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Influence of the incorporation of cashew meal (*Anacardium occidental*) in feed on the laying performance of hens (ISA Brown) in Côte d'Ivoire

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Abstract

In Côte d'Ivoire, the increase in the price of protein raw materials makes poultry production too costly. This study was carried out to develop new sources of vegetable protein (cashew cake) for feeding laying hens during the laying period. For this, 180 19-week-old ISA Brown hens were used. They were housed in 4 boxes, 45 each. These constituted batches were fed T0 (control), T1 (100% cashew meal as main vegetable protein source), T2 (50% cashew meal) and T3 (95 % cashew meal). Bromatological analysis of the feeds revealed an excellent nutrient content. Feed intake, average number of eggs laid, average cumulative egg weight, feed conversion ratio, and egg laying rate were significantly ($p<5\%$) influenced by the formulation. Cashew meal-based feeds improved egg-laying parameters but not significantly. The food supply for chickens was 93.16 ± 11.35 g / d /chicken (T0), 68.38 ± 13.67 g / d / chicken (T1), 85.67 ± 11.23 g / d / chicken (T2) et 65.88 ± 10.38 g / d / chicken. The number of eggs laid was 29.13 ± 8.77 eggs / d (T0), 11.89 ± 7.03 eggs / d (T1), 24.80 ± 7.85 eggs / d (T2) and 13.51 ± 7.57 eggs / d (T3). The average cumulative egg weight was 1645.86 ± 538.63 g / d (T0), 688.36 ± 445.41 g / d (T1), 1356.83 ± 449.62 g / d (T2) and 776.63 ± 467.51 g / d (T3). The consumption index was 3.84 ± 5.53 (T0), 7.26 ± 11.31 (T1), 4.16 ± 6.19 (T2) and 5.13 ± 8.48 (T3). Laying rate was 64.73 ± 19.51% (T0), 26.42 ± 15.64 % (T1), 55.12 ± 12.46% (T2) and 30.03 ± 16.82% (T3). The incorporation of cashew meal in the feed of laying hens as the main source of protein should allow for a variety of protein raw materials to correct any difficulties encountered by some table egg producers in Côte d'Ivoire.

Keywords: Cashew meal; Egg-laying rate; Feed; Protein; Côte d'Ivoire

1 Introduction

The Ivorian agricultural sector represents 35% of the gross domestic product (GDP) and provides employment for 40% of the population. However, livestock farming is very underdeveloped and represents only 4.5% of agricultural GDP and 2% of overall GDP [1]. To meet the growing needs of the population for animal protein, the Ivory Coast government initiated various animal resource development programmed in the 1960s. For the poultry sector, the first programmed focused on the creation of poultry breeding centers in some of the country's towns (Bingerville, Bouaké, Daloa, etc.) [16]. The Ivorian poultry industry covers 96% of the poultry needs of the Ivorian population [3]. The major constraint is related to the quality and cost of feed [4]. Feed is the main component of poultry farming; it represents 70 to 80% of the production costs of broilers or table eggs and plays a major role in the performance and quality of Bakhs products [5], Larbier & Leclercq. [6], Thiemoko [7] and Diallo [8].

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The satisfaction of food inputs is all the more crucial as the cost of ordinary materials is rising on the international market, in particular maize (the main source of energy and the most important in terms of volume in food), but also other protein raw materials (soya, groundnut, fish meal) which, because of competition between humans and animals, and their diversion to biofuels, pose availability problems [9]. Also in most sub-Saharan countries, conventional sources of protein such as soybean and groundnut meal and fishmeal are indeed scarce and therefore expensive [10].

The protein balance of the feed is expensive, even though it is one of the main determinants of the technical and economic result in poultry production. Cashew meal (dry matter 90.8%, protein 29.5%, fat 21.4%, ash 4.1%, crude cellulose 6.3%) (Kouakou et al. [11], (moisture 6.9%, crude protein 21.5%, fiber 1.1%, lipid 46.1%, ash 3.4%, carbohydrate 27.9%, calcium 0.2%, phosphorus 0.7%) [12], a palliative to produce at lower cost.

