-intensive (73) systems. Feeds were produced by fish famers themselves in semi-intensive (53) and intensive (1) systems and commercial feeds were used in semi-intensive (79) and intensive system (4). However, non conventional feed are most used in extensive system, agro-industrial byproducts in extensive and semi-intensive systems, feeds produced by fish farmers and commercial feeds in semi-intensive system.

Table 1: Proximate, mineral compositions and cost of fish feeds

Parameters	Feed sellers commercial feeds (6)			National industrial commercial feeds (4)			Imported industrial commercial feeds (4)			Fish farmers feeds (54)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Moisture (%)	8.71	11.35	10.03 ± 0.91	8.87	9.50	9.19 ± 0.27	9.00	10.00	9.25 ± 0.50	8.55	10.51	9.51 ± 0.51
Crude protein (%)	16.20	24.90	19.15 ± 3.26	28.00	30.15	29.13 ± 1.10	30.00	57.00	40.00 ± 11.80	10.92	35.90	19.06 ± 5.33
Crude lipid (%)	4.30	9.42	6.77 ± 2.25	4.00	7.00	5.51 ± 1.29	5.00	15.00	8.25 ± 4.57	1.83	17.86	6.86 ± 3.14
Ash (%)	5.47	10.84	8.63 ± 1.88	10.76	11.53	11.03 ± 0.36	8.00	11.00	9.50 ± 1.73	4.70	16.97	9.15 ± 2.83
Crude fibre (%)	9.74	43.21	20.77 ± 13.72	6.52	8.21	7.18 ± 0.72	0.10	4.00	2.78 ± 1.80	4.70	56.33	28.22 ± 14.60
Carbohydrate content (%)[a]	18.74	45.57	34.37 ± 11.78	35.67	41.32	37.74 ± 2.47	7.90	44.00	30.48 ± 15.64	15.52	47.85	36.37 ± 9.01
Gross energy (kJ g-1)b	15.74	17.57	16.97 ± 0.57	16.53	17.01	16.81 ± 0.24	17.34	20.81	18.46 ± 1.63	14.44	21.99	16.66 ± 0.96
Protein/Energy ratio	9.52	14.61	11.48 ± 2.00	16.46	18.07	17.33 ± 0.69	17.30	27.39	21.40 ± 4.27	6.40	18.81	11.39 ± 2.95
Calcium (mg g^{-1})	1.73	7.96	5.39 ± 2.13	10.40	19.98	14.28 ± 4.32	6.00	6.00	6.00 ± 0,00	1.22	13.29	5.91 ± 3.26
Phosphore (mg g^{-1})	2.12	15.49	8.05 ± 4.79	10.18	13.02	11.67 ± 1.3	7.00	18.00	12.00 ± 4,55	4.37	65.75	11.90 ± 8.10
Calcium/Phosphore ratio	0.19	3.75	1.15 ± 1.02	0.80	1.80	1.13 ± 0.45	0.86	0.96	0.86 ± 0.07	0.09	1.53	0.60 ± 0.35
Cost (FCFA kg^{-1})[c]	110	300	220 ± 65	240	295	275 ± 20	600	1250	850 ± 285	25	270	110 ± 50

[a] Carbohydrate content = 100 – (% moisture + % protein + % fat + % fibre + % ash).
[b] Gross energy = [23.7 × protein + 39.5 × fat + 17.2 × (Carbohydrate content + fibre)].
[c] Price in CFA pound: 100 FCFA = 0.19 $ based on 2014 exchange prices in Côte d'Ivoire.

Table 2: Proximate, mineral compositions and cost of agro-industrial byproduct directly used to feed fish

