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Utilization of Fish Feeds by Côte d'Ivoire Fish Farmers and Its Influence on the Quantitative Competitive Commercial Fish Production

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RAK and CBA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NBK and INO managed the analyses of the study. Author PLK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study assesses the ability of fish feeds to produce competitive commercial fish in quantity. Three hundred and one (301) fish farms were surveyed in fifteen (15) regions of Côte d'Ivoire between May and November 2013. Fish feeds and farming systems were inventoried, characterized, ranked and sampled on each farm for biochemical analysis. Nine indicators of feeding, five indicators of aquaculture practices and four indicators of production were defined and evaluated. Results show that fish were fed with commercial feeds, feeds produced by fish farmers, agro-industrial byproducts and non conventional feeds. Intensive, semi-intensive, extensive and rice fish farming systems are the farming systems practiced. Use of commercial feeds involves the use

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of the quality feeds by almost 65.5% of farmers, practice of semi intensive system by 92.5% of farmers, regularly feeding with pellet feeds (72.5%) and respect of the feeding and aquaculture practices by the majority of farmers. Also, yields recorded were more than 1000 kg.ha^{-1}year^{-1} and the tilapia commercial weight were more than 350 g for more than 50% of farmers. On the contrast, farm-made feeds, agro-industrial byproducts and non conventional feeds explain the long duration and the low weight of commercial tilapia production as well as the low yields of the majority of farms. Results express the need to improve the production process and the quality of farm-made and feed sellers feeds. Optimal feeding strategies and good aquaculture practices must be also followed to ensure quantitative competitive commercial fish production in Côte d'Ivoire.

Keywords: Fish farming; feeds; biochemical analysis; aquaculture practices; indicators; growth; yield.

1. INTRODUCTION

Fish is one of the cheapest and accessible sources of protein and micronutrients for millions of people in Africa [1]. It's widely acceptable by all social, cultural and religious types [2]. However, fish supply becomes more difficult because of the fully or overexploitation of capture fisheries [3]. Aquaculture is seen as the main source for current growth of fish production and represents the best alternative to compensate the decline in fish resources production. During the last 14 years, the world aquaculture production increased from 32,417,781 to 73,783,725 tonnes and Africa one also went up from 399,688 to 1,694,853 tonnes when Sub-Saharan Africa production rised only from 55,702 to 556,900 tonnes [4]. However this low expansion of Sub-Saharan Africa aquaculture production is due to the heightening of the production of some country such as Nigeria (313,231 tonnes), Ouganda (111,023 tonnes), Ghana (38,545 tonnes), Kenya (24,098) and Zambie (19,281 tonnes) while Côte d'Ivoire production accounts only 3750 tonnes in 2014 [5,6]. However, it remains low in Côte d'Ivoire despites the long years of practice and more than 1,000 fish farms inventoried on the area exploited of about 750 ha [7,8].

Otherwise, the fish production in farms depends on numerous parameters including the farm size, the investment, the farming system, the management practices, the feeds and feedings practices, and the water management [9]. Among these influences, several authors have reported that the major problem of aquaculture in Côte d'Ivoire is the low availability of high-quality fish feeds in most of the farms [10,11]. While, feeds are one the major inputs promoting optimal fish growth and health and play a very vital role in aquaculture growth and expansion [12]. In addition, good farm management practices and good feeding strategies (feed types, feeding rate, frequency and timing) are the factors that influence the growth, feed efficiency and survival of farmed fish and promote good aquaculture fish production [12,13].

This paper examines the fish feeds used in fish farms associate to the farms management and feeding practices and evaluates their impact on aquaculture development, growth and expansion in Côte d'Ivoire.

2. MATERIALS AND METHODS

The evaluation of impact of feeds used in tilapia *Oreochromis niloticus* growth, fish farm production and aquaculture development has followed methods described by Gobert [14]. It consisted to the survey in fish farms, biochemical analysis of fish feeds, classification of survey data, definition of the objective and thematics of data evaluation, identification and evaluation of indicators of best production.