The incorporation of cashew meal as the main source of vegetable protein in animal feed, especially in laying hens, requires knowledge of their needs and the limit of incorporation to allow the expression of their genetic potential. One option is to replace soybean meal with cashew meal in the formulation of feed for laying hens and another is to use increasing levels (50% and 95%) of cashew meal in feed. Are these levels of incorporation sufficient for ISA Brown laying hens to express their genetic potential?

The overall objective of this study is to investigate the nutrition of hens with cashew meal-based feeds. It will aim to :

- Determine the physico-chemical parameters of cashew cake-based feeds;
- Evaluate the egg-laying performance of hens fed cashew meal-based feeds.

2 Material and methods

2.1 Presentation of the study area

The tests were carried out in the city of Abidjan, the economic capital of Côte d'Ivoire, located in the south of the country. The city of Abidjan is located between latitudes 4°10 and 5°30 North and longitudes 3°50 and 4°10 West [13]. The study area is subject to a humid equatorial climate with coastal facies [14]. It is characterised by a transitional climate (Attean climate) which is subdivided into four essential seasons in the annual cycle [15].

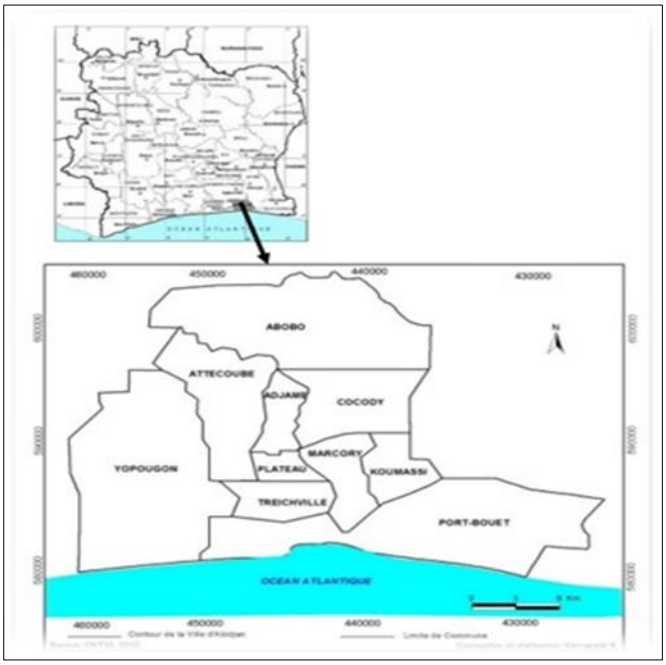

Figure 1 Localization of the study area, city of Abidjan

2.2 Biological material

A total of 180 19-week-old ISA Brown pullets were used. These pullets were previously fed with feed containing 0% cashew meal (T0), 100% cashew meal as the main plant protein source (T1), 50% cashew meal (T2) and 95% cashew

meal (T3) (S7 to S19). The average weight of pullets was 1517.84 g (T0), 1280.49 g (T1), 1481.84 g (T2), 1330.87 g (T3) (Figure 2).

Figure 2 Biological material at S19

2.2.1 Formulation of egg feeds

The raw materials used for the formulation and production of feed are listed in Table 1.

Table 1 Central composition of the feed produced

		Provender		
R W (kg/100Kg feed)	T0	T1	T2	T3
Soybean meal	23	0	11.5	0
Cashew cake	0	23	11.5	21.85
Cottonseed cake	0	0	0	1.15
Fish meal	0.75	0.75	0.75	0.75
Yellow corn	65	65	65	65
Palm oil	1.3	1.3	1.3	1.3
Oyster shell	8	8	8	8
Prémix TNH	1.25	1.25	1.25	1.25
Salt (NaCl)	0.3	0.3	0.3	0.3
Toxo	0.15	0.15	0.15	0.15
Fysal	0.25	0.25	0.25	0.25
Total	100	100	100	100

RW (Raw material), T0 (0 % Cashew cake), T1 (100 % Cashew cake), T2 (50 % Cashew cake), T3 (95 % Cashew cake)

2.3 Methods

2.3.1 Cashew meal production

The cashew meal used in this study was produced on the farm. First, co-products (almond powder and broken kernels) and downgraded kernels (too small, immature, perforated by insects...) were collected from companies involved in the processing of cashew kernels into semi-finished or finished products. The co-products and cashew kernels were sorted and then ground. The powder was heated using a couscous cooker (a device for steaming certain foods). The oil contained in the matrix was extracted using a screwless press machine commonly used in the manufacture of attiéké in Côte D'Ivoire. The cashew cake blocks were crushed by hand and then spread on a clean surface (black tarpaulin) in the sun for 14 hours. The cake produced is then ready to be used.

