Acta Scientiarum
http://periodicos.uem.br/ojs
ISSN on-line: 1807-8672
https://doi.org/10.4025/actascianimsci.v48i1.76210
CC BY

Economic and zootechnical parameters of two offsprings from the same strain of Nile Tilapia

Crespin Luc Quenum[1*], Djétouan Dieudonné Akian[1], Yvan Habib Coulibaly[2] and Lazard Jerôme[3]

[1]Laboratoire de Production Animale, Unité Mixte de Recherche et d'Innovation Sciences Agronomiques et Procédés de Transformation, Institut National Polytechnique Félix Houphouët-Boigny, Yamoussoukro, Côte d'Ivoire. [2]Fish Farm Success, Toumodi, Bélier, Côte d'Ivoire. [3]Pisciculture Tropicale, Le Crès, Hérault, France.*Author for correspondence. E-mail: crespin.quenum@inphb.ci

ABSTRACT. Improvement in fish production is achieved, in part, by enhancing the zootechnical performance. This study evaluated the growth performance of two strains (*Bouaké* and *Brazil*) of Nile tilapia *Oreochromis niloticus* reared in floating cages, in Côte d'Ivoire. The Brazil strain is descended from a long line of the *Bouaké* strain and are both the only strains officially approved for farming in Côte d'Ivoire. Juvenile males with an average body weight of 60.42 and 60.50 g for the *Bouaké* and *Brazil* strains respectively. They were reared in 6 floating cages of 50 m^3 at an initial density of 90 fish m^{-3}. After 120 days, both strains' final body weights were 354.74 g for *Bouaké* and 385.76 g for *Brazil*. Individual daily growth was better for the *Brazil* strain than for the *Bouaké* strain. The survival rate was 97.80% for the *Brazil* strain and 95.91% for the *Bouaké* strain, with no significant difference. In financial terms, the *Brazil* strain had a better gross profit than the *Bouaké* strain.

Keywords: *Bouaké* strain; *Brazil* strain; floating cages; zootechnical performance; Nile tilapia; growth and profitability.

Received on March 20, 2025.
Accepted on November 28, 2025.

Introduction

Since 1980, tilapia farming has experienced a continuous and high growth rate, with production estimated to reach 4.5 million tons in 2020 (Naylor et al., 2021; Food and Agriculture Organization, 2022). Today, although originating from Africa, these fish are mainly farmed in Asia (Prabu et al., 2019). The most widely used species in aquaculture is *Oreochromis niloticus* (Linneaus, 1758), which accounts for approximately 70-80% of production (El-Sayed & Fitzsimmons, 2023). In addition, there is a considerable diversity of strains, populations, and hybrids of tilapia of the genus *Oreochromis* used in aquaculture around the world (Eknath & Hulata, 2009). However, only a few have been rigorously characterized from a genetic and/or zootechnical point of view (Rutten et al., 2004; Conte et al., 2017; Yáñez et al., 2020). Most of them are used without precise knowledge of their origin and/or genotype (Eknath & Hulata, 2009). Then, to make the best choice taking into account multiple parameters (zootechnical, financial, taste, ethical, etc.) before rearing, it is often necessary to compare them (Neira et al., 2009; Putra et al., 2013; Darko et al., 2016; Santos et al., 2019).

Côte d'Ivoire is a country with four major rivers and many lakes and lagoons. The development of the aquaculture sector began in the 1980s with the establishment of fish farming stations (research and production). As a result, Côte d'Ivoire is unique in sub-Saharan Africa in having a fish farming research station in Bouaké, whose uninterrupted activities since 1958 have led to many innovations. They have had a significant impact on the development of tilapia fish farming in Africa and the tropical world (Lazard, 2019). However, national aquaculture production has not grown significantly (on average 5,000 tons/year since 2016, Yao et al., 2017; Food and Agriculture Organization, 2023) while the demand is estimated at 650,000 tons/year. This low production is attributed to the high cost of fish feed, most of which is imported, unfair competition from imported frozen farmed fish, waterways polluted by gold mining activities, a lack of support for private companies, and most certainly poorly known fish strains (Coulibaly et al., 2019; Sanou et al., 2021). Tilapia (*O. niloticus*) is one of the most widely used species in local aquaculture and in the West African sub-region. Despite the introduction of many strains, two grey tilapia strains are the most successful: the *Bouaké* strain and the *Brazil* strain (Akian et al., 2022; Zeabiue et al., 2022; Tré Bi et al., 2023).

The *Bouaké* strain

Although marginally present in Côte d'Ivoire in the Niger (Bagoué and Baoulé rivers) and Volta (Volta Noire) basins, two strains of *O. niloticus* were introduced to the Bouaké station, one from Burkina Faso (Volta basin) and the other from Uganda (Nile basin). Kept separately until 1971, these two strains were then mixed and the product of their inter-fertilization constituted the '*Bouaké* strain' which was the subject of multiple transfers within Côte d'Ivoire, Africa and outside Africa (South-East Asia, Brazil, etc.; El-Sayed & Fitzsimmons, 2023). To establish the genetic status of *O. niloticus* stocks in Côte d'Ivoire, a study of their genetic variability was undertaken in the early 1990s (Lazard & Rognon, 1997; Rognon & Guyomard, 2003). The study of the enzymatic polymorphism of Ivorian domestic strains compared with wild *O. niloticus* strains from West and East Africa revealed a higher rate of heterozygosity in the former than in the latter (Rognon & Guyomard, 2003). This result reflects the synthetic nature of the strain formed in Bouaké (Volta + Nile) and the appropriate management of its genetic variability. In addition, the good zootechnical performance of this strain confirms its interest.