2.1 Fish Farms Survey

All the fish farms surveyed were located in the main fish production areas of Côte d'Ivoire. This country is located on the south coast of West Africa between the Longitudes 2°30 - 8°30 West and the Latitudes 4°30 - 10°30 North. A total of 301 fish farms were surveyed in fifteen (15) regions of the East, South East, Center, West and Central West of Côte d'Ivoire between May and November 2013 in collaboration with Kimou et al. [15]. The annual averages temperature and air humidity were varied respectively between 25-30°C and 80-90% in the East, South East and West and between 14-33°C in the Center and Central West of Côte d'Ivoire respectively during these last year's [16]. A total of 301 fish farms were surveyed in fifteen (15) main fish production areas of Côte d'Ivoire, West Africa between May and November 2013 in collaboration with Kimou

et al. [15]. Fish farmers were identified in each area with data and guidance given by local fish farmer's organizations and the regional technical assistances of Ivorian Agriculture and Fisheries Ministries. All the accessible farms which really produce fish in current year and which had the last year production data were selected. The main criterion for the selection of fish farms was the currently production and marketing of tilapia *Oreochromis niloticus*. All the commercial fish farms in these conditions by area visited were selected. Each of the respondent via a personal interview, questions about feeds used, feeding practices, aquaculture practices and production data. In addition, fish feed was sampled in each fish farm for biochemical composition determination. At the end of the survey, fish farms were grouped in intensive, semi-intensive, extensive and rice fish farming systems based on feeding practices as stated by New [17] and Lazard [18]. Tilapia *Oreochromis niloticus* growth and production parameters were calculated for each farm as follow: Absolute Growth Rate (g d^{-1}) = Weight gain / Duration of growth; Feed Intensity ($kgha^{-1}d^{-1}$) = Total weight of feed used/ Water productive surface/ Length of a cycle; Yield (kgha-1 year-1) = Annual weight of fish produced/ water productive surface.

Table 1. Thematics and recommended values of the parameters

Thematics	Components	Parameters	Recommended values
Feeding	Quality of the feed	Crude protein	25 – 55%
		Crude lipid	10 – 25%
		Carbohydrate content	25 – 40%
		Ash	< 10%
		Crude fibre	< 10%
		Gross energy	15 – 25 kJ g^{-1}
		Protein/Energy ratio	16 – 22 mg kJ^{-1}
		Calcium	2.7 – 5 mg g^{-1}
		Phosphore	2.8 – 8 mg g^{-1}
	Farming systems	Intensive	500 kg m^{-3}
		Semi-intensive	1,5 – 15 t ha-1 $year^{-1}$
		Extensive	0,5-2 t ha-1 $year^{-1}$
		Rice-fish farming	1-2 t $ha^{-1}year^{-1}$
	Feeding practices	Feed used	According fish species and stage requirement
		Feeding frequency	According fish species and stage requirement
		Mode of use of the feed	According fish species and stage requirement
		Type of feed	According fish species and stage requirement
		Feed quantity	According fish species and stage requirement
Production	Aquaculture practices	Manage by a professional	Yes
		Production cycle	Normal
		Control harvesting	One time by month
		Tri fish	by stage
		Use tilapia male	Yes
		Weight of tilapia sexing	< 20 g
	Production parameters	Duration of fish growth	8 month
		Average tilapia commercial weight	350 g
		Tilapia daily weight gain	1.5 g day^{-1}
		Yield	Depending of farming system

[20,12,13,22,18]

Table 2. Fish feeds performance indicators selected

Components	Indicators number	Indicators
Feeding practices	IF-1	Fish farmer used a quality feed
	IF-2	Fish farmer followed intensive system
	IF-3	Fish farmer followed semi intensive system
	IF-4	Fish farmer regularly fed fish
	IF-5	Fish farmer fed fish according stage
	IF-6	Fish farmer fed fish according the species
	IF-7	Fish farmer used pellet feeds
	IF-8	Fish farmer used rationing table to quantify feed
	IF-9	Feeding intensity is more than 100 $kgha^{-1}day^{-1}$
Aquaculture practices	IA-1	Fish farms is managed and supervised by a professional
	IA-2	Fish farmer followed the normal production cycle
	IA-3	Fish farmer makes harvesting control by month
	IA-4	Fish farmer tri fish by stage
	IA-5	Fish farmer sexed tilapia at size less than 40g
Production data	IP-1	Duration of tilapia growth is less than 8 months
	IP-2	Daily weight gain of tilapia is more than 1.5 $gday^{-1}$
	IP-3	Farm annual yield is more than 1000 $kgha^{-1}year^{-1}$
	IP-4	Average commercial tilapia weight is more than 350 g

2.2 Biochemical Analysis of Feeds

The approximate composition of fish feeds was analyzed using standard methods of the Association of Official Analytical Chemists [19]. 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 auto analyzer, Model 1030, Tecator, Hoganas, Sweden), crude fat was extracted (hexane extraction) by using the Soxhlet method (Soxtec System HT6, Tecator) and crude fiber 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 [20]. Sample for calcium and phosphorus composition was analyzed using microwave digestion and atomic absorption spectrophotometer (Varian SAA 110) air-acetylene flame [21]. All the samples were analyzed in triplicate.

