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Effects of partially replacing protein and fiber sources with cashew nut cake and cashew apple bagasse on the production performance of meat quails (*Coturnix japonica* Temminck & Schlegel, 1849)

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ABSTRACT

This study assessed the effect of partially replacing soya meal and wheat bran with Cashew by-product on carcass characteristics, egg production and the physical quality of eggs in meat quails. 270 quails were divided into three treatment groups according to a completely randomized design, each with three replicates. The control treatment was fed commercial poultry feed. The other two treatment groups (T25 and T50) were fed diets containing 25% and 50% cashew nut cake and cashew apple bagasse, respectively, as substitutes for soya bean meal and wheat bran. The growth phase lasted 6 weeks, whilst the laying phase lasted 12 weeks. Carcass yield was influenced by the diet ($P = 0.013$), with the highest proportions observed in the control (71.10 ± 0.79%) and T25 (70.78 ± 0.84%). The breast, thigh and back meat in quails of both sexes were also influenced ($P < 0.05$) by the diet, with the highest proportion found in the control (46.77 ± 0.54%). The diet had no effect on the age at first egg laying ($P = 0.698$) or on the laying rate. Egg weight did not differ ($P = 0.705$). The shape index was significantly ($P = 0.006$) higher in the T25 group (78.5 ± 4.39%). The shell index ($P = 0.398$) and the yolk index ($P = 0.086$) were not affected by the diet. The Haugh unit varied significantly ($P = 0.009$), with the highest values (85.21 ± 4.64) observed in the T25 group. The T25 diet could represent an interesting alternative.

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INTRODUCTION

The growing global demand for sustainable and nutritionally rich food sources highlights the importance of exploring alternatives to conventional livestock farming (Białek *et al.*, 2026). The quail is a short-cycle animal offering numerous benefits in terms of both its meat and its eggs. Indeed, quail meat has a superior lipid composition, characterized by a lower content of saturated fatty acids (less than 3.17 g/100 g of total fatty acids) and a higher content of polyunsaturated fatty acids (more than 5.5 g/100 g of total fatty acids) (Quaresma *et al.*, 2022). Furthermore, quail eggs are rich in protein, essential amino acids, vitamins, minerals and bioactive compounds (Sonji and Sonji, 2025). These characteristics are fueling growing interest in quail farming.

However, their production performance is linked to the quality and balance of their feed ration (Ashour *et al.*, 2022). Consequently, one of the main challenges in successful quail farming is feed, which can account for up to 70% of production costs (Mnisi *et al.*, 2021). Furthermore, Côte d'Ivoire remains dependent on imports of soya for animal feed and of wheat, the bran of which is also used in animal feed (Raffin, 2025). Added to this is the VAT levied since January 2026 on certain inputs for poultry, which were previously exempt from tax (DGI, 2026). All these constraints result in increased production costs in the farming sector. The search for locally available, low-cost raw materials therefore remains essential.

Cashew by-products could offer an alternative to conventional raw materials. Indeed, Côte d'Ivoire is the world's leading producer of raw cashew nuts, with 1.5 million tons expected in 2025 (Government of Côte d'Ivoire, 2026). Furthermore, the rate of local cashew nut processing has risen from 2% in 2011 to around 43% in 2025 (Government of Côte d'Ivoire, 2026), providing a growing quantity of graded-out nuts that can be used in animal feed. Apples, on the other hand, have so far been used to a lesser extent, with the majority remaining in the orchards after the nuts have been harvested. However, these by-products possess chemical properties that are of interest for animal feed.

Cashew apple bagasse is rich in fiber (up to 14 per cent) and protein (up to 19%) (Ojediran *et al.*, 2024; Barroso *et al.*, 2025; Coffi, 2025), whilst cashew nut cake has protein contents of up to 40% (Fofana *et al.*, 2023; Ojediran *et al.*, 2024; Coffi, 2025). Several authors have reported the benefits of these by-products in the diets of chickens (Fofana *et al.*, 2023; Coffi, 2025) and quails (Dembélé *et al.*, 2025; Amani *et al.*, 2026). However, to the best of our knowledge, no study has been conducted on the effect of the interaction between these two by-products in the diet of broiler quails on certain production parameters. This study therefore aims to evaluate the effect of partially replacing protein and fiber sources with cashew nut cake and cashew apple bagasse on carcass yield, laying rate and the physical quality of eggs from meat quails (*Coturnix japonica*). We hypothesis that the partial replacement of wheat bran and soya meal with cashew apple bagasse and cashew nut cake will yield results similar to those of the commercial feed used by farmers.

