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Contribution of *Garcinia kola* to the Productivity and Economic Profitability of the Community Agricultural Area of Kedougou: Financial and Comparative Analysis of Production Factors

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Abstract

Inland fishing predominates in the Kedougou region, which has no coastline. This type of fishing does not yet meet the local population's demand for fish products. In response to this concern, a Community Agricultural Estate housing an integrated fish farm was set up in the commune of Bandafassi, in the village of Itato. Since its creation, this production unit has been faced with the problem of sourcing high-quality, low-cost, monosex male *Oreochromis niloticus* fry. In order to overcome this constraint, the present research focuses on the contribution of *Garcinia kola* to the productivity and economic profitability of the Itato farm. The aim of the research is to assess fish production in the experimental set-up and the production costs of tilapia in a controlled environment. The comparative study of the various production factors shows disparities only in the input factor, where scenarios 2 and 3 use additional products. These are 17-α-methytestosterone for scenario 2 and *Garcinia kola* for scenario 3. These products significantly interfere with fish production, with a fairly high mortality rate for scenario 2 (25% for two production cycles/ cohort2 (B5, B6, B7 and B8) treated with 17-α-methytestosterone). As for scenarios 1 and 3, mortalities are 5% with or without recourse to additional products (*G. kola*). In addition, average fish production for the three (03) scenarios is estimated at 28687.5 kg/2 cycles. It varies from one scenario to another, *i.e.* 30937.5 kg/2 cycles for scenarios 1 and 3 and 24187.5 kg/2 cycles for scenario 2. It is therefore higher in scenarios 1 and 3 than in scenario 2.

This difference is due to the fairly large losses of individuals in scenario 2. Furthermore, the analysis of the profit and loss accounts for tilapia production varies from one scenario to another depending on the type of farm: 476 Franc CFA for scenario 1, 610 Franc CFA for scenario 2 and 472 Franc CFA for scenario 3 (F CFA = franc of the French Colonies of Africa). The Average operating income for all the fish farming units is 34,726,142 Franc CFA. The highest (41,638,075 Franc CFA) and lowest (29,281,075 Franc CFA) ERs were observed in scenarios 3 and 2 respectively. It was 33,259,275 Franc CFA for scenario 1. The difference between the NERs of the three scenarios is more or less significant in terms of results. The operating result (OR) is positive in all 3 scenarios in our study. However, the scenario 3 system generates a higher rate of return (the ratio between an income and the capital employed to obtain that income) (74%) than that generated by the scenario 1 system (69%). As for the scenario 2 system, it generates a lower financial return than the two previous systems (67%). Above all, this work made it possible to construct an approach that would make it possible to answer such a question by relying successively on various methods: a typology, according to the production factors involved in the operation of the Community Agricultural Estate fish farm.

Keywords

Farm Typology, Economic Profitability, 17-*α*-Methytestosterone, *Garcinia kola*, Fish Farming, Tilapia

1. Introduction

Faced with dwindling marine fish resources, the Senegalese authorities have identified aquaculture as one of the likely solutions to the problem of animal protein shortages. Aquaculture is therefore considered as a strategic sector and is one of the pillars of the Emerging Senegal Plan (ESP), which aims to transform Senegal into an emerging country based on sustained and sustainable growth. Today, aquaculture is also seen as a means of creating gainful employment. Production increased from 334 tons in 2011 to 1095 tons in 2014 and 2082 tons in 2016. The rate of increase in production is estimated at 71.3% in 2016 [1]. However, despite immense natural potential (750 km of coastline, 1700 km of rivers, etc.) and favorable local eco-geographical conditions, fish farming has not yet reached a viable economic dimension. Total production in 2010 was only 200 tons, mainly of tilapia (*Oreochromis niloticus*) [2]. Tilapia is the most consumed fish in the world (over 7.6 million tons in 2014) and the second most consumed species group worldwide, behind carp (19.3 million tons) and ahead of salmonids (3.17 million tons of salmon and trout) [3].

Tilapia is the preferred choice for fish farming in Senegal because it can be reared all year round, in open or closed systems, and because of its rapid growth, adaptability to a variety of ecosystems and tasty meat.

In the Kedougou region of eastern Senegal, there is a persistent shortage of fish products. In fact, 90% of fish products come from other regions of Senegal, and fishing activity is dominated by inland fishing. Annual production is estimated at 200 tons of fish (tilapia accounts for around 25% - 30% of landings), which is destined directly for local consumption but does not meet local demand. Furthermore, according to FAO standards, an average person should consume 16 kg of fish per year, whereas in the Kedougou region the average consumption per person per year is 7 kg. This is well below the average consumption of the Senegalese population, which is 25 kg of fish per person per year. These figures show that there is a real shortfall to be made up.