2.3 Objective of Data Evaluation

The objective of the data evaluation is to assess the ability of fish feeds used by farmers to produce competitive commercial tilapia *Oreochromis niloticus* in quantity.

2.3 Thematics of Data Evaluation

The thematics related to the objective are feeding and production. Feeding is relative to quality of feed depending of fish species and stage, farming systems and feed practices where production is relative to aquaculture practices and production parameters. The Table 1 shows the recommended values of the parameters associated to the two defined thematics.

2.4 Identification and Evaluation of Indicators of Best Production

A total of twenty nine indicators were selected for evaluation. There were nine indicators of feeding components, five indicators of aquaculture practices components and four indicators of production components from the objective and the different thematics defined. The Table 2 shows the indicators selected and their respective number. These indicators were evaluated for the different fish feeds used by fish farmers.

3. RESULTS

3.1 Fish Feeds Classification

Four different types of fish feeds were used in surveyed fish farms, including commercial feeds,

feeds produced by fish farmers themselves, agro-industrial byproducts and non conventional feeds. Imported and national industrial commercial feeds and feed sellers commercial feeds were the three categories of commercial feeds available on fish farms. Fish feeds characteristics and proximate compositions are shown in Tables 3 and 4. The highest costs of feeds were recorded with the imported commercial feeds from Israël, Ghana and Holland. These feeds were in pellets, extruded and floating form and presented on different sizes depending on the fish considered stage. The others feeds were produced locally and were presented on flour or pellet forms. Proximate composition of different feeds used shows that the most important level of protein, gross energy and protein/energy ratio were recorded with imported and national industrial feeds followed by feeds produced by fish farmers. Agro-industrial byproducts showed the lowest values. While the highest levels of crude fiber were observed with feeds produced by fish farmers, agro-industrial byproducts and feed sellers feeds. The lowest value was observed with imported industrial commercial feeds. The high values of calcium and phosphor content were recorded with imported and national industrial feeds.

3.2 Farms Systems Classification

Four different systems of fish production were recorded in visited farms: intensive, semi-intensive, extensive and rice fish farming systems. In intensive system only pellets, extruded or floating high quality fish feeds (commercial industrial or produced) were provided to the fish according to the stage. Growth structures were basin, race way, tank and floating cage generally and this system is highly labour intensive and required constant monitoring of water quality and growth parameters. The duration of commercial tilapia 400 – 700 g production in this system varied between 7-8 months with the high yield (Table 5).

Semi-intensive system was used in most of national industrial commercial feeds, feeds produced by fish farmers and agro-industrial byproducts to feed fish. In this system, growth structures were earthen pond and pond-dam with the regular fish feeding. Most of the farmers in semi-intensive systems preferred single harvesting. The average commercial tilapia weight recorded during 9.56 ± 1.5 months of culture was 325.29 ± 59.36 g with the average yield value 3620.87 ± 2701.95 $kgha^{-1}year^{-1}$ (Table 5).

Extensive system was the traditional fish production system. No nursery phases and fish polyculture were followed and the system was less labor. Agro-industrial byproducts and non conventional feed were provided occasionally and growth structures were earthen pond, dam and pond-dam. In this system, the duration of fish production was 11.21 ± 1.07 months, the average tilapia commercial weight was 243.33 ± 38.09 g and the average yield was 489.30 ± 219.96 $kgha^{-1}year^{-1}$ (Table 5).

In rice fish farm system, fish farming was practiced in earthen pond and pond-dam in association with the rice cultivation in the same time. Fish was regularly or occasionally fed with agro-industrial byproducts and/or non conventional feeds. The time of average tilapia commercial weight of 293.75 g ± 70.42 g was 10.13 ± 1.54 months and the average yield recorded was 535.64 ± 254.21 $kgha^{-1}year^{-1}$ (Tables 5).

Results show that the highest feeds intensity and farm production were recorded in intensive systems and the lowest values in extensive and rice fish farming. Also commercial tilapia weight, average growth rate and yield values were higher in intensive system, followed by semi-intensive system and rice fish farming when extensive system recorded the lowest values.