MATERIALS AND METHODS

Study site

The farm building, which was used for livestock rearing, is situated within the Peleforo GON COULIBALY University and served as the Korhogo livestock rearing facility. It is rectangular in shape, measuring 14 m in length and 8 m in width. It is enclosed by low walls 0.5 m high, topped with wire mesh to allow for good air circulation. The temperature inside the farm building ranges between 25 and 28°C.

Biological material

The plant-based biological material consisted of cashew apple bagasse and defatted cashew nut cake. The animal-based material consisted of one-day-old meat-type quails with an average weight of 11.02 ± 1.37 g.

Conduct of the test

Three diets were formulated, namely the control diet, the T25 diet and the T50 diet. The control diet

was a commercial feed intended for broiler chickens and used by quail farmers. The T25 diet comprised 25% cashew nut cake and 25% cashew apple bagasse, replacing soya bean meal and wheat bran. The final diet, T50, consisted of 50% of each of these cashew by-products. The centesimal and chemical compositions of the diets are set out in Tables 1 and 2 respectively. A total of 270 birds were randomly divided into three groups of 30 birds, each with three replicates. Each group was randomly assigned a diet. Starter, growth and laying feeds were provided to the birds during the starter, growth and laying phases respectively. The chicks were heated using 240-watt bulbs during the starter phase. The quails were housed at a density of 30 per m². The start-up and growth phases lasted 6 weeks, whilst the laying phase lasted 12 weeks. Feed and water were provided ad libitum twice a day. Feeders and drinkers were cleaned daily, and access to the rearing building was strictly restricted to prevent disease. In addition, the litter was replaced every five days.

Table 1. Percentage composition of processed foods

Inputs (%)	Starter phase		Growth phase		Laying phase	
	T25	T50	T25	T50	T25	T50
Corn	60	60	65	65	55	55
Soya meal	25.875	17.25	18.75	12.5	22.5	15
Cashew nut cake	8.625	17.25	6.25	12.5	7.5	15
Cashew apple bagasse	0	0	1	2	3	2
Wheat bran	0	0	3	2	1	2
Shell flour	0.98	0.98	1	1	6	6
Sal	0.52	0.52	1	1	1	1
Mineral and vit. supplement	4	4	4	4	4	4
Total	100	100	100	100	100	100

Table 2. Chemical composition of diets

Parameters	Starter phase			Growth phase			Laying phase		
	Control diet	T25	T50	Control diet	T25	T50	Control diet	T25	T50
Crude protein (%)	20.50	20.51	19.35	19.00	17.51	16.63	16.00	18.77	17.73
Crude fat (%)	3.50	3.88	4.93	4.50	3.75	4.53	4.00	3.64	4.57
Crude fiber (%)	4.30	3.33	3.24	3.90	3.25	3.21	3.00	3.36	3.31
Metabolisable energy (Kcal/kg)	2,941.43	2,959.438	3,047.38	3,050.57	2,921.44	2,995.17	2,916	2,765.17	2,851.6

T25: Treatment with 25% apple bagasse and cashew nut cake. T50: Treatment with 50% apple bagasse and cashew nut cake.

Data collection

Characteristics of the carcass

At the end of the growth phase, 12 quails were selected at random from each diet group (6 males and 6 females). They were first weighed individually after an 8-hour fast and then slaughtered in accordance with Article 157 of Law No. 2020-995 on the Veterinary Public Health Code of Côte d'Ivoire. After 5 minutes of rigor mortis, the quails were plucked using hot water, eviscerated and had their legs and heads removed. The carcass, with the legs and head removed, was weighed and identified according to the diet. The carcass yield and the proportions of certain parts relative to the carcass (thigh, back, breastbone and gizzard) were also calculated using the following formula:

$$Carcass\ yield = 100 \times \frac{Carcass\ weight}{Live\ weight}$$

$$Proportion\ of\ a = 100 \times \frac{Weight\ of\ a}{Carcass\ weight}$$

With a = the relevant part (thigh, back, breastbone or gizzard)

Egg-laying parameters

The age at first egg-laying was recorded. This corresponds to the age at which the first egg appeared

in the batch. The egg-laying rate (LR) was calculated for each treatment using the following formula:

$$LR = 100 \times \frac{Number\ of\ eggs\ laid}{Number\ of\ females}$$

Physical quality of eggs

Thirty eggs are selected at random each week for each diet in this study. The eggs are weighed and their length and width measured. They are then cracked open and their contents emptied into a Petri dish. The shells, which had been washed and dried at room temperature, were weighed.