The *Brazil* strain

Nile tilapia were introduced to Northeastern Brazil in 1971 from Bouaké, Côte d'Ivoire (Freato et al., 2012). Nile tilapia stocks from this introduction have been distributed throughout Brazil. Since its introduction, the *Bouaké* strain of Nile tilapia has been commonly referred to as 'Brazilian' Nile tilapia (Lovshin, 2000) and sometimes as the *Bouaké* strain (Fülber et al., 2010). In 2014, as part of an Ivorian-Brazilian cooperation program to revive aquaculture, this strain of tilapia called '*Brazil* strain', genetically related to the *Bouaké* strain, as shown in Figure 1, was introduced in Côte d'Ivoire (Kouadio, 2019; Secrétariat Général du Gouvernement de Côte d'Ivoire, 2015).

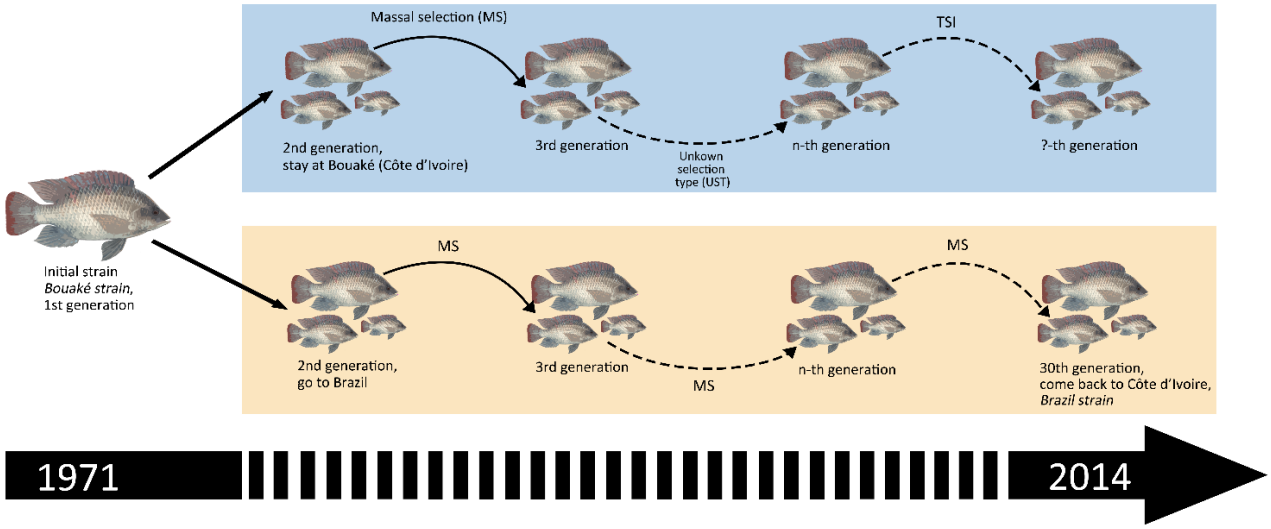


Figure 1. Evolution of the *Bouaké* strain in Côte d'Ivoire and in Brazil.

The aim of this study is to evaluate the *Bouaké* strain and the *Brazil* strain of tilapia reared in floating cages in terms of (i) zootechnical performance and (ii) bio-economic aspects. It will contribute to providing benchmarking information on the status of tilapia farming in West Africa.

Material and methods

Study area

This experimental study was carried out from April to July 2016 at the Lake Taabo (a hydroelectric dam, Côte d'Ivoire), built on the Bandama River downstream of the Kossou dam. The Taabo dam, completed in 1977, created a lake with a surface area of 69 km², which is characterized by an average depth of 8 m, a lack of stratification and a eutrophic lake status (Groga et al., 2012). The experiment was carried out in a private aquaculture company (SEDP: Société d'Elevage et de Distribution de Poisson).

Experimental design and rearing parameters

The experimental design was completely randomized with three replicates for each strain. The six floating cages were placed side by side and within homogeneous water parameters. The usable volume was 50 m^3 (5m x 5m x 2m) per cage with nylon nets with a mesh size of 25 mm.

The rearing period was 120 days. All fishes were *O. niloticus* of the '*Bouaké*' and '*Brazil'* strains. After the larval stage, they were treated with a masculinizing hormone (17-α-methyltestosterone) in the diet. They are therefore true males (XY) or neo-males (XX) (Opiyo et al., 2020). The fingerlings of the '*Bouaké*' strain come from the 2nd generation of the stock established by the SEDP at its breeding center in 2013. Those of the 'Brazil' strain are from the 2nd generation of the stock introduced in 2014.

The fish were stocked in the cages at a uniform density of 4,500 individuals/cage, i.e. 90 fishes m^{-3}. The average weights of the *Bouaké* and the *Brazil* strains were 60.42 ± 0.35 g and 60.50 ± 0.30 g respectively.

The fish were fed with an industrial extruded floating feed (Ranaan Fish Feed Company from Ghana) containing 30% of crude protein, 8.0% ash, 5.0% fat, 4.0% fiber, 9.0% moisture, 1.1% phosphorus, 11500 IU kg^{-1} vitamin A, and 150 mg kg^{-1} of vitamin C (Anani et al., 2023). The pellet size was 4.5 mm for fish between 60 and 200 g and 6.0 mm for fish over 200 g. Fish were hand-fed three times a day (9 pm, 12 am, and 3 pm). The food ration was periodically updated based on the equation (Equation 1) given by Melard (1986) (adapted from Glasser & Oswald, 2001).

$$R_{max} = 0.192 \times W^{0.685} \quad (1)$$

The maximum ration (R_{max}) tilapia can absorb each day varies according to biomass (W). Fish growth was assessed on average every 2 weeks by weighing the fish and observing their state of health. All observed dead fish were systematically removed from the cages, counted, and destroyed.