In response to this concern, the State of Senegal has established a Community Agricultural Estate in the department of Kedougou, with a fish farm producing tilapia and catfish. However, this farm faces the problem of supplying high quality male monosex fry at low cost. This situation prompted this research on the contribution of *Garcinia kola* to the productivity and economic profitability of tilapia production, with the following objectives.

- Evaluate tilapia fish production process and production costs;
- Identify the best operational scenario
- Identify the strategic directions and prospects for growth and development of the tilapia value chain;
- Demonstrate the contribution of feed supplements in achieving the objectives of the production.

The overall analysis of this research work includes, on the one hand, a technical analysis of the production and, on the other hand, an economic analysis of the different scenarios.

2. Materials and Methods

2.1. Presentation of the Study Area

2.1.1. Presentation of the Itato Community Agricultural Estate (DAC) Fish Farm

The DAC fish farm is located in the village of Itato, 15 km from the city of Kedougou. It is close to the Gambia River, a strategic choice that ensures a continuous supply of water to the ponds. The following infrastructure is on site: a pumping station to draw water from the Gambia River, a hatchery, grow-out units consisting of concrete tanks, a store for the storage of feed and rearing materials, and aboveground tanks used as experimental tools for this study.

2.1.2. Hatchery

In order to guarantee control of the production cycle, Community Agricultural Estates Programme (PRODAC) has invested in the construction of a hatchery with a capacity of over one million fry, thus ensuring its own supply. The best hygiene conditions, combined with rigorous quality control at each stage of production (eggs, larvae, fry), mean that each rearing cycle can be carried out under the most controlled conditions. High quality equipment has been installed in the hatchery to ensure its smooth operation in particular and that of the fish farm in general.

2.1.3. Research Methodology

The methodology used to achieve the objectives of the study consists of three phases. The first, devoted to the production system, consists of three (03) cohorts monitored by technicians. The second phase defines the type of treatment per cohort (either hormone, petit kola or simple feed) and the third phase is dedicated to the comparative financial analysis of the three scenarios.

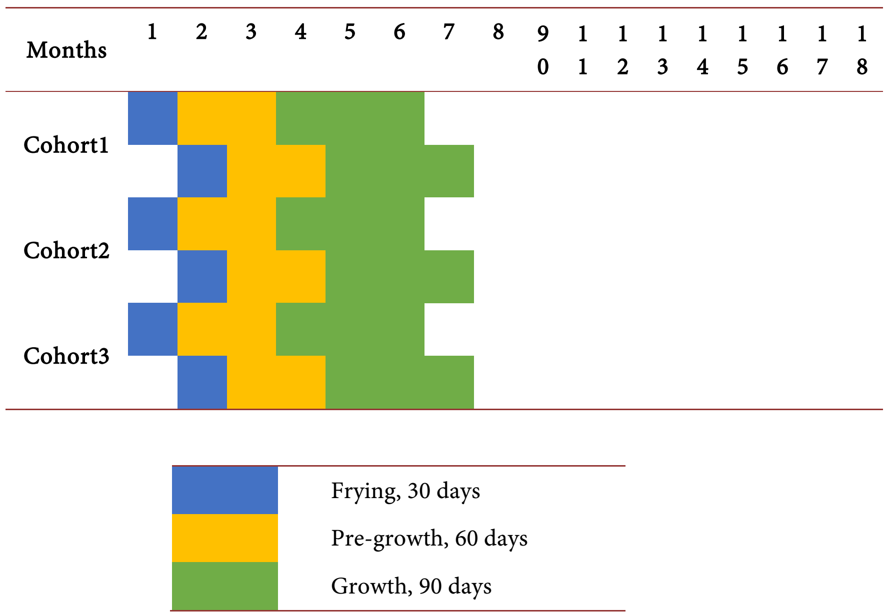
2.1.4. Production System

The station's production system is semi-intensive, with production targets of at least 500,000 juveniles and 20,000 tons of fish per year. For this study, production targets are set at 21,600 male juveniles and 6480 tons of fish per year. The 12 aboveground tanks at the farm are divided into 3 sections. Each technician is responsible for monitoring a cohort from the larval to the juvenile stage. These activities are based on each stage (fry rearing, pre-fattening, fattening) of the fish farm, as follows.

