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Impact of cashew meal (*Anacardium occidentale*) incorporation on the economic profitability of laying hen production (ISA Brown) in Côte d'Ivoire

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Abstract

In Côte d'Ivoire, protein feed in poultry farming is expensive. This study was conducted to evaluate the impact of incorporating cashew meal on the economic profitability of laying hen production (ISA Brown). For this purpose, ISA Brown pullets were selected and fed with cashew meal-based feed. Batches were fed T0 (control), T1 (100% cashew meal), T2 (50% cashew meal) and T3 (95% cashew meal) feed. They were reared for forty-six (46) weeks and subjected to the same prophylaxis (health and medical). The price per kilogram of feed, the production cost and the total investment were impacted by the formulation. The gross profit margin per batch, the sale of livestock products and the economic profitability of the productions were also influenced by the formulation (cashew cake incorporation rate). The price per kilogram of feed (growing, pre-laying, and laying) was 181.04, 192.02 and 204.84 CFA francs (T0), 161.66, 170.02 and 181.84 CFA francs (T1), 170.76, 180.67 and 193.04 CFA francs (T2) and 160.71, 168.72 and 180.69 CFA francs (T3). The total invested was 358296.53 CFA francs (T0), 278625.28 CFA francs (T1), 327834.21 CFA francs (T2) and 269211.67 CFA francs (T3). The sale of livestock products was 551056.66 (T0), 297900 fcfa (T1), 485039.33 fcfa (T2) and 328898.66 fcfa (T3). The economic profitability of production was 1.53 (T0), 1.06 (T1), 1.47 (T2) and 1.22 (T3). The T3 and T2 feeds were the cheapest. The use of cashew meal in animal feed has improved the economic profitability of laying hen production in Côte d'Ivoire and generated significant profit margins.

Keywords: Feed; Cashew meal; Economic profitability; Gross margin; Laying hen

1. Introduction

The Covid health crisis19 has led to an increase in the cost of imported raw materials, which has directly resulted in the high cost of production of laying hens. In most sub-Saharan countries, conventional sources of protein such as soybean and groundnut meal and fishmeal are indeed scarce and therefore expensive (Dahouda et *al.*, 2009). Increasing amounts of cereals and soybeans are imported from the North, resulting in large foreign exchange outflows (Picard et *al.*, 1993). Manufacturers sometimes find it difficult to find maize in quality and quantity. Cottonseed cake and fishmeal, also purchased locally, are not always available, creating stock-outs. Soybean meal, which is the third source of protein, is imported (Ducroquet et *al.*, 2017). However, in most developing countries, significant quantities of agricultural by-products and residues are generated each year. These by-products, which tend to accumulate, could be used in animal feed (Jayathilakan et *al.,* 2012). For example, in Côte d'Ivoire, the world's largest cashew nut producer, cashew kernels could be an interesting alternative to imported soybean meal at high cost (Atteh and Ologbenla, 1993; Aduku, 1993; Odunsi, 2002). Cashew kernel co-product meal fits into this range of agricultural products. The technical and economic aspects are important in animal production in order to consider the sustainability of production.

The objective of this study is therefore to calculate the economic profitability of the various cashew meal-based treatments. It will involve :

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- Calculate the cost of production;
- Calculate the gross profit margin;
- Evaluate the economic profitability for each batch.

2. Material and methods

2.1. Study site

The study was conducted in Port-Bouët, more precisely in the private DVA farm located in Abbeykro behind the Félix Houphouët Boigny Airport, not far from the private Makkaiis estate. The experiment took place from November 2020 to December 2021. The site houses four buildings, two (2) dormitories and a shop for the conservation of raw materials and livestock products. The two large buildings have a capacity of 2000 laying hens and a small building with a capacity of 200 cockerels. The experimental building was built to house the experimental hens (Figure 1).