These data were used to calculate the average weight of the eggs, the average length and width of the shell, the shape index (SI) and the shell index (SIq) using the following formulae:

$$SI = \frac{\text{Diameter of the egg}}{\text{Length of the egg}} \times 100$$

$$SI = \frac{\text{Weight of the eggshell}}{\text{Weight of the egg}} \times 100$$

Subsequently, the length and thickness of the albumen were measured, followed by those of the vitellus after it had been separated from the albumen using a teaspoon (N'Guessan 2020). The data collected were used to calculate the Haugh unit (HU) and the yolk index (YI) using the following formulae:

$HU = 100 \times \text{Log}\,(h + 7.57 - 1.7 \times W^{0.37})$ (Berto *et al.*, 2007)

With h: albumen height (mm); W: egg weight (g); 7.57: correction factor for albumen height; 1.7: correction factor for egg weight.

$$YI = \frac{\text{Thickness of the vitellus}}{\text{Diameter of the yolk}} \times 100\ (\text{Haugh}, 1937)$$

Statistical analyses

The data collected were analyzed statistically using XLSTAT software, version 2014.5.03. The conditions for applying parametric tests were first checked using the Shapiro-Wilk normality test and Levene's test for homogeneity of variances. Means were compared using a one-way analysis of variance (one-way ANOVA) at a significance level of 5 per cent.

RESULTS

Effect of diet on carcass characteristics

Yields ranged from 69.99 ± 0.78 per cent (T50 %) to 71.18 ± 0.81 per cent (Control), with an intermediate value of 70.31 ± 1.08% for animals on the T25 diet (Table 3). No significant difference was observed in the carcass yields of females (P = 0.291). However, the carcass yield of males in the T25 group (71.28 ± 0.78 per cent) was higher than that of the other diets, although the difference was not significant. Across both sexes, this yield was highest in animals from the control group, followed by those from the T25 group. The proportions of breast meat were comparable (P = 0.081) in females regardless of diet. In contrast, in males, the proportion of brisket in the control group (46.35 ± 0.62 per cent) was significantly higher (P = 0.017) than that in the T50 (45.88 ± 0.41 per cent) and T25 (42.90 ± 0.47 per cent) groups. In the mixed cohort, only the control group showed a significantly higher proportion of rib fractures (P = 0.003).

With regard to the thighs, there was no significant difference (P = 0.515) amongst the females. In the male group, the proportion of thighs was significantly higher (P = 0.021) in the animals from the T50 group (23.79 ± 0.20 per cent). Across all sexes, the proportion of thighs in the T50 group (23.72 ± 0.24%) was statistically higher (P = 0.033) than in the other groups. With regard to the back, no significant difference (P = 0.201) was observed in the female group.

In the male group, the control and T25 groups recorded significantly higher proportions (P = 0.013) than the T50 group. As for the mixed group, the control and T25 groups recorded proportions (15.58 ± 0.23% for the control and 17.24 ± 0.26% for T25) of back meat that were significantly (P = 0.002) higher than that of the control group (14.46 ± 0.21%). With regard to gizzard proportions, there were no significant differences among females (P = 0.076), males (P = 0.127) or in the mixed batch (P = 0.0906).