3. Cohort production planning

Table 1 shows the planning of production according to the cohorts.

Table 1. Planning to produce by cohort.



The fry rearing, pre-growth and growing stages are closely monitored to achieve the desired yields for a given treatment. This monitoring includes determining the production cost of each treatment/cohort.

The simulation, designed to analyze production costs, covered two fish production cycles. Table 2 shows the production parameters/2 cycles.

Table 2. Production parameters.

PRODUCTION PARAMETERS	
Half-yearly production (kg)	1080
Number of cycles	2
Number of employees	2
Number of months/cycle	6
Feed requirement (kg)	94.5
Mortality rate	5%
Fry requirement	3600
Average weight of fry (g)	2
Average weight of marketable fish (g)	300

In order to establish the projected income statement, the experiment involved three cohorts:

✓ Cohort 1 (Bac1, 2, 3 and 4), monitored by a technician. This is the batch fed with industrial feed containing 40% protein and no supplements;

✓ Cohort 2 (Bac5, 6, 7 and 8), monitored by the same technician as Cohort 1, is the batch fed with 17-α-methytestosterone and industrial feed containing 40% protein;

✓ Cohort 3 (Bac9, 10, 11 and 12) is monitored by a female technician. This is the batch fed industrial chow containing 40% protein and 20 g of *Garcinia kola* powder;

Tables 3-5 show the production data for two production cycles/cohort.

Table 3. Production data for two production cycles/cohort1.

PRODUCTION DATA	
Annual production (g)	180,000
Number of cycles	2
Number of months/cycle	6
Annual feed requirement (kg)	87.6
Mortality rate	5%
Annual fry requirement	600
Average fry weight (g)	2
Average fish weight (g)	300

Table 4. Production data for two production cycles/cohort2.

PRODUCTION DATA	
Annual production (g)	180 000
Number of cycles	2
Number of months/cycle	6

Continued

Annual industrial feed requirement (kg)	87.6
Hormone requirement (mg)/cycle	140
Alcohol requirement (ml)/cycle	480
Mortality rate	**25%***
Annual fry requirement	600
Average fry weight (g)	2
Average fish weight (g)	300

NB: *Individuals fed with feed containing the hormone have a very high mortality rate.

Table 5. Production data for two production cycles/cohorts3.

PRODUCTION DATA	
Annual production (g)	180,000
Number of cycles	2
Number of months/cycle	6
Annual feed requirement (kg)	87.6
***Garcinia kola* powder requirement (g)/cycle**	80
Alcohol requirement (ml)/cycle	480
Mortality rate	5%
Annual fry requirement	600
Average fry weight (g)	2
Average weight of fish (g)	300

4. Determining the Operating Costs of a Production System

4.1. Cost of Purchase

The cost of materials is calculated under the same conditions as the cost of goods for a commercial enterprise. These are mainly fingerlings which, when grown, will produce commercial tilapia. The delivery costs are zero because the fry come directly from the fish farm. The purchase cost is calculated as follows:

Purchase cost = Purchase price (net of discounts obtained) + Supply costs

4.2. Cost of Production

Production costs include the cost of raw materials used and direct and indirect production-related expenses. Raw materials are generally fish feed and chemical and prophylactic products. Direct labour costs include the salary of the farm technician. The technician is paid 40,000 Franc CFA per month.

4.3. Cost Price

As in a commercial enterprise, this is the cost of the product put on the market.

It includes distribution costs as well as any other costs that the company chooses to allocate to this level, such as storage costs or any other costs considered "non-production". In the case of this study, distribution costs are those associated with marketing.

The cost price of one kilogram of tilapia is **487 Francs CFA** for scenario 1**;** **622 Francs CFA** for scenario 2 and **484 Francs CFA** for scenario 3. Table 6 presents the results of the Tilapia production costs.

$$\text{Production cost} = \text{cost of raw materials} + \text{direct costs (labour)} + \text{Indirect costs (from the allocation table)}$$

Table 6. Tilapia production costs

Expenditure	Unit Cost	Quantity/4 bins	Amount	Quantity/8 bins	Amount
1. Inputs					
Fry	100	600	60,000	1200	120,000
Feed	775	372	288,300	756	585,900
Lubricants (L)	755	360	271,800	-	-
Feed supplements	50	-	-	120	6000
2. Equipment					
Solar panels	75,750	-	-	2	151,500
Small equipment	200,000	-	-	-	200,000

5. Comparative Analysis of Farm Typology

The use of typologies makes it possible to produce synthetic information that can be used, at different scales and in different ways, to support management decisions in the sector.