Figure 3 Cashew meal used for feed production

2.3.2 Feed production

On a clean surface (black tarpaulin), the raw materials were weighed and carefully mixed. The raw materials used in large quantities were weighed and spread out on the tarpaulin. Smaller quantities of raw materials were put together, and a premix was made before they were put together.

2.3.3 Chemical analysis of the feeds

The determination of moisture and dry matter was carried out according to method [16]. This method consists of evaporating the water contained in the cashew cake samples by drying them in a ventilated oven at 105 °C to constant mass. The determination of fat content was done by Soxhlet extraction according to AOAC. 960.39 [17] using hexane as solvent. The protein content of the samples was determined by Kjeldahl according to AOAC method 979.09 [17], which consists of mineralising the protein nitrogen into ammonia and then determining it by acidimetry. The crude cellulose content was determined by the method described by [18]. The residue was filtered through a sintered glass crucible, rinsed thoroughly, dried, weighed, calcined at 500 °C and then reweighed. The difference in weight is the crude cellulose present in the test sample. The ash content was determined according to the AOAC 923.03 method [17], which consists of incinerating 5 g of the sample in an oven at 550°C for 4 hours. The metabolisable energy was calculated by the formula of Sibbald [19]: ME (kcal/kg) = 3951 + 54.4 MG - 88.7 BC - 40.8 CE. The mineral content of the meal was determined after mineralisation of the sample according to the method described by Houba et al [20]. The profile and amount of total amino acids was determined by reverse phase HPLC, using the Pico-Tag system described by Bindlingmeyer et al [21]. Separation, identification and determination of lipo- and water-soluble vitamins were performed by reverse phase HPLC on C18-grafted microsilica. Water-soluble vitamins are directly separated as described by Pellerin et al [22].

2.3.4 Conduct of the laying hens

For this study, 180 19-week-old ISA Brown pullets were used. These pullets were previously fed feed containing 0% cashew meal (T0), 100% cashew meal as the main plant protein source (T1), 50% cashew meal (T2) and 95% cashew meal (T3). The average weight of the pullets was 1517.84 g (T0). The average weight of the T1, T2 and T3 batches was 1280.49 g, 1481.84 g and 1330.87 g respectively.

2.3.5 Prophylaxis

Sanitary prophylaxis

The breeding site was weeded and then disinfected. The wood chopping block was changed and disinfected with a disinfectant (viroset), as well as the wall, the tarpaulins and the net. The rearing equipment (10 litre troughs) is cleaned every morning and evening. The feeders were emptied and cleaned before serving the day's ration. Rodent, reptile, tick, and lice control is carried out. The aim is to reduce the number of outbreaks.

Medical prophylaxis

During the laying period, the medical prophylaxis applied to maintain the laying hens in good health is given in the table. Each treatment is repeated every 2 months (Table 2).

Table 2 Medical prophylaxis during egg laying

Week	Number days	Treatment + Prevention	Dosage
Week 20 - 21	1	Levavet 20 %	1 g / 2 L
	1	Lasota + H120	1000 doses
	5	Tyldox	1 g / 2 L
	5	Vigosine	1 g / 2 L
Week 22	3	Amprol	1 g / L
	5	Amine total	1 g / 5 L
Week 24 - 25	1	Vermectin	1 g / L
	3	Enroxin plus	1 g / 4 L
	1	Clone30	1 g / 5 L
	5	Hépatorein	1 mL / L
Week 26	5	Nacox plus	1 g / 2 L

2.3.6 Feeding plan for the hens

The hens, from the 20th week onwards, were fed with egg-laying feed until the end of the experiments (53rd week). They were served once a day at 3 pm. Leftover feed for each batch was removed and weighed.