Table 3. Effect of diets on carcass yield and edible cuts in broiler quails

Parameters	Sex	Control diet	T25	T50	P-Value
Carcass Yield (%)	Femal	71.18 ± 0.81^{a}	70.31 ± 1.08^{a}	69.99 ± 0.78^{a}	0.2909
	Male	71.00 ± 0.77^{a}	71.28 ± 0.78^{ab}	69.22 ± 0.83^{b}	0.0257
	Mixed-sex	71.10 ± 0.79^{a}	70.78 ± 0.84^{ab}	69.63 ± 0.79^{b}	0.0129
Break (%)	Femal	47.18 ± 0.45^{a}	45.88 ± 0.44^{a}	45.25 ± 0.44^{a}	0.0839
	Male	46.35 ± 0.62^{a}	42.90 ± 0.47^{ab}	45.88 ± 0.41^{b}	0.017
	Mixed-sex	46.77 ± 0.54^{a}	44.45 ± 0.51^{b}	45.54 ± 0.42^{b}	0.003
Thigh (%)	Femal	23.00 ± 0.25^{a}	23.66 ± 0.17^{a}	23.65 ± 0.28^{a}	0.5154
	Male	23.33 ± 0.17^{a}	23.12 ± 0.23^{ab}	23.79 ± 0.20^{b}	0.0208
	Mixed-sex	23.15 ± 0.21^{a}	23.40 ± 0.22^{ab}	23.72 ± 0.24^{b}	0.0332
Back (%)	Femal	15.39 ± 0.28^{a}	16.49 ± 0.22^{a}	14.70 ± 0.20^{a}	0.2011
	Male	15.78 ± 0.18^{a}	18.05 ± 0.32^{a}	14.18 ± 0.30^{b}	0.0127
	Mixed-sex	15.58 ± 0.23^{a}	17.24 ± 0.26^{a}	14.46 ± 0.21^{b}	0.0022

The values assigned to different letters within the same row are statistically different ($P < 0.05$). T25: Treatment with 25% apple bagasse and cashew nut cake. T50: Treatment with 50% apple bagasse and cashew nut cake.

Table 4. Effect of diets on the age in days at first egg laying in meat quails

Control diet	T25	T50	P-value
68.33 ± 2.12^{a}	72.33 ± 11.02^{a}	74.00 ± 2.65^{a}	0.698

The values assigned to different letters within the same row are statistically different ($P < 0.05$). T25: Treatment with 25% apple bagasse and cashew nut cake. T50: Treatment with 50% apple bagasse and cashew nut cake.

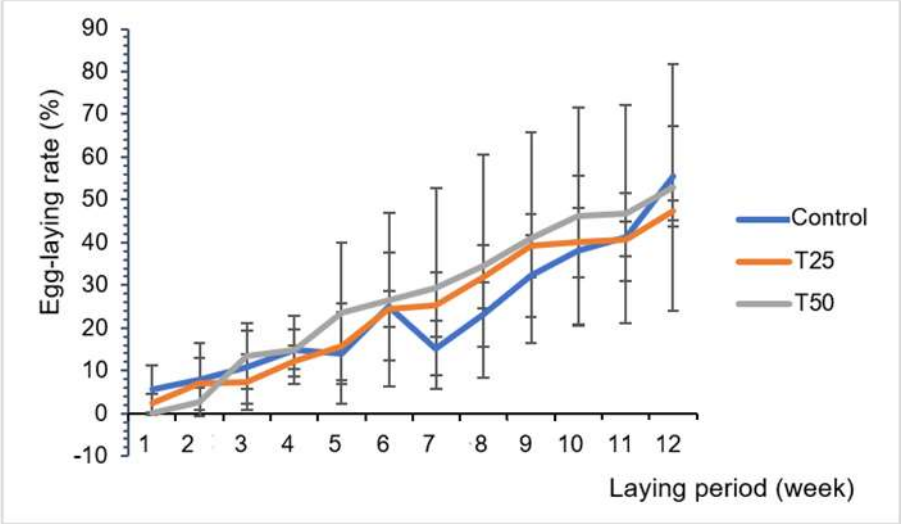


Fig. 1. Effect of diets on the egg-laying rate of meat quails

T25: Treatment with 25% apple bagasse and cashew nut cake. T50: Treatment with 50% apple bagasse and cashew nut cake.

Effect of diet on the age at first egg-laying and the egg-laying rate

The age at first egg laying for each diet is shown in Table 4. Analysis of the table indicates that the quails in the control group laid their first egg at 68.33 ± 2.12 days of age, whilst those in the T25 group laid their first egg four days (72.33 ± 11.02 days) later. As for the quails in the T50 group, they laid their first egg at 74.00 ± 2.65 days of age. Despite the differences observed, the statistical analysis revealed no significant difference in Tukey's HSD test ($P = 0.698$).