Physico-chemical parameters (dissolved oxygen and temperature) were measured before sunrise (6 am) and at sunset (6 pm). The following zootechnical parameters were calculated at the cage level: feed conversion ratio (FCR, Equation 2), daily weight gain (DWG, Equation 3), survival rate (SR, Equation 4), and coefficient of variation of body weight (CV, Equation 5).

$$FCR = Total\ feed\ distributed\ (\text{kg}) / Total\ biomass\ gain\ (kg) \quad (2)$$

$$DWG\ (g/d) = (final\ weight\ gain - initial\ weight\ gain) / number\ of\ days \quad (3)$$

$$SR\ (\%) = (final\ fish\ number / initial\ fish\ number) \times 100 \quad (4)$$

$$CV\ (\%) = (SD / \text{W-bar}) \times 100 \quad (5)$$

where SD is the standard deviation of body weight and W-bar is the mean body weight in the cage.

Economical approach

The economic approach was based on data on rearing costs recorded by the aquaculture company, including feed, cages, small equipment, maintenance, transport of fish, ice for preservation, and juvenile costs.

In addition to the baseline economic evaluation, a simple sensitivity analysis was conducted to assess the robustness of gross profit to variations in key economic variables. Two parameters were tested: (i) the selling price of fish and (ii) the feed price. For each parameter, three scenarios were considered: a pessimistic scenario (−20%), a baseline scenario (observed values recorded during the experiment), and an optimistic scenario (+20%). All other production costs and biological performance indicators were kept constant across scenarios. The objective of this analysis was to evaluate how fluctuations commonly observed in local market conditions could influence the economic outcomes of both strains.

Statistical analysis

All zootechnical and economic variables were initially computed at the cage level and subsequently averaged for each strain (n = 3 cages per strain). The normality of residuals was evaluated using the Shapiro–Wilk test. When statistical assumptions were satisfied, differences between the two strains were analyzed using Student's t-test or Welch's t-test, as appropriate. Survival rates between strains were compared using a Chi-square test. The level of statistical significance was set at 5%. All analyses were performed using R software (R Core Team, 2016).

Results

Physico-chemical parameters

All dissolved oxygen values ranged from 3.57 to 11.20 mg L^{-1} and temperature values from 25.3 to 31.3°C. The fish did not show any symptoms linked to a lack of oxygen.

Zootechnics parameters

Both strains, *Bouaké* and *Brazil*, have a similar survival rate and are not significantly different (p> 0.05, Table 1). FCR values were better in the Brazil strain compared to the *Bouaké* strain. The coefficients of variation of body weight at stocking were low and similar between the two strains, indicating an initially homogeneous population. At harvest, the CV increased in both groups, with a slightly higher dispersion observed in the Brazil strain. This increase in size heterogeneity at the end of the cycle is common in cage rearing systems and did not compromise the overall growth trends observed between strains.

Table 1. Several parameters (means ± standard deviation).

	Bouaké strain	*Brazil* strain
Survival rate	95.91±1.20 % a	97.80±1.05 % a
Global Feed Conversion Ratio	1.67±0.47 a	1.35±0.52 b
Coefficient of Variation (initial stocking)	0.58%	0.49%
Coefficient of Variation (final stock)	0.99%	4.18%

Values with the same index letter on the column are not significantly different (p> 0.05). Chi-square test was used for Survival Rate and Student's t-test for FCR.

Table 2. Variation of zootechnical parameters (means ± standard error (SE)) for all fish (13,500 fishes/strain).

	Body Weight* (g)		FCR		DWG (g d^{-1})	
Period/Strains	*Bouaké*	*Brazil*	*Bouaké*	*Brazil*	*Bouaké*	*Brazil*
Day 0	60.42±0.35 a	60.50±0.30 a	-	-	-	-
1 to 14	79.73±5.27 b	83.66±1.66 a	1.58±0.25 a	0.94±0.05 b	1.38±0.39 a	1.65±0.10 a
15 to 28	117.96±2.43 b	121.73±5.85 a	0.86±0.27 a	0.69±0.17 a	2.73±0.53 a	2.72±0.44 a
29 to 42	151.23±1.17 b	173.63±4.21 a	1.55±0.13 a	0.92±0.18 b	2.37±0.25 b	3.70±0.48 a
43 to 63	187.91±2.14 b	222.06±4.17 a	2.18±0.42 a	1.57±0.06 a	1.74±0.15 b	2.30±0.20 a
64 to 77	217.89±1.96 b	258.82±3.26 a	1.61±0.03 a	1.48±0.45 a	2.14±0.22 a	2.62±0.49 a
78 to 98	279.22±6.57 b	322.77±7.34 a	2.05±0.38 a	1.86±0.23 a	2.60±0.23 a	3.04±0.48 a
99 to 120	334.74±3.32 b	385.76±16.13 a	1.88±0.26 a	1.98±0.35 a	2.96±0.45 a	2.99±0.67 a

*Body weight is measured on the last day of each period. Values with the same index letter on the row for both strains by each zootechnical parameter are not significantly different (p> 0.05). Student's t-test and Welch's t-test were used.