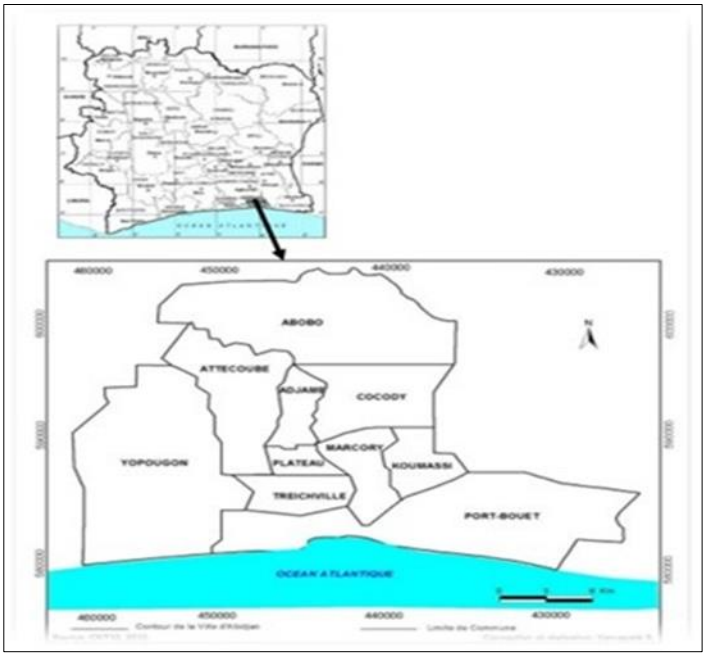

Figure 1 Study site

2.2. Fixed costs

2.2.1. Building and equipment for breeding

This is a 15/3 m building that was arranged in 5 compartments separated by nets. Each compartment had a surface area of 9 m2 in which two troughs and three (3) conical feeders were installed (Figure 2).

Figure 2 Bulding and equipment for breeding

2.3. Variable loads

2.3.1. Formulations

The composition of the feeds distributed in this experiment is shown in Tables 1, 2 and 3. Cashew, soybean and cotton cakes were used as the main source of vegetable protein in this experiment (Figure 3). The raw materials used for the feed formulations (growth and pre-feed) were the same, with the only difference being the rate of incorporation. As for the formulation of egg feeds, in addition to the incorporation rates of the raw materials, wheat bran was removed, and artisanal fish meal was incorporated.

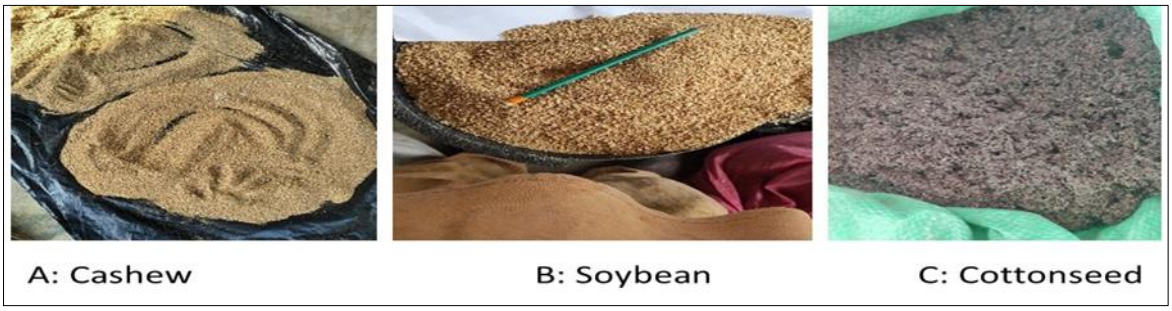

Figure 3 Image of plant protein sources

Table 1 Centesimal composition of feeds distributed in the growth phase

	Provenders			
R M (kg)	**T0**	**T1**	**T2**	**T3**
Cashew meal	-	19	9.5	18.05
Soybean meal	19	-	9.5	-
Cottonseed cake	-	-	-	0.95
Yellow corn	60	60	60	60
Wheat bran	17.8	17.8	17.8	17.8
Premix TNH	1.3	1.3	1.3	1.3
Fysal	0.3	0.3	0.3	0.3
Toxo	0.2	0.2	0.2	0.2
Oyster shell	1	1	1	1
Salt (NaCl)	0.4	0.4	0.4	0.4
Totals	100	100	100	100

R M: raw material, T0: control 0 % cashew meal, T1: substitution of cashew meal for soybean meal 100 % cashew meal, T2: feed with 50 % cashew meal, T3: feed with 95 % cashew meal, NaCl: sodium chloride