Fig. 1 illustrates the trend in the laying rate within each batch of quails. Generally speaking, a regular and increasing laying rate was observed over time in all three batches. Thus, in the first week of laying, these rates – which stood at 5.48 ± 5.88 per cent (Control), 2.42 ± 2.23 per cent (T25) and 0 per cent

(T50) – rose to 25.11 ± 12.61 per cent, 24.42 ± 4.29 per cent and 26.61 ± 20.28 per cent respectively by the sixth week of egg-laying. By the twelfth week of laying, these figures reached 55.50 ± 11.84 per cent, 47.49 ± 2.24 per cent and 52.96 ± 28.86 per cent respectively in the control, T25 and T50 groups. However, a drop in egg production was observed in the control group by the seventh week of laying, reaching 15.29 per cent. Statistical analysis using Tukey's HSD test revealed no significant differences ($P > 0.05$) in egg production rates between the different diets throughout the experiment.

Table 5. Effect of diet on the external physical quality of eggs from meat quails

External parameters	Control diet	T25	T50	P-value
Weight (g)	11.64 ± 0.96^{a}	11.56 ± 1.03^{a}	11.70 ± 1.37^{a}	0.705
Length (mm)	29.87 ± 4.67^{a}	30.54 ± 3.74^{a}	30.72 ± 4.55^{a}	0.349
Width (mm)	22.96 ± 4.62^{a}	24.08 ± 3.72^{a}	23.84 ± 4.41^{a}	0.148
Shape index (%)	76.25 ± 5.28^{a}	78.5 ± 4.39^{ab}	77.09 ± 4.89^{b}	0.006
Shell index (%)	16.86 ± 4.76^{a}	15.99 ± 4.67^{a}	16.14 ± 5.24^{a}	0.398

The values assigned to different letters within the same row are statistically different ($P < 0.05$). T25: Treatment with 25% apple bagasse and cashew nut cake. T50: Treatment with 50% apple bagasse and cashew nut cake.

Table 6. Effect of diet on the internal physical quality of eggs from meat quails

Internal physical parameters	Control diet	T25	T50	P-value
Albumen length (mm)	42.23 ± 4.93^{a}	43.47 ± 4.68^{ab}	40.78 ± 6.39^{b}	0.007
Albumen thickness (mm)	3.49 ± 0.66^{a}	3.64 ± 0.63^{ab}	3.80 ± 0.80^{b}	0.011
Yolk length (mm)	25.51 ± 4.99^{a}	26.59 ± 4.68^{a}	25.05 ± 4.75^{a}	0.100
Yolk thickness (mm)	6.05 ± 2.05^{a}	5.59 ± 2.36^{a}	5.84 ± 2.53^{a}	0.355
Yolk index (%)	25.06 ± 10.88^{a}	21.68 ± 10.68^{a}	24.72 ± 12.72^{a}	0.086
Haugh unit	83.4 ± 4.12^{a}	84.47 ± 3.55^{ab}	85.21 ± 4.64^{b}	0.009

The values assigned to different letters within the same row are statistically different ($P < 0.05$). T25: Treatment with 25% apple bagasse and cashew nut cake. T50: Treatment with 50% apple bagasse and cashew nut cake.

Effect of diet on the external physical quality of eggs from meat quails

The parameters relating to the external physical quality of quail eggs in this study are set out in table 5. Egg weights did not vary significantly ($P = 0.705$) between diets. These ranged from 11.56 ± 1.03 g to 11.64 ± 0.96 g. The same was observed for shell length ($P = 0.349$) and width ($P = 0.148$), as well as for the shell index. Thus, shell lengths ranged from 29.87 ± 4.67 mm to 30.72 ± 4.55 mm, whilst shell widths ranged from 22.96 ± 4.62 mm to 24.08 ± 3.72 mm. For the shape index, the eggs from batches T25 and T50 had significantly higher values (78.5 ± 4.39% for T25 and 78.5 ± 4.39 for T50) than the quail eggs from the control batch (76.25 ± 5.28%) in Tukey's HSD test ($P = 0.006$).

Effect of diet on the internal physical quality of eggs from meat quails

Table 6 presents the calculated internal physical quality parameters of the eggs. The length of the egg albumen differed statistically ($P = 0.007$) between the different diets. The highest value (43.47 ± 4.68 mm) was observed in eggs from batch T25, whilst the lowest value (40.78 ± 6.39 mm) was observed in batch T50. The egg white of the T50 group was thicker (3.80 ± 0.80 mm) than that of the control group (3.49 ± 0.66) ($P = 0.011$). However, the egg white thickness (3.64 ± 0.63 mm) in the T25 group was similar to that of the other two groups. As regards the lengths and thicknesses of the yolks in the T25 and T50 groups, these were similar to those of the control group. The vitellus index was lowest in the eggs from the T25 group (21.68 ± 10.68 per cent), followed by those from the T50 group (24.72 ± 12.72 per cent) and the control group (25.06 ± 10.88 per cent); however, no significant differences were observed in Tukey's HSD test ($P = 0.086$). The Haugh unit value correlated with the level of incorporation of cashew apple bagasse and cashew nut cake. It increased from 83.4 ± 4.12 in the control group to 85.21 ± 4.64 in the T50 group. The Haugh unit