We have used the typology, which is a representation in table form of the disparities existing in our case study, *i.e.* three operating situations of the DAC fish farm, for a more detailed and relevant analysis of the information received about the GEA (Group of Agricultural Entrepreneurs) fish farm. Table 7 presents the farm typologies of the three scenarios.

Table 7. Farm typologies.

Factor	Variables		
	Scenario 1	**Scenario 2**	**Scenario 3**
Outputs	Sale of fry Sale of fish	Sale of fry Sale of fish	Sale of fry Sale of fish
Land	Community Agricultural Area	Community Agricultural Area	Community Agricultural Area
Investment and infrastructure	Fish farming station: fish ponds, hatchery and water tower	Fish farming station: fish ponds, hatchery and water tower	Fish farming station: fish ponds, hatchery and water tower
Inputs	Water	Water	Water

Continued

	Fry	Fry	Fry
	Feed	Feed	Feed
	-	Alcohol	Alcohol
	-	Chemical product 17-α-methyltestosterone	Organic product (G. Kola)
Operating equipment	Solar panels	Solar panels	Solar panels
	Small equipment	Small equipment	Small equipment
	Refurbishment of pools	Refurbishment of pools	Refurbishment of pools
Maintenance and repair	Solar panel maintenance	Solar panel maintenance	Solar panel maintenance
MOD (Workforce)	Operators/GEA	Operators/GEA	Operators/GEA
	Communication expenses	Communication expenses	Communication expenses
Additional expenses	Marketing costs Marketing	Marketing costs Marketing	Marketing costs Marketing
	Marketing-related taxes	Marketing-related taxes	Marketing-related taxes

An agricultural holding is first and foremost a decision-making center, a production unit, an organization and a set of interactions between the various components. It is characterized by the description of its activities, the production obtained and the factors of production mobilized. It is a production unit within which the farmer mobilizes resources of various types (land, labour, inputs, equipment, etc.), which he combines in variable proportions to obtain certain productions (outputs) in order to satisfy his needs and interests. In our study, the comparison between the different elements relating to the factors of production shows that there are only differences in the input factor, where in scenarios 2 and 3 we see the use of additional products in production, 17-α-methyltestosterone for scenario 2 and *Garcinia kola* for scenario 3 (Table 7). This will have a significant impact on fish production, with a relatively high mortality rate for scenario 2 (25%), as shown by the production data for two production cycles/cohort2 (B5, B6, B7 and B8) treated with 17-α-methyltestosterone. For scenarios 1 and 3, mortality was 5% with or without the use of an additional product (*Garcinia kola*). In addition, the average fish production in relation to the three (03) scenarios is estimated at 28687.5 kg/2 cycles. It varies from one scenario to another, *i.e.* 30937.5 kg/2 cycles for scenarios 1 and 3 and 24187.5 kg/2 cycles for scenario 2. It is therefore higher in systems 1 and 3 than in system 2. This difference is due to the relatively high loss of individuals in scenario 2.

NB:

- ***Production targets of at least*** **21,600** ***male fry***;
- ***fingerling requirements for grow-out***: **3600** ***fingerlings***;
- ***Production of*** **6480** ***kg of fish***: ***i.e.*** **6480** ***tons of marketable fish*** (***production from*** **12** ***aboveground tanks***);
- ***Sales of male fingerlings***: **176,400** ***fingerlings sold.***

6. Comparative Financial Analysis of These Fish Farm Scenarios

Operating Account Scenarios

Tables 8-10 present the production data for two production cycles/cohort.

Table 8. Scenario 1 Fish are fed a simple industrial feed containing 40% protein.