3.3 Evaluation of the Feeding Practices Indicators by Type of Fish Feeds Used

The evaluation of the feedie practices indicators shows that the feeding practices on the surveyed farms is depending to the type of the feeds used (Fig. 1). Thus, more than 50% of the farmers who used commercial feeds use quality feeds, followed by semi-intensive system of fish production, regularly fed fish with pellet feeds and used rationing table to quantify feeds. A total of 96.6% of fish farmers who produced themselves their feeds followed semi-intensive system and all of them regularly fed fish. However, the use of agro-industrial byproducts and non-conventional feeds translated the non-compliance with the best feeding practices by almost all the fish farmers. Otherwise, independently of the type of fish feeds used, the majority of farmers did not follow intensive system, feed fish according to the fish species and stage and they had the feeding intensity inferior to 100 $kgha^{-1}day^{-1}$.

Table 3. Fish feeds characteristics

Characteristics	Commercial feeds			Feeds produced by fish farmers	Agro-industrial byproducts	Non conventional feed
	Industrial		Feed sellers			
	Imported	National				
Cost (USD/kg)	1.02 – 2.13	0.41 – 0.50	0.19 – 0.51	0.04 – 0.46	0.03 – 0.18	Free
Origin	Israël/Ghana/Holland	Abidjan	Local	Local	Local	Local available from farmers and breeders
Type	Pellet, Extruded, Floating	Flour / Pellet	- Flour - Pellet - Broken pellets	- Flour	- Flour	-
Pellet size (mm)	- 0,5 - 0,7 - 1,0 - 2,5 - 4,5	- 2	- 2	-	-	-
Availability	Acceptable	Medium	Good	-	Good	Good

Table 4. Proximate composition of fish feeds

Parameters	Commercial feeds			Feeds produced by fish farmers (n = 54)	Agro-industrial by products (n = 4)
	Industrial		Feed sellers feeds (n= 6)		
	Imported (n = 4)	National (n = 4)			
Moisture (%)	9 – 10	8.87 – 9.50	8.71 – 11.35	8.55 – 10.51	8.46 – 10.48
Crude protein (%)	30 – 57	28 – 30.15	16.20 – 24.90	10.92 – 35.90	9.45 – 16.20
Crude lipid (%)	5 – 15	4 – 7	4.30 – 9.42	1.83 – 17.86	0.93 – 14.54
Ash (%)	8 – 11	10.76 – 11.53	5.47 – 10.84	4.70 – 16.97	3.44 – 9.96
Crude fibre (%)	0.10 – 4	6.52 – 7.18	9.74 – 43.21	4.70 – 56.33	8.88 – 51.54
Carbohydrate content (%)	7.9 – 44	35.67 – 41.32	18.74 – 45.57	15.52 – 47.85	22.77 – 48.82
Gross energy (kJ g^{-1})	17.34 – 20.81	16.53 – 17.01	15.74 – 17.57	14.44 – 21.99	15.97 – 18.16
Protein/Energie ratio	17.30 – 27.39	16.46 – 18.07	9.52 – 14.61	6.40 – 18.81	5.92 – 9.84
Calcium (mg g^{-1})	6	10.40 – 19.98	1.73 – 7.96	1.22 – 13.29	0.89 – 3.41
Phosphore (mg g^{-1})	7 – 18	10.18 – 13.02	2.12 – 15.49	4.37 – 65.75	2.92 – 15.07
Calcium /Phosphor ratio	0.86 – 0.96	0.80 – 1.80	0.19 – 3.75	0.09 – 1.53	0.06 – 1.28

Table 5. Growth and production parameters of different production systems

Parameters	Intensive		Semi-intensive (n= 156)	Extensive (n = 129)	Rice fish farming (n = 12)
	Hyper intensive (n =1)	Intensive (n = 3)			
Duration of fish growth (Months)	7	7.67 ± 0.29	9.56 ± 1.5	11.21 ± 1.07	10.13 ± 1.54
Feed intensity ($g^{-1}ha^{-1}day^{-1}$)	2916.67	123.70±31.92	46.72 ± 36.19	8.70 ± 5.18	6.93 ± 4.57
Average tilapia commercial weight (g)	500 - 700	400 ± 129.90	325.29 ± 59.36	243.33 ± 38.09	293.75 ± 70.42
Average growth rate (gd^{-1})	2.86	1.75 ± 0.60	1.15 ± 0.19	0.73 ± 0.12	0.97 ± 1.16
Average farm production (kg)	720 000	26 333.33 ± 2081.66	2937.12 ± 7180.64	519.93 ±602.69	395.25 ±163.65
Yield ($kgha^{-1}year^{-1}$)	1 200 000	19 222.22 ± 7515.41	3620.87 ± 2701.95	489.30 ± 219.96	535.64 ± 254.21