Parameters	Rice bran	Corn bran	White corn bran	Wheat bran
Moisture (%)	8.63 ± 0.79	8.46 ± 0.57	9.76 ± 1.09	10.48 ± 0.53
Crude protein (%)	12.38 ± 0.87	9.45 ± 0.90	12.93 ± 0.69	16.20 ± 0.37
Crude lipid (%)	14.54 ± 1.23	0.93 ± 0.21	9.65 ± 0.80	4.30 ± 0.50
Ash (%)	9.31 ± 0.76	3.44 ± 0.29	9.96 ± 0.87	5.47 ± 0.35
Crude fibre (%)	25.85 ± 2.81	51.54 ± 7,75	8.88 ± 0.55	40.79 ± 2.59
Carbohydrate content (%)[a]	29.30 ± 4.13	26.19 ± 8.18	48.82 ± 1.56	22.77 ± 2.59
Gross energy (kJ g-1)[b]	18.16 ± 0.40	15.97 ± 0.13	16.80 ± 0.31	16.47 ± 0.18
Protein/Energy ratio	6.81 ± 0.44	5.92 ± 0.54	7.70 ± 0.37	9.84 ± 0.26
Calcium (mg g^{-1})	0.93 ± 0.07	3.41 ± 0.13	0.89 ± 0.15	1.73 ± 0.14
Phosphore (mg g^{-1})	15.07 ± 1.02	2.92 ± 1.65	14.43 ± 1.62	9.27 ± 1.27
Calcium/Phosphor ratio	0.06 ± 0.01	1.28 ± 0.08	0.06 ± 0.01	0.19 ± 0.01
Cost (FCFA kg^{-1})[c]	20	40	30	105

Values are expressed as means ± standard deviation.
[a]Carbohydrate content = 100 – (% moisture + % protein + % fat + % fibre + % ash).
[b]Gross energy = [23.7 × protein + 39.5 × fat + 17.2 × (Carbohydrate content + fibre)].
[c]Price in CFA pound: 100 FCFA = 0.19 $ based on 2014 exchange prices in Côte d'Ivoire.

Species produced: Results of the feeds used to feed different cultured fish species are shown in Table 3. Among the fish feeds, agro-industrial byproducts associated or not to non conventional feed are most used to feed tilapia *Oreochromis niloticus* (59.10%), *Heterotis niloticus* (78.36%), catfish *Heterobranchus longifilis*, *Clarias gariepinus* and *Hetero-clarias* (45.45%) and African carp *Labeo coubie* (100%). Contrary, commercial feeds were frequently using (33.33%) to feed bagrid catfish (*Chrysichthys nigrodigitatus*) and *Parachana africana* (33.33%). However, commercial feeds and feeds produced by fish farmers were often used to feed tilapia (13.75 and 9.97%) and catfish (17.05 and 12.50%) respectively. Commercial and fish farmers feeds, and agro-industrial byproducts were associated to feed tilapia, *Heterotis niloticus*, and catfish on some farms contrary to African carp and *Parachana africana*.