Table 2 Composition of a tonne of feed distributed in the pre-sowing phase

	Provenders			
R M (kg)	**T0**	**T1**	**T2**	**T3**
Cashew meal	-	220	110	209
Soybean meal	220	-	110	-
Cottonseed cake	-	-	-	11
Yellow corn	640	640	640	640
Wheat bran	80	80	80	80
Premix TNH	12.5	12.5	12.5	12.5
Fysal	2.5	2.5	2.5	2.5
Toxo	1.5	1.5	1.5	1.5
Oyster shell	40	40	40	40
Salt (NaCl)	3.5	3.5	3.5	3.5
Totals	1000	1000	1000	1000

R M: raw material, T0: control 0 % cashew meal, T1: substitution of cashew meal for soybean meal 100 % cashew meal, T2: feed with 50 % cashew meal, T3: feed with 95 % cashew meal, NaCl: sodium chloride

Table 3 Composition of a tonne of feed distributed in egg laying

	Provenders			
R M (kg)	**T0**	**T1**	**T2**	**T3**
Cashew meal	-	230	115	218.5
Soybean meal	230	-	115	-
Cottonseed cake	-	-	-	11.5
Yellow corn	650	650	650	650
Wheat bran	7.5	7.5	7.5	7.5
Premix TNH	12.5	12.5	12.5	12.5
Fysal	2.5	2.5	2.5	2.5
Toxo	1.5	1.5	1.5	1.5
Oyster shell	80	80	80	80
Salt (NaCl)	3	3	3	3
Palm oil	13	13	13	13
Totaux	1000	1000	1000	1000

R M: raw material, T0: control 0 % cashew meal, T1: substitution of cashew meal for soybean meal 100 % cashew meal, T2: feed with 50 % cashew meal, T3: feed with 95 % cashew meal, NaCl: sodium chloride

2.3.2. Veterinary products

Laying hens were immunized against many diseases during the rearing phase (growing and pre-laying). During the laying period, the booster vaccination, and the maintenance of good health of the hens were observed. The costs for the veterinary products involve the service and visit of the veterinarians.

2.3.3. Energy

Two sources of energy supply the site (an electric current provided by the Compagnie Ivoirienne d'Electricité (CIE) and a solar panel that provides backup in case of power cuts) and a borehole for watering the animals and other uses.

2.3.4. Livestock products

The livestock products consisted of eggs collected each day during the laying period. At the end of egg production, the hens were reformed before being sold on the local market (Figure 4).

Figure 4 Livestock products (eggs and reformed hens)

2.4. Methods

2.4.1. Feed formulation

The purchase price of the raw materials and additives used for feed formulation and production was used to calculate the feed costs for each batch. Thus, cashew meal was produced on the farm. Soybean meal, cottonseed meal, wheat bran, TNH premix, fysal, toxo and shell were purchased from feed marketing companies. Yellow maize, salt (NaCl) and artisanal fishmeal were purchased commercially.

2.4.2. Bird monitoring

The production cycle of laying hens (ISA Brown) is subdivided into four (4) main physiological phases (start-up, growth, pre-laying, and laying). During the physiological phases, chicks, pullets, and layers were reared according to the recommendations of the strain (ISA Brown). Feed was formulated according to the needs of the birds. The feed was fed at the same time each day (15:00). The zootechnical parameters during the physiological phases were measured and calculated. The expenses incurred were recorded and used to calculate the profitability of the productions.

2.4.3. Zootechnical parameters

In this study, feed intake was used for the calculation of feed costs. The mortality rate was used to calculate the number of hens sold. The number of eggs laid was used to calculate the number of egg trays sold. The downgraded egg rate was used to calculate the downgraded eggs sold.

2.4.4. Economic evaluation

Feed production cost (FPC)

Centesimal formulas were used to calculate the kilogram of feed distributed. Thus, the cost of feed production was calculated by multiplying the feed intake of the hen by the number of hens by the price per kilogram of feed. The cost of feed production was calculated according to the formula:

$$FPC = FI \times nd \times nhens \times price\ per\ kg\ of\ feed$$

Total investment (TI)

For each treatment, the total investment was the sum of all the expenses made to improve production. For each treatment (T0, T1, T2 and T3), it was made up of the costs of obtaining chicks, production of feed consumed, veterinary products and unforeseen but useful expenses for improving production.

$$TI = \sum expenses$$

Sale of livestock products (eggs and reformed hens) (SLiPro)

Farming products were made up of the day's eggs and reformed hens after laying. In each batch, the daily eggs were collected, sorted, weighed, and placed in trays for sale on the local market. The reformed hens were sold after the hens had laid. The sale of livestock products (eggs and reformed hens) was sold on the local market.