Parameters	Unit	Quantity	Unit price in F CFA	Amount in F CFA
Variable costs				
Fry		108,000	15	1,620,000
Feed required	Kg	7560	450	3,402,000
Subtotal				5,022,000
Fixed costs				
Purchase of solar panels	FCFA	4	75,750	303,000
Maintenance of solar panels	FCFA/2 cycles	2	10,000	20,000
Depreciation of solar panels /10 years	F CFA/an			30,300
Purchase of small equipment	F CFA			200,000
Depreciation of small equipment/5 years	F CFA/an			40,000
Maintenance of production pond (lump sum)				100,000
Labour (MOD)	FCFA/2 cycles	15	600,000	9,000,000
Subtotal fixed costs				9,693,300
Production cost per kg of fish	FCFA/2 cycles			476
Other costs				
Marketing costs (packaging, local sales)	FCFA/2 cycles	3094	100	309,375
Marketing tax (flat rate)	FCFA/2 cycles			30,000
Communication expenses (flat rate)	FCFA/2 cycles			10,000
Subtotal other expenses				349,375
Total operating costs				15,064,675
Cost per kg of fish	FCFA/2 cycles			487
Operating income				
Sales/fry sales	FCFA/2 cycles	99,000	15	1,485,000
Sales/Fish sales	FCFA/2 cycles	30937.5	1500	46,406,250
Residual value (depreciation of solar panels & depreciation of small equipment	FCFA/2 cycles			432,700
Total operating income	FCFA/2 cycles			48,323,950
Operating income				
Net profit	FCFA/2 cycles			33,259,275
Margin on variable costs	FCFA/2 cycles			42,869,250
Break-even point	FCFA/2 cycles			10,828,840
Rate of return	F CFA/2 cycles			69.4%

Table 9. Scenario 2 Fish are treated with 17-α-methytestosterone and industrial feed containing 40% protein.

Parameter	Unit	Quantity	Unit price in F CFA	Amount in F CFA
Variable costs				
Fry		108,000	15	1,620,000
Feed required	Kg/2 cycles	7560	450	3,402,000
Hormones (mg)/cycle (fixed price)	mg/2 cycles	140		200,000
Alcohol (ml)/cycle (fixed price)	ml/2 cycles	480		6000
Subtotal				5,228,000
Fixed costs				
Purchase of solar panels	FCFA	2	75,750	151,500
Maintenance of solar panels (fixed price)	FCFA/2 cycles	2	10,000	20,000
Depreciation of solar panels/10 years	F CFA/an			15,150
Maintenance of production tanks (lump sum)				100,000
Purchase of small equipment (lump sum)	FCFA			200,000
Depreciation of small equipment/5 years	F CFA/an			40,000
Labour (MOD)	FCFA/2 cycles	15	600,000	9,000,000
Subtotal fixed costs				9,526,650
Production cost per kg of fish	F CFA/2 cycles			610
Other costs				
Marketing costs (packaging, local sales)	FCFA/2 cycles	2419	100	241,875
Marketing tax (flat rate)	FCFA/2 cycles			30,000
Communication expenses (flat rate)	FCFA/2 cycles			10,000
Subtotal other expenses				281,875
Total operating costs				15,036,525
Cost per kg of fish	F CFA/2 cycles			622
Operating income				
Sales of fry	F CFA/2 cycles	77,400	100	7,740,000
Sales of fish	F CFA/2 cycles	24187.5	1500	36,281,250
Residual value (depreciation of solar panels & depreciation of small equipment)	F CFA/2 cycles			296,350
Total operating income	F CFA/2 cycles			44,317,600
Operating profit				
Net profit	F CFA/2 cycles			29,281,075
Margin on variable costs	F CFA/2 cycles			38,793,250
Break-even point	F CFA/2 cycles			10,810,516
Rate of return	FCFA/2 cycles			66.5%

Table 10. Scenario 2 Fish are treated with industrial feed containing 40% protein and 20 g of *G. kola* powder.

Parameter	Unit	Quantity	Unit price in F CFA	Amount in F CFA
Variable costs				
Fry		108,000	15	1,620,000
Feed required	Kg/2 cycles	7650	450	3,442,500
Garcinia kola powder (g)/cycle (fixed price)	mg/2 cycles	140		20,000
Alcohol (ml)/cycle (fixed price)	ml/2 cycles	480		6000
Subtotal				5,088,500
Fixed costs				
Purchase of solar panels	F CFA	2	75,750	151,500
Maintenance of solar panels (fixed price)	FCFA/2 cycles	2	10,000	20,000
Depreciation of solar panels/10 years	F CFA/an			15,150
Purchase of small equipment (lump sum))	FCFA			200,000
Depreciation of small equipment/5 years	F CFA/an			40,000
Entretien Bassins production (forfaitaire)				100,000
Labour (MOD)	FCFA/2 cycles	15	600,000	9,000,000
Subtotal fixed costs				9,526,650
Production cost per kg of fish	FCFA/2 cycles			472
Other costs				
Marketing costs (packaging, local sales)	FCFA/2 cycles	3094	100	309,375
Marketing tax (flat rate)	FCFA/2 cycles			30,000
Communication expenses (flat rate)	FCFA/2 cycles			10,000
Subtotal other expenses				349,375
Total operating costs				14,964,525
Cost per kg of fish	FCFA/2 cycles			484
Operating income				
Sales of fry	FCFA/2 cycles	99,000	100	9,900,000
Sales of fish	FCFA/2 cycles	30937.5	1500	46,406,250
Residual value (depreciation of solar panels & depreciation of small equipment)	FCFA/2 cycles			296,350
Total operating income	FCFA/2 cycles			56,602,600
Operating profit				
Net profit	FCFA/2 cycles			41,638,075
Margin on variable costs	FCFA/2 cycles			51,217,750
Break-even point	FCFA/2 cycles			10,473,126
Rate of return	F CFA/2cycles			73.9%