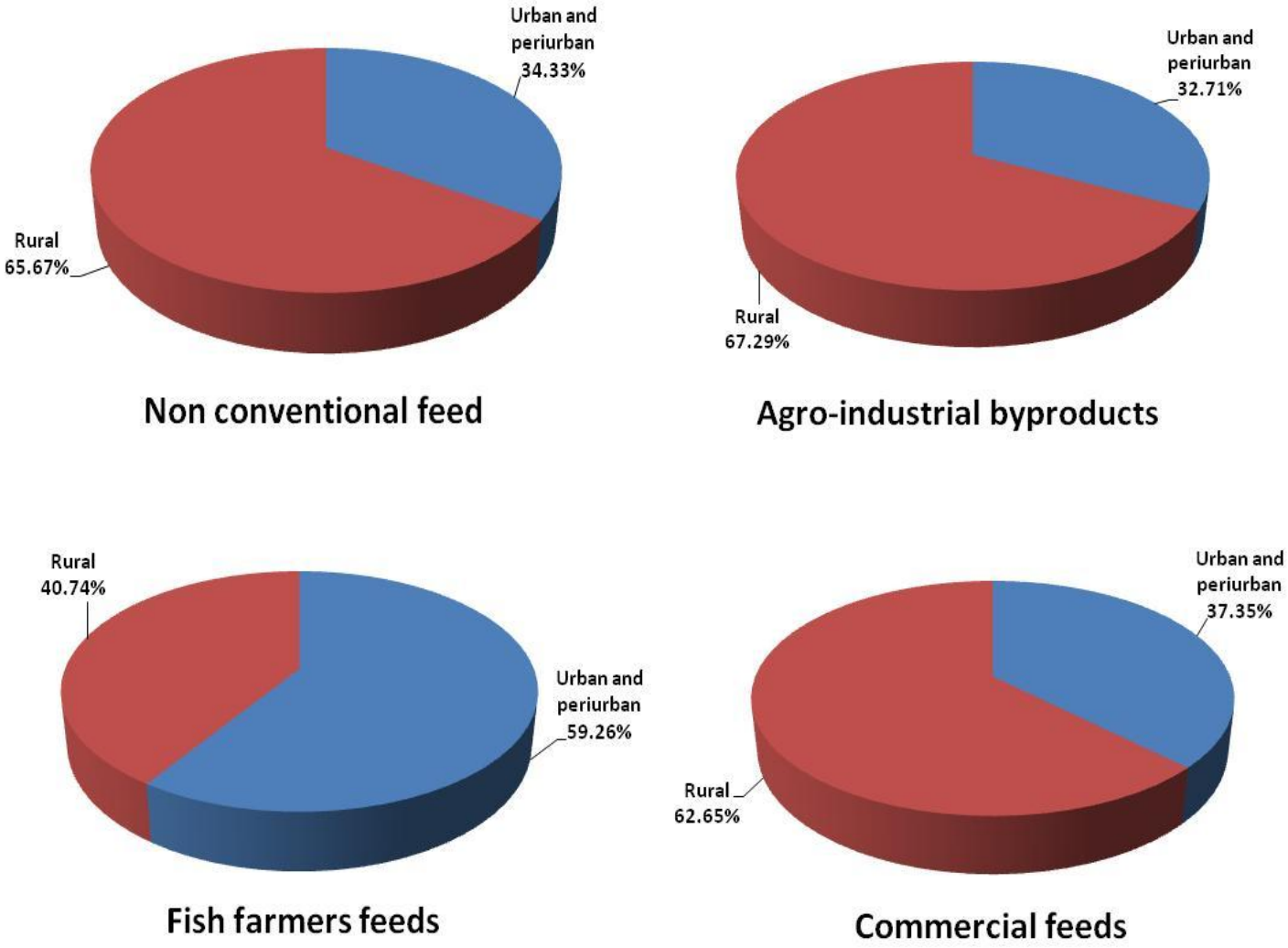
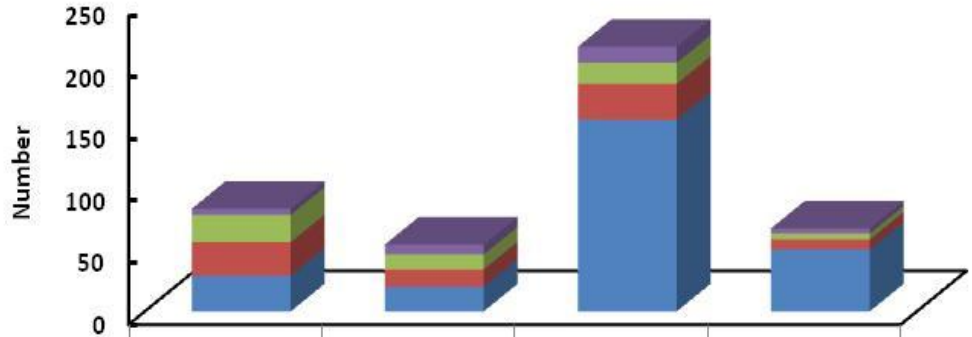
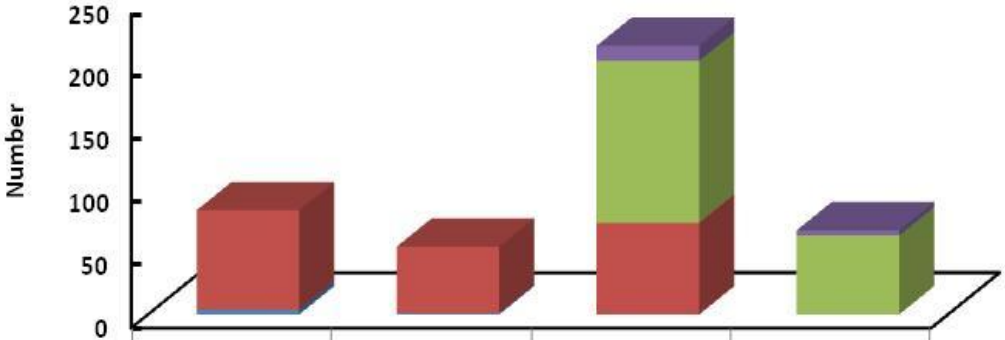