Sale of eggs = number of trays X price of a tray

Sale of reformed hens = number of hens X price of a hen

Profit margins

- Gross profit margin (GPM)

The gross profit margin for each treatment was calculated. This was done by considering the sale of the rearing products (eggs and reformed hens) minus the total investment. Thus, it was calculated according to this formula:

$$GPM = SLiPro - TI$$

- Net margin (MBN)

The net margin is the value of the production minus all production costs. This calculation considers all expenses (planned and unplanned) for a good production of hens: MBN = Production - production cost

- Profitability of production (RP)

The profitability of a production is the ratio of capital to profit. Capital is the investment and profit is the sale of livestock products.

$$RP = Capital / Profile$$

3. Results

3.1. Unit price of raw materials and feed additives

The cost of acquiring raw materials and feed additives on the farm is given in the table. Cashew meal was the least expensive (300 CFA francs/kg) compared to soybean meal (400 CFA francs/kg). Cottonseed cake was the cheapest (200 CFA francs) of the plant proteins. Local fishmeal was purchased at 300 CFA francs per kilogram. Yellow maize was purchased at 115 fcfa/kg. Wheat bran was obtained at 40 fcfa. The red palm oil cost 550 fcfa per kilogram. TNH premix, fysal, toxo, salt (NaCl) and oyster shell were purchased at 1380 fcfa, 1800 fcfa, 2400 fcfa, 100 fcfa and 38 fcfa per kilogram respectively (Table 4).

Table 4 Unit prices of raw materials and food additives

R M	Cas m	soym	cotm	LFM	YM	WB	RPOi	PTNH	Fys	Tox	OS	Salt
fcfa / kg	300	400	200	300	115	40	550	1380	1800	2400	38	100

R M: raw material, cas m: cashew meal, soym: soybean meal, cotm: cottonseed meal, LFM: local fish meal, YM: yellow maize, WB: wheat bran, RPOi: red palm oil, PTNH: premix TNH, Fys: fysal, Tox: toxo, OS: oyster shell, fcfa: franc of the African financial community

3.2. Cost per kilogram of feed

The price per kilogram of T0 feed distributed during the physiological phases (growth, pre-spawning, and spawning) (181.04; 192.02 and 204.84 fcfa) was the most expensive compared to T1 feed (161.66; 170.02 and 181.84 fcfa), T2 feed (170.76; 180.67 and 193.04 fcfa) and T3 feed (160.71; 168.72 and 180.69 fcfa). At the same time, T1 and T3 are by far the cheapest (Table 5).

Table 5 Price per kilogram of physiological phase feed

	Provenders			
Physiological stages	**T0**	**T1**	**T2**	**T3**
Growth (fcfa / kg)	181.04	161.66	170.76	160.71
Pre-laying (fcfa / kg)	192.02	170.02	180.67	168.92
Spawning (fcfa / kg)	204.84	181.84	193.04	180.69

T0: control 0 % cashew meal, T1: substitution of cashew meal for soybean meal 100 % cashew meal, T2: feed with 50 % cashew meal, T3: feed with 95 % cashew meal, fcfa: franc of the African financial community

3.3. Cost of production of distributed feeds

3.3.1. Growth phase

The batch of laying hens fed with feed T0 consumed 207890.90 g of feed which corresponds to 37636.56 fcfa. The T1, T2 and T3 batches consumed 190673 g (30896.65 fcfa), 205569 g (35181.07 fcfa) and 175994 g (28350.87 fcfa) respectively during the growth phase (Table 6). The cost of production of T3 and T1 feed was the least expensive.

Table 6 Production costs of feeds distributed in the growth phase

	Provendes			
Indices	**T0**	**T1**	**T2**	**T3**
FI / d (g)	2 969.87	2 723.9	2 936.7	2 514.2
Feed consumed (g)	207 890.9	190 673	205 569	175 994
Price per kg (fcfa/kg)	181.04	162.04	171.14	161.09
PCGF (fcfa)	37 636.56	30 896.65	35 181.07	28 350.87

T0: 0% cashew meal, T1: 100% cashew meal, T2: 50% cashew meal, T3: 95% cashew meal, FI/d: feed intake per day, PCGF: production cost of growth feed, fcfa: African financial community franc.