recorded in the control group differed (P = 0.009) from that of the T50 group. However, that of the T25 group (84.47 ± 3.55) did not differ from that of the aforementioned groups.

DISCUSSION

In Japanese quail, carcass yield generally ranges between 69 and 80% (Abeer *et al.*, 2023). The values observed in this study therefore fall within the range reported by the aforementioned study. Our results are similar to those obtained by Alkan *et al.* (2010), who reported carcass yields of between 61 and 72% with quails from different lines. Piroz-Maleki *et al.* (2026) reported that increasing dietary methionine to 1.3% during the grower phase improved carcass and breast yields in male Japanese quail..

With regard to the proportion of breast meat, no significant differences were observed among females, whilst in males and in the mixed group, the control group yielded the best results. According to Ibrahim *et al.* (2022), a diet balanced in digestible protein and essential fatty acids significantly improves the development of pectoral muscles in Japanese quail. Similarly, El-Katcha *et al.* (2021) reported that a reduction in the protein quality of diets significantly reduces the breast meat proportion in quails without significantly affecting overall carcass yield. The better values observed in the control group are thought to be linked to a higher crude protein content (20.50% at the start and 19% during the growth phase) in their rations compared with the experimental groups (T25 and T50), which had 20.51% and 17.51% for T25 and 19.35% and 16.63% for T50. The crude protein content of the experimental diets during the growth phase was low compared with the control diet.

Thigh proportions were higher in the T50 group, particularly in males and mixed-sex subjects. This phenomenon was also reported by Biesiada *et al.* (2008), who observed that certain dietary changes can influence the anatomical distribution of muscle tissue.

The proportion of back meat was particularly improved in the males in the T25 group as well as in the mixed group. This likely reflects a favorable effect of a moderate level of protein inclusion on muscle and bone development in the back. As the back consists of supporting muscles and the bony framework, its growth depends on the availability of minerals and protein. According to Akingboye *et al.* (2024), male quails grow faster than females. The results therefore suggest that the T25 diet may have better supported this anatomical development, in contrast to the T50 diet, which is potentially less digestible.

The quails fed cashew nut cake and cashew apple bagasse reached their first laying age at the same time as those in the control group. This suggests that the feeds we produced and tested were of the same high quality as the commercial feed. However, these ages at first laying were higher than those reported by Pandey *et al.* (2025) in their study, where values ranged from 37.89 to 39.22 days of age. This difference could be explained by the phenotypic differences between the quails used. Indeed, those authors used laying-type quails with better laying performance, unlike in the present study, where the quails were meat-type.

Egg-laying rates did not differ significantly between the diets over the 12-week laying period. They ranged from 47.49 ± 2.24% to 55.50 ± 11.84%. This may be due to the crude protein content of the feeds, which were broadly similar. These levels were 16%, 18.77% and 17.73% for the control, T25 and T50 feeds respectively. Another possible explanation could be the relatively low levels of dietary protein. According to the work of Jesuyon *et al.* (2022), the laying rate drops from 57.94% to 43.99% with feeds containing dietary protein levels of 18% and 24%. However, these rates are significantly lower than those obtained by Djinandji *et al.* (2022), who recorded values of over 71% in laying quails fed a diet enriched with *Moringa oleifera* powder.

The partial replacement of soya meal and wheat bran with cashew nut cake and cashew apple bagasse did not affect egg weight. The eggs therefore had weights similar to those produced on the commercial feed. This finding may be due to the sufficient availability

of protein and energy in the test diets, which were similar to those in the commercial feed, and to their nutritional balance. Indeed, research by Ashour *et al.* (2024) revealed that the interaction between the protein content and metabolizable energy in the feed influenced the weight of quail eggs. They obtained eggs weighing 11.9 g with a diet containing 20% crude protein and 2,900 kcal/kg of metabolizable energy, compared with 11.2 g with a diet containing 22% protein and 2,900 kcal/kg of metabolizable energy. The egg weights in this study are comparable to those reported by several authors for quails, notably Guimarães *et al.* (2021) (11.3 g to 11.6 g) and Matos *et al.* (2023) (11.80 g to 11.96 g). However, they were higher than the weights reported by Salih *et al.* (2021), which were 10.48 ± 0.09 g and 10.77 ± 0.10 g for diets using soya meal and fish meal as protein sources respectively.