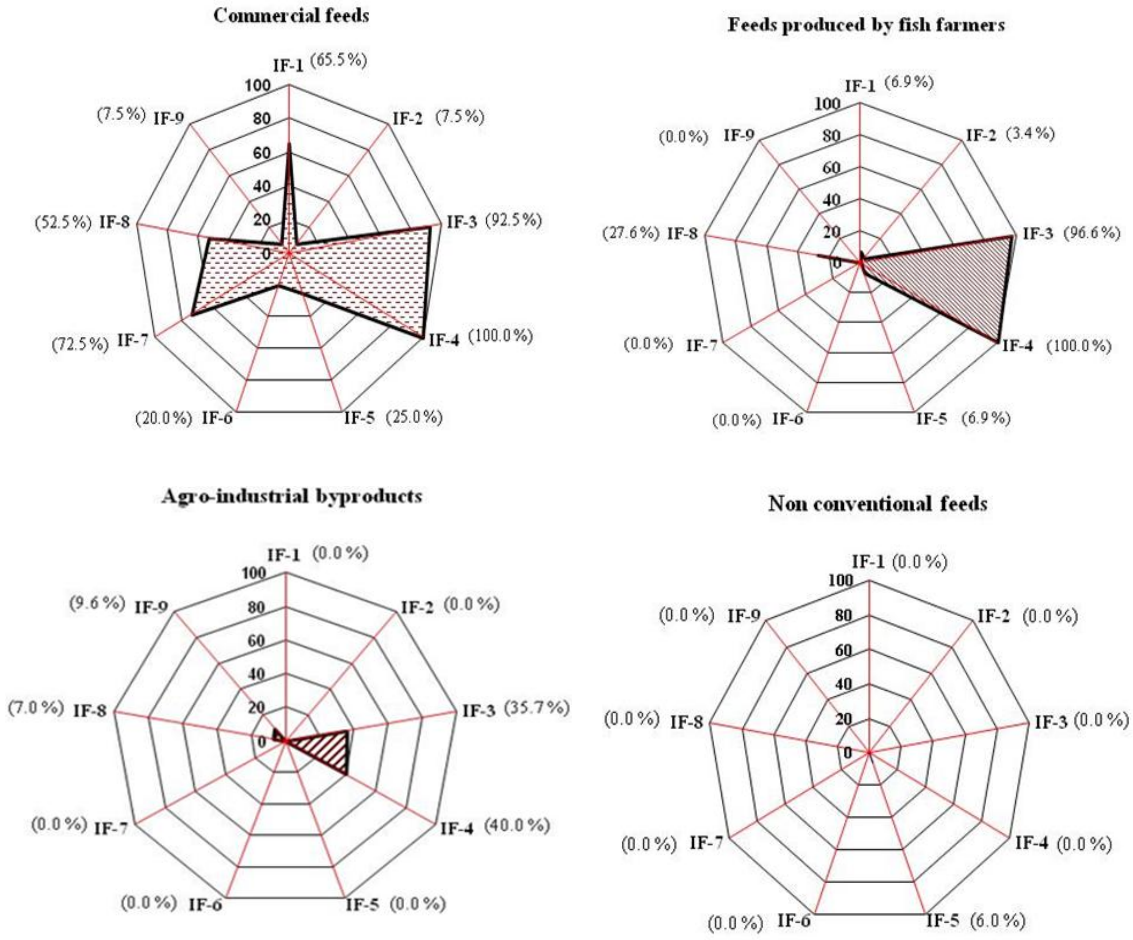


Fig. 1. Profil of feeding practices by type of fish feeds used

IF-1: Fish farmer used a quality feed; IF-2: Fish farmer followed intensive system; IF-3: Fish farmer followed semi intensive system; IF-4: Fish farmer regularly fed fish; IF-5: Fish farmer fed fish according stage; IF-6: Fish farmer fed fish according the species; IF-7: Fish farmer used pellet feeds; IF-8: Fish farmer used rationing table to quantify feed; IF-9 Feeding intensity is more than 100 kgha-1day-1

3.4 Evaluation of the Aquaculture Practices Indicators by Type of Fish Feeds Used

The respect of the good aquaculture practices by surveyed fish farmers also depended on the type of feeds used (Fig. 2). The use of commercial feeds by fish farmers and feeds produced by fish farmers themselves translated the control harvesting by month, sort fish by growth stage, and sexing tilapia at the size less than 40 g for more than 50% of farmers. The, use of agro-industrial byproducts only reflected the monthly control harvesting by more than 50% of fish farmers. The use of non-conventional feed was linked to the non-compliance of all aquaculture practices by the majority of these fish farmers. Independently of the fish feeds used, majority of the fish farms were not managed by a professional and the normal cycle of the fish production was not followed.