From day 1 to day 28, the daily weight gain of both *Bouaké* and *Brazil* strains remained similar (Table 2). Thereafter, the Brazil strain maintained a constant growth rate ahead of the *Bouaké* strain, which correlated with a higher feed intake and a better feed conversion ratio. This higher growth rate accentuated the weight differences between the two strains. There was a peak in growth rate between days 30 and 40, followed by a slight slowdown and recovery around day 60, followed by a constant rate until the end of the trial (Figure 2).

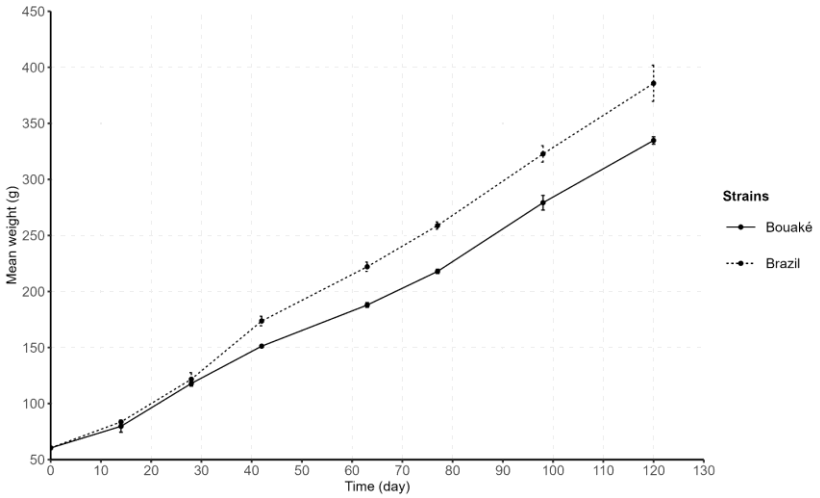


Figure 2. Comparative growth curves of both *Brazil* and *Bouaké* strains. Values on the graph represent the mean weight ± SE.

Economic parameters

At the time of the experiment, the unit cost of a juvenile was estimated at approximately $ 0.27, whereas the cost of one kilogram of feed was approximately $ 0.89 kg^{-1}. The Brazil strain was sold at a higher price than the *Bouaké* strain because, in this marketing system, the larger the size of the fish, the higher the price per kg (category of '> 700 g' sold at $ 4.23 per kg, '[500; 700] g' at $3.09 per kg, '[350; 500] g' at $ 2.68 per kg, '< 350 g' at $ 1.95 per kg; Table 3, Figure 3). The Brazil strain then obtained the best gross profit (Table 3).

Table 3. Operating account for the two strains *Bouaké* and *Brazil* (13,500 fishes/strain).

Items	*Bouaké* strain		*Brazil* strain	
	Total cost	% of cost	Total cost	% of cost
Costs				
Fixed costs (amortization and salaries)	$ 482.64	4.79	$ 482.64	4.81
Variable costs				
- Fingerlings (juvenile of 60 g)	$ 3,668.13	36.42	$ 3,668.13	36.55
- Feed (size pellet: 4.5 and 6 mm)	$ 5,655.53	56.16	$ 5,619.55	56.00
- Miscellaneous*	$ 264.81	2.63	$ 264.81	2.64
Total costs (A)	$ 10,071.11	100	$ 10,035.13	100
Products				
Obtained biomass	4,466.5 kg		4,992.24 kg	
Total selling price** (B)	$ 11,188.11		$ 13,272.06	
Mean of the selling price (B/biomass)	$ 2.50 kg^{-1}		$ 2.66 kg^{-1}	
Costs of fish produce (A/biomass)	$ 2.25 kg^{-1}		$ 2.01 kg^{-1}	
Gross profit (B - A)	$ 1,117.00		$ 3,236.75	
Gross profit per kg (Gross profit/biomass)	$ 0.25 kg^{-1}		$ 0.32 kg^{-1}	
Gross profit (in % of total selling price)	10%		24%	

*concern small equipment, maintenance, transport of fish and ice for preservation; **depending on the fish size from Figure 3; USD 1 = 614.62 XOF.

Variations in the selling price of fish had a strong effect on gross profit for both strains. For the *Bouaké* strain, gross profit ranged from a negative value under the -20% scenario to more than $ 3,300 under the +20% scenario. For the Brazil strain, gross profit varied from approximately $ 600 (-20% scenario) to nearly $ 5,900 (+20% scenario). In all scenarios, the Brazil strain maintained a higher gross profit than the *Bouaké* strain.

Changes in feed price also influenced profitability. For the *Bouaké* strain, a 20% decrease in feed price substantially improved gross profit, whereas a 20% increase reduced it to nearly zero. For the Brazil strain, gross profit ranged from about $ 2,100 (+20% feed price) to more than $ 4,300 (-20% feed price). As observed for the selling price scenarios, the Brazil strain remained economically more resilient to feed price fluctuations.