2.3.7 Measurement of laying parameters

The hens were weighed at the beginning of the experiment and every weekend. Also, leftover feed, eggs laid in each batch were collected and weighed. At the end of the experiment, the zootechnical parameters for each batch such as mortality rate, average feed consumption, feed conversion ratio, weight variation and laying rate were evaluated [23]. The study of egg quality focused on physical characteristics (average egg weight, shell weight, yolk weight, white weight, colouring and overall egg composition) [24]. The week of laying was observed in all batches.

2.4 Statistical analysis of the data

The results obtained in this study were analysed using SAS software. The mean values per batch from the study criteria were subjected to an analysis of variance (ANOVA), followed by a comparison of means using the Newman-Keuls test at the 5% significance level. Numerical calculations and graph construction were performed using Excel.

3 Results

3.1 Physicochemical composition of the hen feed rations

The moisture content of feed T0 was 11.79 ± 0.31%. The moisture content of feeds T2, T1 and T3 was 11.38 ± 0.14%, 10.93 ± 0.07% and 10.59 ± 0.30% respectively. Statistical analysis revealed no significant difference ($P \geq 0.05$) between T1, T2 and T3. Between provends T0 and T1, T2 and T3, static analysis revealed a significant difference at the 5% level. The best moisture contents were recorded with the cashew meal-based feeds (T1, T2 and T3) (Table 3).

The dry matter of the T0 feed was 88.68 ± 0.32%. Feed dry matter was 89.81 ± 0.19% (T1), 89.53 ± 0.46% (T2) and 89.97 ± 0.03 (T3). Statistical analysis revealed no significant difference between T1, T2 and T3 at the 5% level. Between T0 and T1, T2 and T3, static analysis revealed a significant difference at the 5% level. The best dry matter content was recorded with cashew meal-based feeds (T1, T2 and T3) (Table 3).

The protein content of the feeds recorded was 19.57 ± 0.14% (T0), 19.66 ± 0.08% (T1), 20.09 ± 0.12% (T2) and 19.00 ± 0.86% (T3). Statistical analyses revealed no significant differences ($p < 0.05$) between the protein levels of the different feeds (T0, T1, T2 and T3) (Table 3).

Feed T1 (8.03 ± 0.11%) had the highest ash content. The lowest levels were observed in feed T3 (3.45 ± 0.05%) (Table 3).

The fat content of T1 (9.08 ± 0.07%) and T2 (9.23 ± 0.20%) feed was statistically ($p < 0.05$) higher than that of T0 (7.97 ± 0.08%) and T3 (7.98 ± 0.02%) feed (Table 3).

Feed T2 (5.89 ± 0.28%) and T3 (5.21 ± 0.21%) had the highest crude fibre levels compared to feed T0 (4.89 ± 0.10%) and T1 (4.98 ± 0.08%). Statistical analysis revealed a significant difference between the crude fibre of T2 feed and that of T0, T1 and T3 feed at the 5% significance level.

The resulting metabolizable energy of the feeds (egg-laying) was 3641.72 ± 19.58 Kcal / Kg DM (T0), 3675.15 ± 15.83 Kcal / Kg DM (T1), 3721.77 ± 10.28 Kcal / Kg DM (T2) and 3782.22 ± 17.67 Kcal / Kg DM (T3). Statistical analysis revealed a significant difference at the 5% level according to the Student-Newman-Keuls test (Table 3). The T3 feed is more energetic.

3.2 Food intake

The feed intake per day per hen of the T0 feed group was 93.16 ± 11.35 g / day / hen. The feed intake per day per hen of the T2, T1 and T3 feed lots was 85.67 ± 11.23 g / day / hen; 68.38 ± 13.19 g / day / hen and 65.88 ± 10.03 g / day / hen respectively. Statistical analysis revealed a significant difference ($p \leq 0.05$) between feed consumption of hens fed T0 feed and those fed T2, T1 and T3 feed according to the Student-Newman-Keuls test (Table IV).

3.3 Laying week

The laying week of the hens was week 20 (T0 and T2), week 22 (T1) and week 23 (T3) (Table IV).