Figure 2: Fish Feeds Used According to the Localization of Fish Farms



	Commercial feeds	Fish farmers feeds	Agro-industrial byproducts	Non conventional feed
Fish farmers	5	8	13	4
Economic operators	22	12	17	5
Salaried	27	14	29	8
Farmers	29	20	155	50

Figure 3: Fish Feeds Used According to the Principal Function of Fish Farmers



	Commercial feeds	Fish farmers feeds	Agro-industrial byproducts	Non conventional feed
Rice-fish farming			12	4
Extensive			129	63
Semi-intensive	79	53	73	
Intensive	4	1		

Figure 4: Fish Feeds Used According to the Fish Farming Systems

Table 3: Fish feeds used to feed different species cultured

Parameters	Frequency	Percentage (%)	Cumulative percentage (%)
Tilapia (*Oreochromis niloticus*)			
Commercial feeds	40	13.75	13.75
Fish farmers feeds	29	9.97	23.72
Agro-industrial byproducts	113	38.83	62.55
Commercial feeds + Fish farmers feeds	18	6.19	68.74
Commercial feeds + Agro-industrial byproducts	25	8.59	77.33
Fish farmers feeds + Agro-industrial byproducts	7	2.41	79.74
Agro-industrial byproducts and non conventional feed	59	20.27	100
Total	**291**	**100**	
Heterotis (*Heterotis niloticus*)			
Commercial feeds	8	4.68	4.68
Fish farmers feeds	12	7.01	11.69
Agro-industrial byproducts	88	51.46	63.15
Commercial feeds + Fish farmers feeds	3	1.75	64.90
Commercial feeds + Agro-industrial byproducts	10	5.85	70.75
Fish farmers feeds + Agro-industrial byproducts	4	2.34	73.09
Agro-industrial byproducts and Non conventional feed	46	26.90	100
Total	**171**	**100**	
Catfish (*Hetebranchus longifilis, Clarias gariepinus, Hetero-clarias*)			
Commercial feeds	15	17.05	17.05
Fish farmers feeds	11	12.50	29.55
Agro-industrial byproducts	24	27.27	56.82
Commercial feeds + Fish farmers feeds	10	11.36	68.18
Commercial feeds + Agro-industrial byproducts	10	11.36	79.54
Fish farmers feeds + Agro-industrial byproducts	2	2.27	81.81
Agro-industrial byproducts and Non conventional feed	16	18.19	100
Total	**88**	**100**	
African carp (*Labeo coubie*)			
Agro-industrial byproducts	3	25.00	25.00
Agro-industrial byproducts and non conventional feed	9	75.00	100
Total	**12**	**100**	
Bagrid catfish (*Crysichthys nigrotigitatus*)			
Commercial feeds	6	33.33	33.33
Fish farmers feeds	3	16.67	50.00
Agro-industrial byproducts	3	16.67	66.67
Commercial feeds + Fish farmers feeds	1	05.56	72.23
Commercial feeds + Agro-industrial byproducts	3	16.67	88.9
Agro-industrial byproducts and Non conventional feed	2	11.11	100
Total	**18**	**100**	
Parachana (*Parachana africana*)			
Commercial feeds	1	33.33	33.33
Fish farmers feeds	1	33.33	66.66
Agro-industrial byproducts	1	33.33	100
Total	**3**	**100**	

3.4 Growth, production, and economic parameters in the different fish farming systems according of fish feeds used

As illustrated in Table 4, fish fed with commercial feeds in intensive system reported 491.67 ± 146.49 g average commercial tilapia weight after 7.50 ± 0.50 months of fish feeding. Average growth rate was 2.22 ± 0.75 gd^{-1}, feed intensity 123.70 ± 31.92 $kg^{-1}had^{-1}$, production cost 700 ± 220 $FCFAkg^{-1}$ and average yield to 19222.22 ± 7515.41 $kgha^{-1}year^{-1}$.

Table 4: Growth, production, and economic parameters in intensive fish farming system with the commercial feeds

Parameters	Commercial feeds (3)
Commercial tilapia weight (g)	491.67 ± 146.49
Length of a cycle (Month)	7.50 ± 0.50
Average Growth Rate (g d^{-1})	2.22 ± 0.75
Feed Intensity ($kg^{-1}ha\ d^{-1}$)	123.70 ± 31.92
Production Cost (FCFA kg^{-1})[a]	700 ± 220
Yield (kg ha^{-1} $year^{-1}$)	19222.22 ± 7515.41

*Values in the same row with different superscripts are significantly different (P < 0.05).
[a]Price in CFA pound: 100 FCFA = 0.19 $ based on 2015 exchange prices in Côte d'Ivoire.