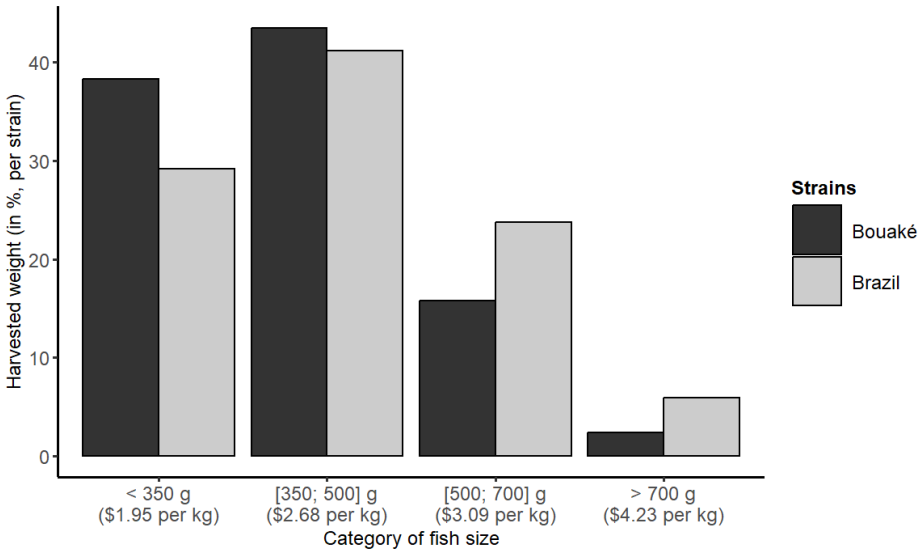


Figure 3. Weight of fish harvested by marketing category.

Discussion

Rearing performances

Throughout the experiments, dissolved oxygen levels were all above 3 mg L^{-1} up to a depth of 2 m, which is the optimal range for tilapia culture (Ross, 2000). Similarly, the temperature data correspond to the norms for optimal growth of the species between 25 and 30°C (Boyd & Tucker, 1998) and maximum growth between 28 and 30°C (Santos et al., 2013).

The trials showed a significantly higher individual daily weight gain in favor of the Brazil strain compared to the *Bouaké* strain (Table 2; Tré Bi et al., 2023; Zeabiue et al., 2022). These differences, although statistically supported, should be interpreted within the context of the experimental scale and design. The evolution of the growth parameters (DWG, FCR) in each of the two strains during rearing was similar. This probably indicates that the diet (endogenous, exogenous) had the same effects (growth rate) in the fish of the two strains, although the feed conversion ratios were different. However, a feed conversion ratio below 1.5 (commercial reference for 4.5-6 mm pellets) could confirm that the endogenous diet (phytoplankton and zooplankton) had an important effect on fish growth beyond environmental conditions. Indeed according to Groga et al. (2012), Lake Taabo is classified as a eutrophic lake, which explains that it could also contribute to the growth of tilapia as an endogenous food source of the rearing environment. In tilapia, which are planktivorous organisms, this significant addition can significantly influence the efficiency of exogenous food use (Tacon & Silva, 1997; Ulloa & Verreth, 2002). The rapid increase in DWG could therefore be explained by a double feed intake (distributed feed and endogenous feed) with a significant amount of endogenous feed, and the decrease in DWG by the scarcity of endogenous feed. During this period of decline, the water level of the lake increased due to the flooding of the river (Bandama) and numerous rains in the watershed resulting in a decrease in the concentration of planktonic biomasses. However, the trials were carried out under the same conditions, and the Brazil strain maintained a higher level of growth relative to the ration distributed. This performance suggests that this strain digests feed more easily.

Performance of comparative strains

Several comparative evaluation tests of the *O. niloticus* strains from various origins present in Brazil have been carried out with the '*Bouaké*' strain (Table 4). In their study, Fülber et al. (2010) found that the GIFT strain performed better than the '*Chitralada*' and '*Bouaké*' strains. Wagner et al. (2004) classified the following strains according to decreasing growth performance: first-generation '*Chitralada*' (CHI1), second-generation '*Chitralada*' (CHI2), intraspecific hybrid (HIS), and '*Bouaké*'. Similarly, Vieira et al. (2005) showed that the 'Supreme' strain was the best, followed by the '*Chitralada Aquabel*', '*Chitralada Codapar',* and '*Bouaké*' strains. On the other hand, Neves et al. (2008) concluded that there was no significant difference between the '*Bouaké*' and '*Chitralada*' strains.

Table 4. Some studies on growth performance with the *Bouaké* strain.

Strains	Crude protein	Initial body weight (g)	Final body weight (g)	Daily Weight Gain (g d^{-1})	Rearing period (days)	Rearing facilities	Authors
Bouaké	25%	37.39±9.88	400.68	1.781	204	Ponds for fry	Fülber et al. (2010)
Chitralada	25%	41.87±11.45	406.43	1.787	204		
GIFT	25%	45.49±11.61	485.95	2.159	204		
Bouaké	30%	37.39±9.88	273.62	1.158	204		
Chitralada	30%	41.87±11.45	294.83	1.240	204		
GIFT	30%	45.49±11.61	320.74	1.349	204		
HIS	30%	44.3	93.65	0.796	62	Concrete tanks	Wagner et al. (2004)
Bouaké	30%	31.5	71.79	0.650	62		
CHI1	30%	47.2	108.17	0.983	62		
CHI2	30%	51.2	114.31	1.018	62		
Chitralada - Codapar	-	59.14	306.82	1.848	134	Ponds and tanks	Vieira et al. (2005)
Suprême	-	65.74	344.73	2.082	134		
Bouaké	-	48.70	263.49	1.603	134		
Chitralada - Aquabel	-	58.40	340.50	2.105	134		
Bouaké	45%	8.265	153.00	0.856	169	Ponds and tanks	Neves et al. (2008)
Chitralada	45%	8.660	183.35	1.034	169		
Bouaké	30%	80.42±0.35	354.74±3.33	2.286	120	Floating cages	Present study
Brazil	30%	60.50±0.30	385.76±16.14	2.711	120		

Examination of the results in Table 4 shows that the *'Bouaké'* strain performed lower than the strains it was compared to. These results contrast with those of the present study. This situation can be explained by a genetic improvement carried out in Brazil on the *'Bouaké'* strain originally introduced in this country, which became the *'Brazil'* strain (Lovshin, 2000).