3.5 Evaluation of the Production Indicators by Type of Fish Feeds Used

Profile of fish production by type of fish feeds used presented in Fig. 3 shows that the production parameters values were depending on the type of fish feeds used. The use of commercial feeds reflected annual yield more than 1000 $kgha^{-1}year^{-1}$ and the tilapia commercial weight more than 350 g from more than 50% of farmers. A total of 93.1% of farmers who produced themselves their feeds recorded more than 1000 $kgha^{-1}year^{-1}$. However, the use

of agro-industrial byproducts and non-conventional feeds by fish farmers expressed the low productions parameters values by the majority of the farmers.

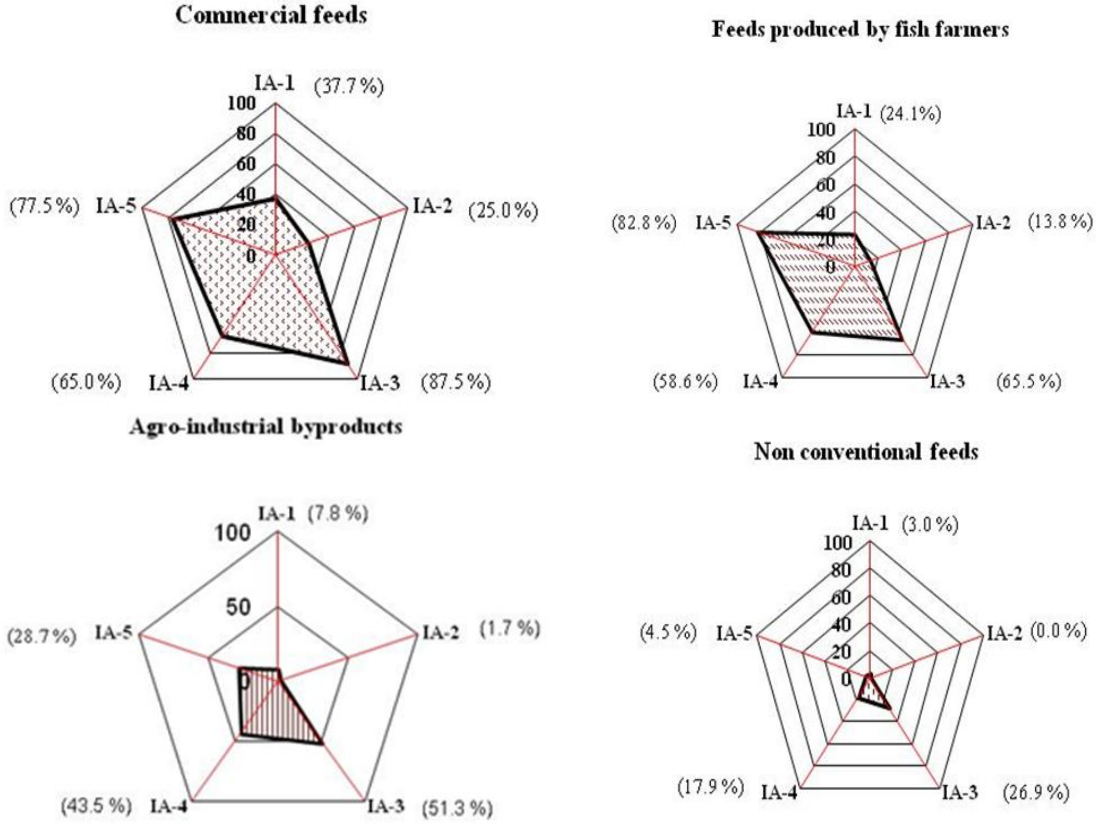
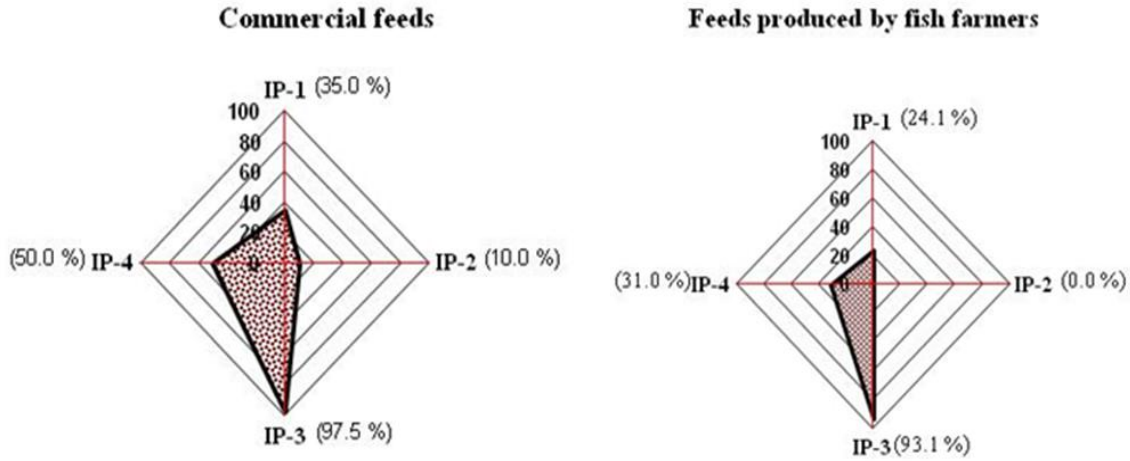