3.4 Average number of eggs laid per day

The average number of eggs laid was estimated at 29.13 ± 8.77 (T0). The average number of eggs laid per day was estimated to be 29.13 ± 8.77 (T0). The average number of eggs laid per batch in T2, T3 and T1 was 24.80 ± 7.85, 13.51 ± 7.57 and 11.89 ± 7.03 respectively. Statistically, the number of eggs laid per batch showed a significant difference ($p \leq 0.05$) between the hens fed with feed T0 and those fed with feed T2, T3 and T1 according to the Student-Newman-Keuls Test (Table IV). Hens in batch T1 had the lowest average number of eggs laid.

3.5 Average cumulative egg weight

The average cumulative egg weight each week of the hens fed T0 feed was recorded as 1645.86 ± 538.63 g. For the batches fed with T2, T3 and T1 feed, the cumulative average weekly egg weights collected were 1356.83 ± 449.62 g, 776.63 ± 467.51 g and 688.36 ± 445.41 g respectively. Statistical analysis revealed a significant difference ($p \leq 0.05$) between the average cumulative weight of eggs laid each week by hens fed feed T0 and those fed feed T2, T3 and T1 according to the Student-Newman-Keuls Test (Table IV). The average egg weight of hens fed T3 remained low.

3.6 Feed conversion ratio

The feed conversion ratio of the hens in the T0 feed lot was calculated to be 3.84 ± 5.53. The feed conversion rates for the T1, T3 and T2 feed lots were 7.26 ± 11.31, 5.13 ± 8.48 and 4.16 ± 6.19 respectively. Statistical analysis revealed a significant difference ($p \leq 0.05$) between the feed conversion ratio of hens fed T0 and those fed T1, T3 and T2 according to the Student-Newman-Keuls test (Table 4).

3.7 Laying rate

The average laying rate of the hens fed T0 feed was recorded as 64.73 ± 19.51%. The batches fed with T2, T3 and T1 feed recorded 55.12 ± 17.46%, 30.03 ± 16.82% and 26.42 ± 15.64% respectively. Statistical analysis revealed a significant difference ($p \leq 0.05$) between the average laying rate of hens fed T0 feed and those fed T2, T3 and T1 feed according to the Student-Newman-Keuls test (Table IV).

3.8 Downgraded egg rates

As for the downgraded egg rate, the highest rate was recorded with the T1 feed (6.18%). With the other feeds with low cashew meal content, the downgraded egg rate calculated with T0 (4.58%), T2 (4.42%) and T3 (3.94%) are more or less equal.

3.9 Mortality rate

The mortality rate of the hens in the feedlot T0 was 8.88%. The mortality rate of the hens in batches T3, T1 and T2 was 4.44, 6.66 and 11.11% respectively. Table 4.

Table 3 Physicochemical composition of chicken feed

	Provenders					
Parameters	**T0**	**T1**	**T2**	**T3**	**F**	**Pr >F**
Moisture (%)	11.32 ± 0.32^{a}	10.19 ± 0.19^{b}	10.46 ± 0.46^{b}	10.30 ± 0.03^{b}	11.14	0.0031
Dry matter (%)	88.68 ± 0.32^{b}	89.81 ± 0.19^{a}	89.53 ± 0.46^{a}	89.97 ± 0.03^{a}	11.14	0.0031
Protein(%)	19.57 ± 0.14^{a}	19.66 ± 0.08^{a}	20.09 ± 0.12^{a}	19.00 ± 0.86^{a}	3.04	0.0924
Ash (%)	7.56 ± 0.14^{b}	8.03 ± 0.11^{a}	5.12 ± 0.09^{c}	3.45 ± 0.05^{d}	1265.41	<0.0001
Fat (%)	7.97 ± 0.08^{b}	9.08 ± 0.07^{a}	9.23 ± 0.20^{a}	7.98 ± 0.02^{b}	108.60	<0.0001
Raw fibre (%)	4.89 ± 0.10^{b}	4.98 ± 0.08^{b}	5.89 ± 0.28^{a}	5.21 ± 0.21^{b}	17.29	0.0007
EM (Kcal/kg D M)	3641.72 ± 19.58^{d}	3675.15 ± 15.83^{c}	3721.77 ± 10.28^{b}	3782.22 ± 17.67^{a}	42.33	<0.0001

(a, b, c values with different letters on the same line are significantly different), T0 (0 % Cashew cake), T1 (100 % Cashew cake), T2 (50 % Cashew cake), T3 (95 % Cashew cake), EM (metabolizable energy), DM (Dry matter)