3.3.2. Pre-feeding phase

The feed production costs were T0, T1, T2 and T3 were 14329.80 CFA francs, 10507.74 CFA francs, 12772.54 CFA francs and 9135.590 CFA francs respectively. Provisions T0 and T2 were the most expensive compared to T1 and T3 (Table 7).

Table 7 Production costs of feeds distributed in the pre-sowing phase

	Provenders			
Index	**T0**	**T1**	**T2**	**T3**
AFC / d (g)	78.97	65.4	74.81	57.23
Feed consumed (g)	74 626.65	61 803	70 695.45	54 082.35
Price per kg (fcfa/kg)	192.02	170.02	180.67	168.92
PC Pre-feed (fcfa)	14 329.80	10 507.74	12 772.54	9 135.59

d: day, AFC: average feed consumption, T0: 0% cashew meal, T1: 100% cashew meal, T2: 50% cashew meal, T3: 95% cashew meal, Prov cons: feed consumed, PCPre-feed: production cost of pre-feed, fcfa: African financial community franc.

3.3.3. Egg-laying phase

During the egg-laying phase, the feed distributed was estimated at 198378.51 CFA francs (T0), 129269.25 CFA francs (T1), 171928.94 CFA francs (T3) and 123773.57 CFA francs (T3). The study shows that T3 feed was the least expensive feed compared to the other feeds T0, T1 and T2 (Table 8).

Table 8 Production cost of egg feed distributed during this phase

	Provenders			
Index	**T0**	**T1**	**T2**	**T3**
Qt fe / d (g)	4 192.45	3 077.47	3 855.58	2 965.39
Feed consd (g)	968 455.95	710 895.57	890 638.98	685 005.09
Price per kg (fcfa/kg)	204.84	181.84	193.04	180.69
PC Pre (fcfa)	198 378.51	129 269.25	171 928.94	123 773.57

qtp: quantity of feed, T0: 0% cashew meal, T1: 100% cashew meal, T2: 50% cashew meal, T3: 95% cashew meal, feed consd: feed consumed, PC Pre-feed: production cost of pre, fcfa: African financial community franc

3.4. Sale of livestock products

The livestock products were sold and sorted in each batch. The EVP of lot T0 was 551056.66 fcfa. The EVP of lots T1, T2 and T3 was 297900 CFA francs, 485039.33 CFA francs and 328898.66 CFA francs respectively. The EVP of lot T1 was the lowest compared to those of lots T3, T2 and T0 (Table 9).

Table 9 Sale of livestock products

	Provenders			
Index	**T0**	**T1**	**T2**	**T3**
No. of eggs sold	6 420.85	2 578.5	5 475.59	2 998.48
No. of trays	214.02	85.95	182.51	99.94
Tray price (fcfa)	2 000	2 000	2 000	2 000
Sale of eggs (fcfa)	428 056.66	171 900	365 039.33	199 898.66
Live hen	41	42	40	43
Unit price (fcfa)	3 000	3 000	3 000	3 000
Sale of hens (fcfa)	123 000	126 000	120 000	129 000
SLiPro (fcfa)	551 056.66	297 900	485 039.33	328 898.66

T0: 0% cashew meal, T1: 100% cashew meal, T2: 50% cashew meal, T3: 95% cashew meal, No: number, SLiPro: sale of livestock products, fcfa: African financial community franc

3.5. Gross profit margin and economic profitability of the production

Lot T0 obtained a gross profit margin of 192760.13 fcfa. The gross profit margins for lots T1, T2 and T3 were 19274.71 CFA francs, 157205.11 CFA francs and 59686.99 CFA francs. The lowest profit margins were obtained with lots T1 (19274.71 fcfa) and T3 (59686.99 fcfa) (Table 10).

Lot T0 showed a profitability of 1.53. As for T1, T2 and T3, the profitability of the production was 1.06, 1.47 and 1.22. Overall, all productions were profitable. The lowest profitability was recorded with batch T1 (1.06).