Fig. 2. Profil of aquaculture practices by type of fish feeds used

IA-1: Fish farms is managed and supervised by a professional; IA-2: Fish farmer followed the normal production cycle; IA-3: Fish farmer makes harvesting control by month; IA-4: Fish farmer tri fish by stage; IA-5: Fish farmer sexed tilapia at size less than 40 g



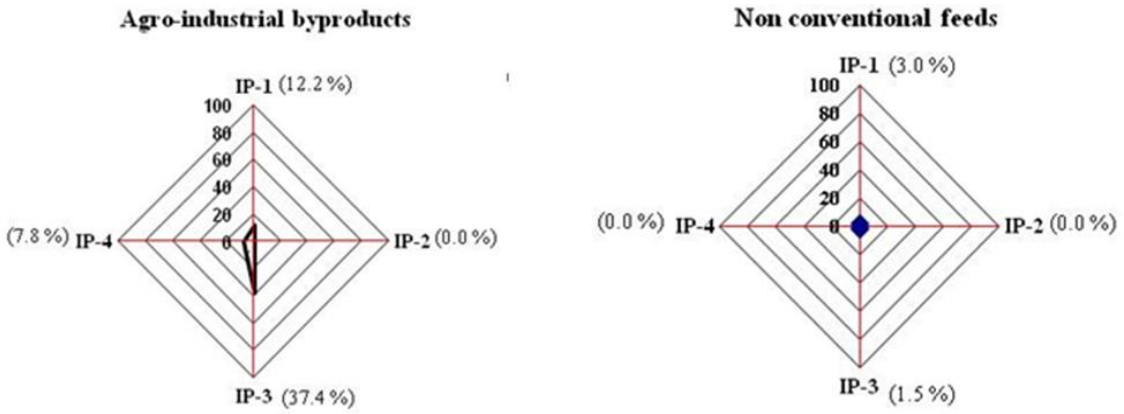


Fig. 3. Profil of fish production by type of fish feeds used

IP-1: Duration of tilapia growth is less than 8 months; IP-2: Daily weight gain of tilapia is more than 1.5 gday^{-1}; IP-3: Farm annual yield is more than 1000 kgha^{-1}year^{-1}; IP-4: Average commercial tilapia weight is more than 350 g

4. DISCUSSION

The use of commercial feeds involve the use of quality feeds by almost 65.5% of farmers, practice of semi intensive system by 92.5% of farmers, and regularly fish feeding with pellet feeds by 72.5% of the farmers and the respect of the feeding strategy and aquaculture practice by the majority of farmers. This consequently improves fish growth and production values compared to the use of other inventoried feeds. In fact, feed quality and feeding strategy are of great importance in fish growth [23]. Most fish require diets containing 18 to 55% of crude protein, 10-25% of lipid, 25-30% of carbohydrate, less than 10% of ash and fibers, 16-25 kJ/g of energy depending on the production structure and system and the fish species and sizes [20,12,22]. Complete diets supply all the ingredients necessary for the fish optimal growth, health and body composition characteristics such as fat content and fillet yield. Indeed, the nutrient composition of fish is closely related to the nutritional value of the feed and farming fish should be an excellent source of protein, vitamins, minerals, and omega-3 long chain fatty acid [24,25,26]. However, results show that some commercial feeds such as feeds sellers feeds were not always meet the nutritional requirement of fish and reduce growth and farms yield.