Table 4 Laying performance

	Provenders			
Laying performance	**T0**	**T1**	**T2**	**T3**
F I (g / D / chicken)	93.16 ± 11.35^{a}	68.38 ± 13.19^{c}	85.67 ± 11.23^{b}	65.88 ± 10.03^{d}
Laying week (W)	20	22	20	23
A nubr of eggs laid / D	29.13 ± 8.77^{a}	11.89 ± 7.03^{d}	24.80 ± 7.85^{b}	13.51 ± 7.57^{c}
A Cu egg weight (g)	1645.86 ± 538.63^{a}	688.36 ± 445.41^{d}	1356.83 ± 449.62^{b}	776.63 ± 467.51^{c}
Feed conservation ratio	3.84 ± 5.53^{c}	7.26 ± 11.31^{a}	4.16 ± 6.19^{b}	5.13 ± 8.48^{b}
Laying rate (%)	64.73 ± 19.51^{a}	26.42 ± 15.64^{d}	55.12 ± 17.46^{b}	30.03 ± 16.82^{c}
% doun egg rates	4.58	6.18	4.42	3.94
Mortality rate (%)	8.88	6.66	11.11	4.44

(a, b, c values with different letters on the same line are significantly different), T0 (0 % Cashew cake), T1 (100 % Cashew cake), T2 (50 % Cashew cake), T3 (95 % Cashew cake), FI (food intake), D (days), W (week), A nubr (average number), A Cu egg (average cumulative), doun (downgraded)

4 Discussion

4.1 Physicochemical composition of the feeds

The results of physicochemical analyses showed variability in the bromatological parameters (moisture, dry matter, ash, fat, crude fibre and metabolizable energy) of the different feeds.

The determination of feed moisture is important as it limits the shelf life of the feed. In T0, T1, T2 and T3 feeds, the feed moisture is lower than the O.C.C. standard [25]. According to this standard, the moisture content should not exceed 14% and the dry matter 86%. This state of dryness is favourable for the preservation of feed, since in dehydrated or heavily dried products, the water activity reaches sufficiently low values to prohibit the development of a high proportion of micro-organisms [26].

The ash represents all the minerals contained in the feed. T0 and T1 feeds give high values compared to T2 and T3 feeds. At the same time, the results of the experiments are lower than the 12.42% Raharinirina [27], of the feed distributed during his experiment on protein feeding and performance of the ISA BROWN strain of laying hens, aged 21 to 50 weeks. However, these low ash values reflect low levels of mineral elements (macro and micro mineral elements). Mineral supplementation during this physiological phase to allow the hens to express their genetic potential would be welcome.

As far as fats or oils are concerned, the dosage is very important as too rich a feed would increase the energy, giving the advantage of being very energetic but having the disadvantage of being subject to the risk of rancidity in case of prolonged storage. Overall, the fat content of the feed is higher than that obtained by some authors 1.96% Nesseim [28] in the egg-laying feed of farm E3, 6.09 (TS1), 6.04% (TS2), 7.25% (TS3) and 6.93% (TS4) Manasse [29] and 3 - 6% at laying [30]. These high levels are thought to be due to the cashew kernel oil extraction technique. As the extraction technique is artisanal, the tightness is subject to the appreciation of the producer, hence the high fat content of the feed. However, the T1 and T2 feedstuffs had very high fat contents. This may on the one hand limit the conservation due to the rancidity of the oil. On the other hand, it will increase the abdominal fat which may reduce the feed intake of the hens. This will result in reduced performance during the laying phase.

The estimation of the metabolizable energy from the results of the analyses gives values all higher than the 2700 Kcal / Kg of ISA feed [31] recommended in laying. However, these results are comparable to those of 3619.28 and 3705.15 Kcal / Kg DM [29]. The high levels of metabolizable energy in feed are thought to be due to a manufacturing defect. Indeed, dietary energy is mainly derived from carbohydrates, but also from fats and proteins:and Alders [32]. However, high levels are recorded with T2 and T3 feeds.