As shown in Table 5, length of a cycle, in semi-intensive system recorded with the various fish feed was not significantly different. In contrary, commercial tilapia weight, average growth rate, feed intensity, production cost and yield were statistically different (p<0.05). Commercial tilapia weight and average growth rate with fish fed commercial feeds were significantly high in comparison to those of fish fed with agro-industrial byproducts and feeds produced by fish farmers. For the feeds used in semi-intensive system, feed intensity was highest with agro-industrial byproducts (79.03 ± 47.68 kg ha^{-1} d^{-1}) and lowest with fish farmers feeds (30.85 ± 12.61 kg ha^{-1} d^{-1}) and commercial feeds (28.36 ± 13.93 kg ha^{-1} d^{-1}). Conversely, production cost was high with fish fed with commercial feeds (475 ± 115 FCFA kg^{-1}), following by those fed with feeds produced by fish farmers themselves (335 ± 125 FCFA kg^{-1}) and the lowest values were observed in fish fed with agro-industrial byproducts (210 ± 90 FCFA kg^{-1}). The yield of fish farms in this system follows the same trend. High yield was recorded with fish fed with commercial feeds (4252.38 ± 2657.27 $kgha^{-1}year^{-1}$), following by fish fed with fish farmers feeds (2837.83 ± 1544.05 kg $ha^{-1}year^{-1}$) while lowest yield were observed from fish fed with agro-industrial byproducts (2506.89 ± 1710.65 kg ha^{-1} $year^{-1}$).

Table 5: Growth, production, and economic parameters in semi-intensive fish farming system according to fish feed used

Parameters	Commercial feeds (n=37)	Fish farmers Feeds (n=29)	Agro-industrial byproducts (n=41)
Commercial tilapia weight (g)	336.49 ± 57.91[b]	305.52 ± 66.05[a]	302.07 ± 48.08[a]
Length of a cycle (Month)	9.46 ± 1.52[a]	9.62 ± 1.64[a]	9.55 ± 1.54[a]
Average Growth Rate (g d^{-1})	1.20 ± 0.17[b]	1.07 ± 0.21[a]	1.06 ± 0.12[a]
Feed Intensity (kg ha^{-1} d^{-1})	28.36 ± 13.93[a]	30.85 ± 12.61[a]	79.03 ± 47.68[b]
Production Cost (FCFA kg^{-1})[a]	475 ± 115[c]	335 ± 125[b]	210 ± 90[a]
Yield (kg ha^{-1} $year^{-1}$)	4252.38 ± 2657.27[c]	2837.83 ± 1544.05[b]	2506.89 ± 1710.65[a]

*Values in the same row with different superscripts are significantly different (P < 0.05).
[a]Price in CFA pound: 100 FCFA = 0.19 $ based on 2015 exchange prices in Côte d'Ivoire.

Extensive system present similar values of fish growth, fish farms production and economic parameters in spite of fish feeds used (Table 6). Commercial tilapia weight, length of a cycle and yield ranged between 242.94 ± 41.07 and 243.71 ± 35.32 g, 11.18 ± 1.13 and 11.24 ± 1.03 months and 550.18 ± 218.28 and 469.28 ± 221.34 kg ha-1 $year^{-1}$ respectively in this system.

In the rice fish farming, commercial tilapia weight, length of a cycle, average growth rate, feed intensity, production cost and yield were similar independently of fish feed used (Table 7). In this system, commercial tilapia weight ranged between 272.50 ± 78.16 and 304.38 ± 69.20g obtained in 9.63 ± 1.89 – 10.38 ± 1.41 months and yield varied between 518.75 ± 106.8 and 544.08 ± 310.50 kg ha^{-1} $year^{-1}$.