In addition, the inadequate quality of 93.10% of farms-made feeds, all of agro-industrial byproducts and non-conventional feeds explain the high percent of commercial tilapia weight inferior to the African market requirement (350 g) reported by Lazard [18]. The high duration of commercial tilapia production, and the low yields of farms recorded with these feeds. In fact, incomplete and partial diet can't totally support fish growth and fish life processes. It's only intended to help to support the natural food [12].

Otherwise, the inadequate quality of feeds produced by farmers themselves and feeds sellers could be due to the low management and supervision of fish farms by professionals. Moreover, according to Brechbühl [27] and Koumi et al. [11], majority of farmers are agricultural culture farmers at the time so they do not know the fish feeds requirement, the process of fish feeds formulation and production. The low quality of farm made feeds was already reported by Gabriel et al. [2] and Jamu and Ayinla [28]. However, the improvement of the production process and quality of farm-made feeds is possible and it could improve fish growth and yield. According to Ayinla [29], Gabriel et al. [2] and Hecth [30], almost 70% of all aquafeeds used in Nigeria are compounded farm-made feeds and there are produced on dry pellet form using imported hammer mills, mixers and pelletizers, local grinder, local diesel pelleting machine or local electric pelleting machine, locally fabricated kiln, oven or sun to dry. On the contrast, all farm made feeds inventoried during the study are on flour form and can't maximize fish growth and feed use efficiency because the processing technology influences the feed physical properties and the nutrient digestibility [31]. In fact, the pellet feed have numerous advantages including less feed wastage, uniform feed intake and destruction of growth inhibitors [2]. Also, delivering the feed to fish at the right

time, in the correct form and in the right amount is necessary for optimal growth [9].

In Côte d'Ivoire, developing specific farm-made feed formulations with the local raw material could reduce fish feeds price, promote and improve aquaculture fish production such observed in Nigeria (313,231 tonnes), Ouganda (111,023 tonnes), Ghana (38,545 tonnes), Kenya (24,098 tonnes) and Zambie (19,281 tonnes) since year 2005 [30,29,5]. Also, the high use of agro-industrial byproducts and non-conventional feeds and the high percent of farmers in extensive systems observed in this study are reported such as the main reasons of the low aquaculture fish production in the most African sub-Saharan countries [30,2]. In fact, these feeds have low nutritional quality due to their low protein content, amino acid imbalance, low protein/energy ratio, with high fiber and presence of antinutritional factors [31,20]. They can only support the organic fertilization. However, the farms yields reported with the use of agro-industrial byproducts and non conventional feeds in this study express the need to use in addition, the organic (manure or compost) and/or inorganic fertilizers (urea, super phosphate, ammonium nitrate…) in order to accelerate the growth of insects, benthic algae, phytoplankton and zooplankton to improve fish growth and farm yield [29,9].

To improve Ivorian farming fish production, quality of feeds sellers and fish farmers feeds must be improve. So it's essential to put at the disposal of fish farming the local quality feeds at the least possible cost manufactured with appropriate manufacturing machinery and the good processing technologies. Therefore, it is essential to follow optimal feeding strategies and good aquaculture management practices to ensure quality and quantity fish yield. Results express the need to promote investment in intensive and semi intensive systems in order to enhance quantitative competitive commercial fish production in Côte d'Ivoire.

5. CONCLUSION

Côte d'Ivoire fish feeding is characterized by the utilization of low quality feeds in semi-intensive and extensive systems in the majority of farms. Quality feeds, production and process of feeds, feeding practices and aquaculture practices are not well known in the majority of the farms. The high frequency of low quality feeds use influence fish growth and aquaculture production. Aquaculture development in Côte d'Ivoire will induce nutrition improvement, generate of supplementary income, diversification of income activities and create of employment. Otherwise, developing and management of local quality fish feeds manufactured with the good processing technologies by the use of local raw material could reduce fish feeds price and play vital role in aquaculture growth and expansion. Also, training farmers on optimal feeding and aquaculture practices will improve production yield and induce durability of aquaculture.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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