4.2 Laying performance of the hens

Laying lasted from week 20 to week 53. During this phase, the hens were fed a laying feed. The laying start is the week in which the first egg is collected in each batch. It varied from batch to batch and from formulation to formulation. Thus, batches T0 and T2 were the first to enter laying (20th week). Batches T1 and T3 entered oviposition in week 22 and 23 respectively. This variation in the weeks of entry into egg laying is believed to be a consequence of the lack of control of several key points during the previous physiological phases (growth and pre-laying) of rearing. The growth and pre-laying feeds distributed were too rich in metabolizable energy, which led to a decrease in feed intake in the batches. As a direct consequence, growth performance (feed intake, body weight, average daily gain, feed conversion ratio, etc.) decreased.

Feed consumption was influenced by formulation. Feed T0 and T2 were consumed more than feed T1 and T3. These consumption levels for the most part are lower than 88.5 (Cα), 89.0 g / d / hen (Lα), 89.8 g / d / hen (LTPα) and 89.8 g / d/ hen (LFα) g / d/ hen Omri Nat [33] from his study impact of fenugreek on laying performance, physico-chemical and dietary quality, stability of polyunsaturated fatty acids enriched lipids and yolk coloration of the hen egg. Feed consumption varies according to many factors related to the animal (age, weight, sex, production, etc.), the feed (energy level, physical characteristics) and finally the climate conditions [34]. These low consumption levels can be partly explained by the manufacturing technique (energy level) of the feed. The results corroborate those of some authors Balnave and Bracke. [35] and Vigne et al [36], who argue that the main dietary factor affecting food intake is the concentration of energy in the food. An increase in dietary energy leads to a decrease in consumption Chancy [37] and Tougan et al [38]. Indeed, the incorporation of cashew meal at levels above 50% improves energy. As the hens' requirements are low, the use of other raw materials with low energy values should allow the correction of the hens' intake. In batches T1 and T3, the low intake could be attributed to the physical characteristics of the feed. The colouring and palatability of the cashew meal developed sorting in the hens of these batches.

The egg count is important because it allows us to assess the visual quality of the eggs in addition to calculating the egg laying rate. Thus, the average number of eggs collected 29.13 ± 8.77 (T0) is higher than those 24.80 ± 7.8 (T2), 13.51 ± 7.57 (T3) and 11.89 ± 7.03 (T1). Overall, the average number of eggs laid by the hens in each batch per day is low. This could be explained by the fact that feed was under-consumed in the flocks. Egg size, egg quality and laying intensity are strongly influenced by the diet received by the laying hen [39]. Decreasing or even breaking the diet decreases the number of eggs obtained [40]. However, high levels of cashew meal incorporation (over 95%) would be depreciating due to a considerable decrease in the number of eggs laid.

The laying rate of the hens was calculated from the number of eggs collected each day and the number of hens started. The T0 batch shows 64.73 ± 19.51%. This is higher than 55.12 ± 17.46%, 30.03 ± 16.82% (T3) and 26.42 ± 15.64% (T1). These results are lower than those of some authors Silué *et al*. [41], with diets containing 0; 10; 15 and 20% cashew kernel meal, obtained 79.59, 72.49, 73.03 and 65.09% of laying rate during their experiments on the zootechnical

performance, economic and physical quality of eggs of hens subjected to diets providing different concentrations of cashew kernel meal (Ivory Coast). Tossou et *al*. [42] obtained 74.9% (battery cages) and 68.80% (floor on litter) of their studies on the influence of the housing system on some zootechnical and economic performances of laying hens in South Benin. Omri Nat [43], this author recorded 92.52 (Cα), 84.52 (FCα), 88.09 (FAα) 91.53 (FPGα) during these experiments on the impact of fenugreek on laying performance, physico-chemical and dietary quality, stability of polyunsaturated fatty acids enriched lipids and yolk coloration of the hen egg. The low egg-laying rate could be explained by the fact that the hens are generally underfed. The productivity of hens is often conditioned by the feed. Indeed, several authors, Larbier and Le Turdu [44], state that the diet of both breeding and laying hens plays an important role in their zootechnical performance. Our results corroborate the thesis that the productivity of hens is often conditioned by the feed. However, the laying rate was influenced by the formulation. High levels of incorporation (above 50%) would be inadvisable in egg production to ensure acceptable productivity.