Table 6: Growth, production, and economic parameters in extensive fish farming system according to fish feed used

Parameters	Agro-industrial byproducts (n=66)	Agro-industrial byproducts + Non conventional feed (n=63)
Commercial tilapia weight (g)	243.71 ± 35.32[a]	242.94 ± 41.07[a]
Length of a cycle (Month)	11.24 ± 1.03[a]	11.18 ± 1.13[a]
Average Growth Rate (g d^{-1})	0.73 ± 0.12[a]	0.75 ± 0.12[a]
Feed Intensity (kg ha^{-1} d^{-1})	9.45 ± 6.41[b]	7.89 ± 3.36[a]
Production Cost (FCFA kg^{-1})[a]	80 ± 35[a]	80 ± 50[a]
Yield (kg ha^{-1} $year^{-1}$)	469.28 ± 221.34[a]	550.18 ± 218.28[a]

*Values in the same row with different superscripts are significantly different (P < 0.05).
[a]Price in CFA pound: 100 FCFA = 0.19 $ based on 2015 exchange prices in Côte d'Ivoire.

Table 7: Growth, production, and economic parameters in rice-fish farming according to fish feed used

Parameters	Agro-industrial byproducts (n=8)	Agro-industrial byproducts + Non conventional feed (n=4)
Commercial tilapia weight (g)	304.38 ± 69.20[a]	272.50 ± 78.16[a]
Length of a cycle (Month)	10.38 ± 1.41[a]	9.63 ± 1.89[a]
Average Growth Rate (g d^{-1})	0.97 ± 0.15[a]	0.92 ± 0.16[a]
Feed Intensity (kg^{-1}ha d^{-1})	6.86 ± 5.49[a]	7.08 ± 2.50[a]
Production Cost (FCFA kg^{-1})[a]	50 ± 25[a]	50 ± 20[a]
Yield (kg ha^{-1} $year^{-1}$)	544.08 ± 310.50[a]	518.75 ± 106.8[a]

*Values in the same row with different superscripts are significantly different (P < 0.05).
[a]Price in CFA pound: 100 FCFA = 0.19 $ based on 2015 exchange prices in Côte d'Ivoire.

4. DISCUSSION

Fish farmers use several varieties of feeds to feed fish in Côte d'Ivoire. Agro-industrial byproducts and the non conventional feed are cheap and readily locally available in the country. However, their proximate and mineral compositions reported in this study is in agreement of several authors show that they have low nutritional quality due to their low protein content, low protein/energy ratio with high fibre and variety of antinutrional substances content [12, 7, 15, 16]. Also quality of feeds formulated by fish farmers themselves and feed sellers are rich in fibre and poor in protein and protein/energy ratio. In addition, the quality of these feeds varies greatly and do not always meet the cultured fish requirement. This could be due of the fact that these feeds are composed according to the price and the availability of the primary materials by non professional and are hardly based on scientific advices. Feed sellers and fish farmers are not always professional in making fish feed and unknown the principles of fish feed formulation. However, available national industrial commercial feeds protein content varie between 28 and 30.15% and do not cover all nutritional needs of the fish in relation of fish species, size and type of the system. In fact, fish dietary requirement varied between 25-55% protein, 4-10 % lipid, 25-40% carbohydrate content**,** 15-25kJg^{-1} energy, 16-22 $mgkJ^{-1}$ energy/protein ratio, and 0.7-1 calcium/phoshor ratio while ash and fibre content must be lower than 10% [17, 6, 7, 18, 19]. Proximate and mineral compositions of reported feeds allows to observed that only high cost imported commercial feeds meet well the nutritional requirement of fish species depending of the fish size and presented in the adequate form to maximize their uptake by fish. The results of fish feeds used confirms the lack of low cost high quality feeds on the most of fish farms reported in Côte d'Ivoire [3, 8, 9, 4].

The high utilization of agro-industrial byproducts and the non conventional feed are associated not only to their low cost and their good availability but also to the high number of the farmers among fish farmers. These farmers essentially fed fish with these feed stuffs in extensive and semi-intensive farming system in majority as reported by the survey. According to several authors, almost of fish farmers are cocoa, coffee, palm oil, rubber and over agricultural culture farmers at the time, so fish culture is a secondary activity [3, 20]. Owing to this, they did not spend much time and money to culture fish. Moreover, the high presence of farmers in farming fish confirm the inadequate finance, poor technology, low educational level and inadequate informations on the fish feeding, practice and management of fish farm [21]. In general, these farmers are either illiterate or have had little schooling and this low level of education limiting the access to information and training [21]. The high utilization of agro-industrial byproduct has also reported in Ghana (77.78%) and in lot of African country [20, 9]. According to the fish farmers, these feed materials are used because they were advised by aquaculture popularization project in Côte d'Ivoire rural areas and by agricultural extension agents from the Ministry of Fisheries in Ghana because they were affordable and also nutritious to provide carbohydrates and proteins for fish growth [20].