The shape index obtained for the T25 and T50 diets ranged from 78.5 ± 4.39% to 77.09 ± 4.89%, whilst that for eggs from the commercial diet was 76.25 ± 5.28%. According to Nedeljka (2006), the shape index of a normal egg lies between 70% and 77%. The values obtained in our study indicate that the eggs are of good quality in terms of shape. These results may be due to sufficient calcium and phosphorus content in the tested diets. Indeed, a sufficient and balanced amount of these minerals enables proper egg formation (Stanquevis *et al.*, 2021). Other authors have reported shape index of 74% to 79% with turmeric (Abeer *et al.*, 2023), 77% to 79% with papaya leaves incorporated into quail feed at rates ranging from 5% to 20% (Inuwa *et al.*, 2023) and from 76% to 77% in eggs from laying hens fed diets containing 50% and 25% cashew apple bagasse and cashew cake meal respectively (Coffi, 2025).

The shell index was also unaffected by the feed, thus demonstrating that cashew nut cake and bagasse can partially replace commercial feed. Coffi (2025) made the same observation in eggs from laying hens fed diets containing cashew nut cake and cashew apple bagasse at levels of 25% and 50%. However, our figures were lower than those reported by this author, which were 12.03% for a 25% inclusion of cashew cake and bagasse, and 12.59% for a 50% inclusion of these by-products. This difference may be linked to the species of bird used in the various studies.

In this study, the feed had no effect on the yolk index. The yolk index ranged from 21.68 ± 10.68% to 25.06 ± 10.88%. However, the values observed were significantly lower than those reported by Abeer *et al.* (2023) and Hossain *et al.* (2024), which were between 42.13% and 54.86%, and between 45.91 ± 1.39% and 48.60 ± 1.02%, respectively. The low indices in our study indicate low-quality egg yolk, as evidenced by a less rounded yolk shape. This could be due to the temperature (26 and 28 °C) and the storage duration, which was 7 days. These factors may have increased the permeability of the vitelline membrane and caused it to weaken (Marinho, 2011). These observations are consistent with those of Carvalho *et al.* (2023), who reported a decrease in the vitellus index from 0.395 to 0.216 (39,5% to 21,6%) after 10 days' storage of quail eggs at room temperature (26.8 °C). Similarly, Ayuti *et al.* (2021) observed a deterioration in the vitellus index from 0.35 ± 0.020 to 0.20 ± 0.032 (35% to 20%) after 31 days of storage at a temperature of 27 °C.

The Haugh unit is used to determine the freshness of eggs. This parameter was influenced by the feed. The highest values were observed in eggs from batches T25 (84.47 ± 3.55) and T50 (85.21 ± 4.64). According to the classification by Brasil *et al.* (2022) for quail eggs, if the Haugh unit is greater than or equal to 80, the egg is fresh; if the Haugh unit is less than 80, the egg is spoiled.

CONCLUSION

The partial replacement of soya meal and wheat bran with cashew nut cake and cashew apple bagasse, respectively, resulted in performance comparable to that of commercial feed in terms of age at first laying, laying rate, egg weight, shell index and yolk index. However, the best carcass yields were obtained with the control treatment (71.10 ± 0.79%) and the T25 treatment (70.78 ± 0.84%) for all sexes combined. The T25

treatment produced eggs with good shape indices (78.5 ± 4.39%), whilst the freshest eggs came from the T25 and T50 treatments, with Haugh units of 84.47 ± 3.55 and 85.21 ± 4.64 respectively. The T25 diet could represent an attractive alternative without compromising carcass yield, egg production or certain internal egg qualities.

RECOMMENDATION(S)

The T25 diet could represent an attractive alternative without compromising carcass yield, egg production or certain internal egg qualities. However, studies on certain parameters such as digestibility, feed conversion ratio during the laying phase, quail health and a technical-economic analysis would help determine the sustainable use of these feeds.

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