In genetic terms, this is a paradoxical situation since it concerns two populations of the same species (*O. niloticus*) with the same origin and separated from each other in 1971. One (*Bouaké* strain) was established and maintained in Côte d'Ivoire and the other (*Brazil* strain) was introduced in Brazil in 1971 and 'reintroduced' in Côte d'Ivoire in 2014. The history of the two strains in their respective environments is unknown, but, likely, they did not remain isolated from other strains of the same species. For example, the introduction of the *Chitralada* strain from Thailand in 1996 (Baggio et al., 2016) in Brazil and a new Volta 1957 strain (Lazard, 1990) from Burkina Faso in Côte d'Ivoire most likely resulted in cross-fertilization with the 'local' strains. The results of the present experiment confirm this. In general, the impact of introducing genetically related species, especially strains, is likely to have a significant demographic impact on the abundance of natural populations (Chevassus-au-Louis & Lazard, 2009), especially as Nile tilapia is considered an invasive species (Abd Hamid et al., 2023).

Economic aspects

The *Bouaké* strain generates a gross profit of $ 0.25 per kg, while the Brazil strain reaches $ 0.32 per kg. The sensitivity analysis showed that a variation of ±20% in the selling price of fish leads to the largest changes in gross operating profit, which confirms that profitability is primarily driven by fluctuations in market prices. In this context, fish farms should prioritize a proactive commercial strategy that focuses on optimizing the timing of sales, targeting the most profitable size categories, and securing stable market outlets (Moyo & Rapatsa, 2021). At the national level, the development of aquaculture in Côte d'Ivoire would be strengthened by public policies designed to protect locally produced fish against low-priced imported tilapia, which often depress domestic market prices.

According to the operating accounts for both strains, feed represents more than 50% of total production costs, making it the main component of operating expenses. Particular attention must therefore be given to feed quality, storage conditions, rationing, and regular monitoring of fish growth, since feed composition and the frequency of distribution directly affect growth rate and feed conversion efficiency. Because these zootechnical responses determine overall feed consumption, the price of feed is a strategic economic variable for producers (Neira et al., 2009). The sensitivity analysis also showed that changes in feed price can substantially modify gross profit, even if the effect is less pronounced than variations in the selling price of fish. In this context, selecting a strain with efficient feed utilization remains a key decision for aquaculture operators seeking to optimize the economic performance and resilience of cage farming systems.

Conclusion

The Brazil strain showed slightly better growth and feed efficiency, resulting in higher gross profit and greater economic stability in the sensitivity scenarios. For cage farmers in Côte d'Ivoire, these results indicate that choosing this strain can reduce vulnerability to feed and market price fluctuations and improve overall profitability. Both strains remain usable, but the Brazil strain offers clearer economic advantages for producers seeking more resilient and cost-effective tilapia farming.

Data availability

Does not apply.

Aknowledgement

We are very grateful to the private aquaculture company SEDP, which provided financial and logistical support for this work.

References

Abd Hamid, M., Md Sah, A. S. R., Idris, I., Mohd Nor, S. A., & Mansor, M. (2023). Impacts of tilapia aquaculture on native fish diversity at an ecologically important reservoir. *PeerJ*, *11*, e15986. https://doi.org/10.7717/peerj.15986

Akian, D. D., Quenum, C. L., Koua, D. N. Z., Houra, J. A. K., Clota, F., Bégout, M. L., & Yao, K. (2022). Comparative study of larvae production by the Nile tilapia (*Oreochromis niloticus*, Linné, 1758) Bouaké strain between earthen ponds and hapas. *Aquaculture Research, 53*(17), 6049-6055. https://doi.org/10.1111/are.16075

Anani, F. A., Atsakpo, P. D. K., Donkor, K. K., Ayarika, F. A., Johnson-Ashun, M., & Dankwa, E. T. (2023). Profitability of using five different commercial tilapia starter feeds on the ghanaian market in Nile Tilapia, *Oreochromis niloticus* fingerlings production. *Aquaculture Studies*, *24*(2), 1-8. https://doi.org/10.4194/AQUAST1343

Baggio, R. A., Orélis-Ribeiro, R., & Boeger, W. A. (2016). Identifying Nile tilapia strains and their hybrids farmed in Brazil using microsatellite markers. *Pesquisa Agropecuária Brasileira*, *51*(10), 1744-1750. https://doi.org/10.1590/s0100-204x2016001000006

Boyd, C. E., & Tucker, C. S. (1998). *Pond aquaculture water quality management*. Kluwer Academic Publishers.

Chevassus-au-Louis, B., & Lazard, J. (2009). Perspectives pour la recherche biotechnique en pisciculture. *Agriculture*, *18*(2), 91-96. https://doi.org/10.1684/agr.2009.0289

Conte, M. A., Gammerdinger, W. J., Bartie, K. L., Penman, D. J., & Kocher, T. D. (2017). A high quality assembly of the Nile Tilapia (*Oreochromis niloticus*) genome reveals the structure of two sex determination regions. *BMC Genomics*, *18*(1), 341. https://doi.org/10.1186/s12864-017-3723-5

Coulibaly, S., Bonhoulou, R., Ossey, Y. B., & Atsé, B. C. (2019). Etude comparative de la commercialisation et la consommation du Tilapia élevé en Côte d'Ivoire et importé de la Chine. *Agronomie Africaine*, *8*(1), 17-22.