Table 10 Gross profit margin

	Provenders			
Index	**T0**	**T1**	**T2**	**T3**
VPE (fcfa)	551 056.66	297 900	485 039.33	328 898.66
Total inves (fcfa)	358 296.53	278 625.28	327 834.21	269 211.67
MBB (fcfa)	192 760.13	19 274.71	157205.11	59 686.99
R E	1.53	1.06	1.47	1.22

T0: 0% cashew meal, T1: 100% cashew meal, T2: 50% cashew meal, T3: 95% cashew meal, VPE: sale of livestock products, invested, MBB: gross profit margin, fcfa: franc of the African financial community, RE: economic return

4. Discussion

The formulations used in this study differed in the incorporation rates of the vegetable protein sources. Thus, in feed T0 the only plant protein source was soybean meal. In feed T1, a single plant protein source (cashew meal) was also used. This is the substitution of soybean meal for cashew meal. Feeds T2 and T3 used two (2) sources of vegetable protein. Cashew meal and soybean meal were incorporated at 50% (T2) and cashew meal and cotton meal were used at a ratio of 95:5 cashew to cotton (T3). The other raw materials and additives were used in the same way.

The variation in the acquisition costs of protein raw materials can be explained in part by the origin of these materials. For example, the cashew meal used was produced on the farm from the co-products of cashew kernels collected from companies based in Abidjan in Côte d'Ivoire. Soybean meal is imported and purchased commercially. Cottonseed cake is purchased commercially but produced in Côte d'Ivoire. The prices of co-products vary according to their availability and nutritional value. The prices of certain co-products, such as oilcake, are based on the world market and can vary greatly, sometimes unexpectedly, for various reasons (availability of land, harvest forecasts, bad weather, geopolitical factors, etc.). Soybean meal is generally used as a benchmark for nitrogenous co-products.

The low price per kilogram of cashew meal-based feeds can be partly explained by the formulation. This price is lower than the 207.66 F CFA/kg (control diet) and 219.052 F CFA/kg (experimental diet) (Ouattara et *al.,* 2014) of their study on the effects of roasted Vigna unguiculata (cowpea) seeds as a source of protein, in the diet of local laying hens in Burkina Faso, on their zootechnical performance and the economic profitability of the diets. According to Chapoutot et *al.* (2019), when a co-product is available and its feed value and recommendations for use are confirmed, the economic relevance of its introduction in a given feed system should be verified. For example, feed formulations involving a high cashew meal content had a low price per kilogram of feed compared to the control. Cashew meal had to alter the cost of feed production. The low production costs of cashew meal-based feeds in this study can be explained by the low level of feed consumption in these batches on the one hand and the low feed prices per kilogram on the other. Thus, cashew meal allowed for the production of feed at a lower cost (growth, pre-laying and laying).

The sale of livestock products (VPE) in lot T1 was the lowest compared to those of lots T3, T2 and T0. This could be explained by the poor laying performance. In this batch, the number of eggs marketed (2578.5 fcfa) was the lowest compared to the other batches T0 (6420.85 fcfa), T2 (5475.59 fcfa) and T3 (2998.48 fcfa).

The low profitability was recorded with lot T1. This result could be explained by the low profit margin generated by this batch of hens. On the whole, production generated a profit margin. Thus, the production of eggs for consumption with cashew meal-based feeds will allow for a significant economic profitability. These results were superior to those 0.65 (RT), 0.67 (R10), 0.68 (R15) and 0.66 (R20) (Silué et *al.,* 2020) of their study on the zootechnical, economic and physical quality performance of eggs from hens fed diets containing different concentrations of cashew kernel meal (Côte d'Ivoire). Also, these results were above 0.5 for all batches (T0, T1, T2 and T3). The production was profitable according to the theory of Perrin et *al.* (1979). These results ensure sustainability, reinvestment and improvement of production. To survive in a sustainable way, a company must optimise its production factors and derive surpluses and benefits from them. Profitability is the first necessary but not sufficient condition for survival. The concept of profitability seems very simple at first glance: capital generates profit, and therefore the ratio between capital and profit is expressed as a rate of return. It therefore reflects the relationship between the income obtained or expected and the resources used to obtain it. The concept applies to companies but also to any other investment. Profitability then represents the evaluation of the performance of resources invested by investors (FAO, 2005).

5. Conclusion

This study was conducted to evaluate the impact of cashew meal incorporation on the economic profitability of laying hen production (ISA Brown).

The results showed that the price per kilogram of feed, the cost of production and the total investment were impacted by the formulation. The gross profit margin per batch, the sale of livestock products and the economic profitability of the productions were also influenced by the formulation (cashew meal incorporation rate).

The use of cashew meal in feed for laying hens reduced the production cost of feed. The T3 and T2 feeds were the cheapest. Overall, all feeds achieved a profitability ratio above 1.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

All The author declare no conflict of interest.

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