Regarding the average cumulative egg weight, it is important to calculate it as it is used in the calculation of the average egg weight and the consumption index. Thus, the cumulative average egg weight 1645.86 ± 538.63 g (T0) is higher than 1356.83 ± 449.62 g (T2), 776.63 ± 467.51 g (T3) and 688.36 ± 445.41 g (T1). This variation in the average cumulative weights could be explained by the variation in the number of eggs per batch and the under-consumption of feed. The egg depends mainly on factors related to the hen (genetic origin and especially age) but also on her diet during the laying period. The pullet's diet contributes indirectly by influencing its sexual maturity, live weight, and body composition at the start of production [45].

Feed efficiency is mainly assessed by the feed conversion ratio (FCR). In broilers, this is the amount of feed required to produce 1 kg of live weight; in layers, the amount of feed required to produce 1 kg of eggs (or 1 egg). These indices are good indicators of a balanced diet in terms of all the nutrients necessary for the health and development of the birds. In this experiment, the hens receiving T0 feed showed 3.84 ± 5.53 better than 4.16 ± 6.19 (T2) better than 5.13 ± 8.48 (T3) and 7.26 ± 11.31 (T3). The poor consumption indices are obtained with T1 and T3. As for provends T0 and T2, similar values to those of Silué *et al*. [24] with the experimental diets RT (3.23±0.37), R10 (3.53±0.33), R15 (3.62±0.24) and R20 (4.02±0.20) were observed. It is important to note that a low feed conversion ratio is desired in poultry farming [46].

In terms of downgraded egg rates, batch T1 had the highest rate. Downgraded eggs are not necessarily related to the feed, but abnormalities from various sources can downgrade the egg (white shell colouring of red-shelled eggs, too much blood stain, cracking, fouling due to waste, too small a size, too large a size...).

During the laying period, the calculated mortality rate of the hens in the batch fed with feed T0 was 8.88%. The mortality rates of the hens in batches T3, T1 and T2 were 4.44, 6.66 and 11.11% respectively. These results are mostly higher than the 6.60% achieved by Raharinirina [37] during his experiments and the 6.80% achieved by Leclercq and *al.* [47] with Leghorn-type layers during the period from 21 to 70 weeks. The low mortality rate was recorded with the T3 batch. The duration of the experiments is one of the factors affecting the mortality rate. Since the raw materials are used in animal feed, especially for laying hens in Côte d'Ivoire, they would not contain lethal substances. As for cashew meal, similar studies conducted by Silué *et al*. [24] showed that cashew kernel meal does not contain anti-nutritional factors lethal to poultry.

5 Conclusion

The objective of this study was to evaluate the egg-laying performance of hens fed cashew meal-based feeds.

The results showed that feed intake, average number of eggs laid, average egg weight, feed conversion ratio and laying rate were significantly ($p < 0.05$) influenced by the formulation. Cashew meal-based feeds improved the laying parameters but not significantly. The feed intake of the hens was 93.16 ± 11.35 g/ d/hen (T0), 68.38 ± 13.67 g/ d/hen (T1), 85.67 ± 11.23 g/ d/hen (T2) and 65.88 ± 10.38 g/ d/hen. The number of eggs laid was 29.13 ± 8.77 eggs / d (T0), 11.89 ± 7.03 eggs / d (T1), 24.80 ± 7.85 eggs / d (T2) and 13.51 ± 7.57 eggs / d (T3). The average cumulative egg weight was 1645.86 ± 538.63 g/d (T0), 688.36 ± 445.41 g/d (T1), 1356.83 ± 449.62 g/d (T2) and 776.63 ± 467.51 g/d (T3). The feed conversion ratio was 3.84 ± 5.53 (T0), 7.26 ± 11.31 (T1), 4.16 ± 6.19 (T2) and 5.13 ± 8.48 (T3). The egg-laying rate was 64.73 ± 19.51% (T0), 26.42 ± 15.64% (T1), 55.12 ± 12.46% (T2) and 30.03 ± 16.82% (T3).

The incorporation of cashew meal in the feed of laying hens as the main source of protein should allow for a variety of protein raw materials to correct any difficulties encountered by some table egg producers in Côte d'Ivoire.

Compliance with ethical standards

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Disclosure of conflict of interest

All The author declare no conflict of interest

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