Darko, F. A., Quagrainie, K. K., & Chenyambuga, S. (2016). Consumer preferences for farmed tilapia in Tanzania: a choice experiment analysis. *Journal of Applied Aquaculture*, *28*(3), 131-143. https://doi.org/10.1080/10454438.2016.1169965

Eknath, A. E., & Hulata, G. (2009). Use and exchange of genetic resources of Nile tilapia (*Oreochromis niloticus*). *Reviews in Aquaculture*, *1*(3-4), 197-213. https://doi.org/10.1111/j.1753-5131.2009.01017.x

El-Sayed, A. M., & Fitzsimmons, K. (2023). From Africa to the world—The journey of Nile tilapia. *Reviews in Aquaculture*, *15*(S1), 6-21. https://doi.org/10.1111/raq.12738

Food and Agriculture Organization. (2022). *The state of world fisheries and aquaculture 2022*. FAO. https://doi.org/10.4060/cc0461en

Food and Agriculture Organization. (2023). *Global aquaculture production*. Fisheries and Aquaculture. https://www.fao.org/fishery/en/collection/aquaculture?lang=en

Freato, T. A., Freitas, R. T. F., Pimenta, M. E. S. G., Oliveira, G. R., Neto, R. V. R., & Mattos, B. O. (2012). Evaluation of Nile tilapia strains cultivated in cages under different feeding programmes. *Revista Brasileira de Zootecnia*, *41*(6), 1332-1336. https://doi.org/10.1590/S1516-35982012000600002

Fülber, V. M., Ribeiro, R. P., Braccini, G. L., Vargas, L. D., & Marengoni, N. G. (2010). Desempenho produtivo de três linhagens de tilápia-do-Nilo (*Oreochromis niloticus*) alimentadas com dois níveis de proteína. *Acta Scientiarum. Animal Sciences*, *32*(1), 77-83. https://doi.org/10.4025/actascianimsci.v32i1.6862

Glasser, F., & Oswald, M. (2001). High stocking densities reduce *Oreochromis niloticus* yield: model building to aid the optimisation of production. *Aquatic Living Resources*, *14*(5), 319-326. https://doi.org/10.1016/S0990-7440(01)01130-5

Groga, N., Ouattara, A., Costa, S. Da, Dauta, A., Beauchard, O., Moreau, J., Gourene, G., & Laffaille, P. (2012). Water quality and water-use conflicts in Lake Taabo (Ivory Coast). *Open Journal of Ecology*, *2*(1), 38-47. https://doi.org/10.4236/oje.2012.21005

Kouadio, F. K. N. (2019). Coopération Sud-Sud pour le développement agricole : étude prospective de la souche brésilienne de l'*Oreochromis niloticus* dans le développement de la pisciculture ivoirienne. *International Journal of Geography, Geology and Environment*, *1*(1), 48-57.

Lazard, J. (1990). Transferts de poissons et développement de la production piscicole : exemple de trois pays d'Afrique subsaharienne. *Revue Hydrobiologie Tropicale*, *23*(3), 251-265.

Lazard, J. (2019). *Piscicultures du monde. Aujourd'hui et demain*. Presses des Mines. (Collection Académie d'agriculture de France).

Lazard, J., & Rognon, X. (1997). Genetic diversity of tilapia and aquaculture development in Côte D'Ivoire and Niger. *Israeli Journal of Aquaculture*, *49*(2), 90-98.

Lovshin, L. L. (2000). Tilapia culture in Brazil. In B. A. Costa-Pierce, & J. E. Rakocy (Ed.), *Tilapia aquaculture in the Americas* (Vol. 2; pp. 133-140). The World Aquaculture Society.

Melard, C. (1986). Les bases biologiques de l'élevage intensif du Tilapia du Nil. *Cahiers d'Ethologie appliquée*, *6*(3), 1-252.

Moyo, N. A. G., & Rapatsa, M. M. (2021). A review of the factors affecting tilapia aquaculture production in Southern Africa. *Aquaculture*, *535*(1), 736386. https://doi.org/10.1016/j.aquaculture.2021.736386

Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., Little, D. C., Lubchenco, J., Shumway, S. E., & Troell, M. (2021). A 20-year retrospective review of global aquaculture. *Nature*, *591*(7851), 551-563. https://doi.org/10.1038/s41586-021-03308-6

Neira, I., Engle, C. R., & Ngugi, C. (2009). Economic and risk analysis of tilapia production in Kenya. *Journal of Applied Aquaculture*, *21*(2), 73-95. https://doi.org/10.1080/10454430902892842

Neves, P. R., Ribeiro, R. P., Vargas, L., Natali, M. R. M., Maehana, K. R., & Marengoni, N. G. (2008). Evaluation of the performance of two strains of Nile tilapia (*Oreochromis niloticus*) in mixed raising systems. *Brazilian Archives of Biology and Technology, 51*(3), 531-538. https://doi.org/10.1590/S1516-89132008000300012

Opiyo, M. A., Obiero, K. O., Abwao, J., Awuor, F. J., Kyule, D., & Munguti, J. (2020). Comparative growth performance of genetically male, sexreversed, and mixed-sex Nile Tilapia (*Oreochromis niloticus*) reared in earthen ponds in Sagana, Kenya. *Aquaculture Studies*, *21*(1), 23-30. https://doi.org/10.4194/2618-6381-v21_1_03