In this study, a remarkable effort was observed from salaried and an economic operator to use formulated and commercial feeds. However, formulated feeds by fish farmers localized in the urban and periurban areas could be due to the good availability of most of raw materials in these areas. This practice expresses the will to increase availability and utilization of low cost feeds on the fish farming to reduce production cost of fish and improve profit. Moreover the absence of technical assistance observed at these farms could explain the low quality of some feeds produced by these farmers. Most of the species cultured such as tilapia, Heterotis, catfish, African carp and parachana are fed generally with agro-industrial byproducts combined or not to non conventional feed. In addition, extensive and semi-intensive systems which are most practiced by fish farmers use in majority agro-industrial byproducts and non conventional feed. In spite of the low nutritional quality of agro-industrial byproducts, they can support the organic fertilization in the ponds to improve availability of natural foods very good consumed by some cultured fish such as tilapia, *Heterotis niloticus*, *African carp*, *Labeo coubie* and *parachanas* to support their growth [22, 23]. Moreover, length of a cycle, commercial tilapia weight, average growth rate of *Oreochromis niloticus* and yield with agro-industrial byproducts combined or not to non conventional feed in semi intensive and extensive system recorded in this study reveals insufficient organic fertilization to allow good growth of tilapia. In addition, the survey showed significant difference in growth, economic and production values among farming system and feed used. These could be due to the large size of ponds, absence of good farm management practices like sexage, stoking density, monoculture and feeding strategies which characterize extensive system. In rice-fish farming, the abundance of natural food in ponds due to the association of rice and fish culture such as observed by Avit *et al*. [24] and the regular distribution of agro-industrial byproducts could explain the improvement of commercial tilapia weight and average growth rate observed in this system compared to the extensive system. Showed significant difference in growth, economic and production values among farming system and feeds used could be due to the best quality of farm management practices in intensive and semi intensive systems compared to the extensive and rice-fish farming system but also to the high number of salaried and economic operators in these farming system who used greatly commercial pellet feeds with better feed efficiency. These feeds recorded higher commercial tilapia weight, yield and growth rate with the lower length of a cycle and feed intensity. Growth and production confirms that the high quality commercial feeds in semi intensive and intensive farming systems improve aquaculture production because feed is one of the major inputs in aquaculture production. However, the high cost of high quality imported commercial feeds expresses the need to put at the disposal of fish farmers locally produced quality fish feeds at the least possible cost manufactured with the good processing methods which includes sourcing, extruding, mixing, pelleting, drying and storing that take cognizance of the requirements of the various species and stages of fish cultured. According to several authors, these feed technologies are very crucial as it determines bioavailability of nutrients, feed acceptability, palatability and durability which often have profound effect on performance of fish [6, 7, 9].

It's also noticed that most productive systems and most productive fish feeds are least used. However, the least yield recorded with non conventional feed and agro-industrial byproducts could be assigned to the low stocking density and low quantity of fish that achieve market size at end of cycle associated to these feeds utilization. This situation of low inputs, low production was already reported in freshwater prawn farming system and in fish farm [25, 26, 27, 9]. In fact, fish production is also dependent on stocking density, survival rate, and growth rate which are in turn affected by farm management practices such as fertilization and feeding, mono or polyculture, production strategies and environmental factors [28, 29]. Improvement of fish production on fish farm should pass by fish farmers training of feeding, management and production practices, the prohibition of using agro-industrial byproduct directly to feed cultured fish in the commercial fish farms, improvement of fish feed produced by feed sellers, availability of low cost high quality feed but also by promote a fish production among economic operators and salaried to increase capacity of good quality fish feeds utilization. However, the availability of high quality fish feeds in the Côte d'Ivoire fish farm requires governmental will and best organization of fish farmers but also an orientation of Ivorian fish farm development projects toward a competitive commercial fish farms.

5. ACKNOWLEDGEMENT

The authors wish to thank the PASRES, Ivorian strategic programme to support scientific research for the financing of this project, Project number 97. The authors also express their sincere thanks to the national association of fish farmers (ANAQUACI), regional fish farmers organizations and the regional extension officers of Côte d'Ivoire agriculture and fisheries ministries for their assistance during the survey.

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