7. Discussion

In order to assess the financial performance of the different fish farming scenarios identified, the following financial indicators were considered: production cost per kg of fish, net operating income (NOI) and financial return. For the sake of simplicity, the operating account for each scenario was prepared for 2 production cycles (one production year). A production cycle is an activity that includes all operations from the preparation of the infrastructure to the harvesting of marketable fish.

Production costs consist of all expenses incurred in the production of fish for two (02) production cycles. Variable costs or operating costs are costs whose amount varies with the level of production. They include the cost of purchasing fry and feed, energy costs (solar panels, maintenance), small equipment, salaries for occasional paid labour, etc. Fixed costs are costs that do not depend on the level of fish production. In this case they are the depreciation costs of the equipment. Cost accounting has made it possible to evaluate the costs of equipment used both for fish farming activities and for other activities in the fish farm unit. To derive the cost of producing one kilogram (kg) of tilapia, we need to calculate the ratio of all these production-related costs to the total quantity (kg) of fish produced by the farm. In our study, the cost of production varies from one scenario to another depending on the type of farm (476 FCFA for scenario 1, 610 FCFA for scenario 2 and 472 FCFA for scenario 3).

Operating income (OI): Operating income is the portion of net income generated by the current and normal activity of a system. It is calculated as the difference between the operating revenue and the operating costs of the system over the course of its financial year [4]. The average ROE for all fish farming units is 34,726,142 FCFA. The highest (41,638,075 FCFA) and lowest (29,281,075 FCFA) ROEs were observed in scenarios 3 and 2, respectively. It was FCFA 33,259,275 for scenario 1. The difference between the NERs of the three systems is more or less significant ($p < 0.05$) in relation to the figures for the results obtained. The operating result (ER) is positive in all 3 scenarios of our study.

However, the Scenario 3 system generates a higher rate of return (the ratio between an income and the capital employed to obtain that income) (74%) than the Scenario 1 system (69%). As for the Scenario 2 system, it generates a lower financial return than the two previous systems (67%); (**Table 11**). **Table 11** shows the summary of the three financial profitability comparison indicators for the three operating scenarios.

Table 11. Comparison indicators for the three operating scenarios.

INDICATORS	SCENARIOS 1	SCENARIOS 2	SCENARIOS 3
Production cost in CFAF/kg	**476**	**610**	**472**
cost price in FCFA/kg	487	**622**	484
Sales in FCFA	47,891,250	44,021,250	56,306,250
Net profit in FCFA	**33,259,275**	**29,281,075**	**41,638,075**
Margin on variable costs in FCFA	42,869,250	**38,793,250**	51,217,750
Rate of return in %	**69**	**67**	**74**

8. Conclusion

We have tried to provide some answers to the structuring question of this work: "Contribution of *Garcinia kola* to the productivity and economic profitability of the farm on the Kedougou communal farm: Financial and comparative analysis of production factors". To do this, we opted for a systemic approach based on consideration of the context in which fish farming is carried out in a given area. Above all, this work has allowed us to construct an approach that makes it possible to answer such a question by relying successively on different methods: a typology of the production factors involved in the operation of the DAC fish farm, through an analysis that makes it possible to classify the main types of variable according to the nomenclature of production factors. The environmental analysis of each of the main types of scenario allowed the assessment of their potential impact, their level of efficiency and the points to be improved; a fractional factorial design experiment allowed the testing of two parameters, namely the use of the hormone 17-α-methyl testosterone and *Garcinia kola* on productivity and economic profitability, in order to define the most influential and to propose "optimal" scenarios from the point of view of their sustainability, according to the convincing results obtained in terms of profitability with the *G. kola* powder test. *G. kola* powder test is in order to find the most appropriate combinations of factors for optimizing the fish farming system(s) based on the producers' practices, taking into account technical, economic and environmental criteria.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this article.

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