Prabu, E., Rajagopalsamy, C. B. T., Ahilan, B., Jeevagan, I. J. M. A., & Renuhadevi, M. (2019). Tilapia – an excellent candidate species for world aquaculture: a review. *Annual Research & Review in Biology, 31*(3), 1-14. https://doi.org/10.9734/arrb/2019/v31i330052

Putra, N. S. S. U., Lapong, I., Rimmer, M. A., Raharjo, S., & Dhand, N. K. (2013). Comparative performance of four strains of Nile tilapia (*Oreochromis niloticus*) in brackish water ponds in Indonesia. *Journal of Applied Aquaculture*, *25*(4), 293-307. https://doi.org/10.1080/10454438.2013.834282

R Core Team. (2016). *R: A Language and Environment for Statistical Computing (Version 3.3.0)*. https://www.r-project.org/

Rognon, X., & Guyomard, R. (2003). Large extent of mitochondrial DNA transfer from *Oreochromis aureus* to *O. niloticus* in West Africa. *Molecular Ecology*, *12*(2), 435-445. https://doi.org/10.1046/j.1365-294X.2003.01739.x

Ross, L. G. (2000). Environmental physiology and energetics. In M. C. M. Beveridge, & B. J. McAnderson (Eds.), *Tilapias: biology and exploitation* (pp. 89-128). Springer Netherlands.

Rutten, M. J. M., Komen, H., Deerenberg, R. M., Siwek, M., & Bovenhuis, H. (2004). Genetic characterization of four strains of Nile tilapia (*Oreochromis niloticus* L.) using microsatellite markers. *Animal Genetics*, *35*(2), 93-97. https://doi.org/10.1111/j.1365-2052.2004.01090.x

Sanou, A., Coulibaly, S., Coulibaly, M., N'Goran N'Dri, S., & Atse, B. C. (2021). Assessment of heavy metal contamination of fish from a fish farm by bioconcentration and bioaccumulation factors. *Egyptian Journal of Aquatic Biology and Fisheries*, *25*(1), 821-841. https://doi.org/10.21608/EJABF.2021.151995

Santos, V. B., Mareco, E. A., & Silva, M. D. P. (2013). Growth curves of Nile tilapia (*Oreochromis niloticus*) strains cultivated at different temperatures. *Acta Scientiarum. Animal Sciences*, *35*(3), 235-242. https://doi.org/10.4025/actascianimsci.v35i3.19443

Santos, V. B., Silva, V. V., Almeida, M. V., Mareco, E. A., & Salomão, R. A. S. (2019). Performance of Nile tilapia *Oreochromis niloticus* strains in Brazil: a comparison with Philippine strain. *Journal of Applied Animal Research*, *47*(1), 72-78. https://doi.org/10.1080/09712119.2019.1571495

Secrétariat Général du Gouvernement de Côte d'Ivoire. (2015). *Communique du Conseil des Ministres du Mercredi 05 Août 2015*. https://www.gouv.ci/publications/conseils-des-ministres/244

Tacon, A. G. J., & Silva, S. S. (1997). Feed preparation and feed management strategies within semi-intensive fish farming systems in the tropics. *Aquaculture*, *151*(1-4), 379-404. https://doi.org/10.1016/S0044-8486(96)01494-9

Tré Bi, T. C. O., Anvo, M. P., Doumbia, L., & Kouassi, N. C. (2023). Evaluation of the zootechnical performance during the grow-out phase of an improved strain of *Oreochromis niloticus* reared in ponds in the Ivorian environment. *International Journal of Innovation and Applied Studies*, *39*(2), 965-972.

Ulloa, R. J. B., & Verreth, J. A. J. (2002). Growth, feed utilization and nutrient digestibility in tilapia fingerlings (Oreochromis aureus Steindachner) fed diets containing bacteria-treated coffee pulp. *Aquaculture Research*, *33*(3), 189-195. https://doi.org/10.1046/j.1365-2109.2002.00655.x

Vieira, P. V., Ribeiro, R. P., Moreira, H. L. M., Povh, J. A., Vargas, L., & Barrero, N. M. L. (2005). Avaliação do desempenho produtivo de linhagens de tilápia do Nilo (*Oreochromis niloticus*) em Maringá-PR. *Revista Acadêmica: Ciência Animal*, *3*(3), 19-26. https://doi.org/10.7213/cienciaanimal.v3i3.9147

Wagner, P. M., Ribeiro, R. P., Moreira, H. L. M., Vargas, L., & Povh, J. A. (2004). Avaliação do desempenho produtivo de linhagens de tilápia do Nilo (*Oreochromis niloticus*) em diferentes fases de criação. *Acta Scientiarum. Animal Sciences*, *26*(2), 187-196. https://doi.org/10.4025/actascianimsci.v26i2.1864

Yáñez, J. M., Joshi, R., & Yoshida, G. M. (2020). Genomics to accelerate genetic improvement in tilapia. *Animal Genetics*, *51*(5), 658-674. https://doi.org/10.1111/age.12989

Yao, A. H., Koumi, A., Atse, B. C., & Kouamelan, E. P. (2017). Etat des connaissances sur la pisciculture en Côte d'Ivoire. *Agronomie Africaine*, *29*(3), 227-244.

Zeabiue, C., Ouattara, I. N., Berte, S., & Kamagate, B. (2022). Performances zootechniques des alevins de trois souches du tilapia du nil *Oreochromis niloticus* L., 1758 du paysage aquacole de la Cote d'Ivoire élevées en happa implante dans un étang. *Agronomie Africaine*, *34*(2), 191-198.