



Research Article

TRIAL OF PARTIAL SUBSTITUTION OF MAIZE (*ZEA MAYS*) BY *PARKIA BIGLOBOSA* PULP IN THE DIET OF JAPANESE QUAIL (*COTURNIX JAPONICA*)

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ABSTRACT

Poultry farming has always been a means of combating malnutrition. In recent years, quails farming has offered us new choices of taste, with meat production to meet the increased demand in animal proteins. However, the big problem in the poultry sector remains the cost of food. To overcome this problem, the use of agricultural by-products in animal feeding remains capital. These by-products are readily available and rich in nutrients, as it is the case with *Adansonia digitata* and *Parkia biglobosa* pulp. This is the context in which this study is taking place, which is a contribution to the valorization of *P. biglobosa* pulp as a partial replacement for corn in quail nutrition as a source of energy and nutrients. A total of 540 curds was selected with an average body weight of 7.00 ± 0.02 g and one day of age. Four batches of treatments were constituted, namely, batch control, batch 5%, batch 10% and batch 15% according to the rates of substitution of corn by *P. biglobosa* pulp in their feed. The weekly weighings of the birds made it possible to follow their weight growth and the average weekly gain of the birds. The consumption index was thus determined on the basis of food consumption. The results showed that the substitution of maize by *P. biglobosa* pulp improved the weight and the average daily gain of the birds in the growth phase. Feed consumption and feed conversion ratio were low for the control batch compared to the treated batches during both rearing phases. Food consumption and the consumption index were more in favor of the control especially in the start-up phase compared to the treated batches. The pulp of *P. biglobosa*, by virtue of its nutritional quality, can therefore be used in quail feed at corn substitution rates of 5 to 15% without adversely affecting its zootechnical performance.

Keywords: *Parkia biglobosa* pulp, *Coturnix japonica*, Food conversion, Zootechnical performances.

INTRODUCTION

In Togo, agriculture is a key sector in the national strategy for economic development and the fighting against poverty. Indeed, since the end of colonization, development programs have assigned it the role of ensuring first and foremost food self-sufficiency, then, later, that of guaranteeing food security, a pledge of real sustainable development. The contribution of the livestock sub-sector is estimated at 6.73% to the national Gross Domestic Product (GDP) and 14% to the Gross Agricultural Domestic Product (PIBA) which represents 40% of the GDP (MAEP, 2008). Short-cycle farming, especially poultry farming, has always been an effective way to fight

hunger and malnutrition. In recent years, quail farming, or coturniculture, has attracted attention from specialists as a new avenue for diversifying poultry farming, offering consumers new taste choices and boosting meat production to meet the growing demand for animal protein (Ukashatu *et al.*, 2014). Quail meat is renowned for its low caloric value and for its high quality protein and high biological value (Haruna *et al.*, 1997). These qualities, especially the low fat content, are likely to distract consumers, especially those prone to hypertension, from the consumption of quail meat (Odo & Nnadi, 2013). The quail is indeed a small rustic bird, early, very prolific and less demanding in space as in food consumption compared to other poultry.

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Developing coturniculture in Togo will then contribute to the fight against poverty through the creation of income-generating activities, eliminate hunger and malnutrition through the production of quality meat and eggs for the population. However, the major obstacle facing the poultry sector remains the cost of feed, which represents nearly 60% of the total expenses of poultry farms as for any other type of farming (Shamna *et al.* 2013). For a long time, and because of their high energy and protein content, corn-soy diets have been considered as staple feeds for poultry regardless of the type of production (egg, meat). Maize (*Zea mays*) forms the basis of most livestock feeds and is particularly popular with poultry, rabbits and pigs (Durunna *et al.*, 2000). The grains are very useful as food for humans and animals as well as raw materials for industries. The high cost of cereals and the uncertainty of their sustainable supply as an energy source for livestock and poultry require the search for alternative and perhaps cheaper options (Agiang *et al.*, 2004). So, develop alternative animal feeding systems based on agricultural by-products, such as

A. digitata and *Parkia biglobosa* pulps, which are known to be rich in carbohydrates, mineral and vitamin complexes. It can be a source of solution for the reduction of feed costs in poultry farming in general and coturniculture in particular. This will make quail farming even more favorable to all pockets as an income generating activity. This study aims to promote the breeding of animals based on local non-conventional ingredients, in the interest of increasing productivity per unit of available basic resources. It is in this context that, this study aims to contribute to the valorization of *P. biglobosa* pulp as a partial replacement of corn in quail feed as a source of energy and nutrients.

MATERIAL AND METHODS

Animal material

Day-old quail, from mature quail eggs (Plate 1), were selected on the basis of an average live weight of 7.00 ± 0.02 g.



Plate 1. Photos of male quail (a); female quail (b) and quail eggs (c).



Photo 1. *Parkia biglobosa* pulp meal.

Methodology

The bromatological profile of the *P. biglobosa* pulp was obtained by the AOAC method (Official Methods of Analysis).

Ingredients used

The ingredients used for the food formulation consisted of corn, soy, bran cubed to which we added the *P. biglobosa* pulp (Photo 1).

Experimental design

A total of 540 day-old quails were divided into four treatments, namely Control, T 5%, T 10% and T 15%. They

were fed feeds with 0%, 5%, 10% and 15% corn substitution rate by *P. biglobosa* pulp respectively. The quail were randomly assigned to four treatment batches. Within each treatment batch, we have three replicates of 45 quail per replicate.

Feed formulation of the animals

The control batch feed was formulated according to the nutritional requirements of Japanese quail. From this control batch feed, we made a substitution of corn by cowpea pulp without considering the energy imbalance between the two ingredients, as shown in table 1.

Table 1. Feeding formulas for start-up and growth phases.

Ingredients	Start-up				Growth			
	Control	T 5%	T 10%	T 15%	Control	T 5%	T 10%	T 15%
<i>Parkia biglobosa</i> pulp	0	5	10	15	0	5	10	15
White corn	50	45	40	35	65	60	55	50
Wheat bran	3	3	3	3	6	6	6	6
Soya seed cake	22	22	22	22	4	4	4	4
Roasted soya seed	10	10	10	10	12	12	12	12
Fish meal	6.5	6.5	6.5	6.5	5.5	5.5	5.5	5.5
Flesh concentrate	6	6	6	6	5	5	5	5
Oyster shell	2	2	2	2	2	2	2	2
Premix flesh	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Méthionine	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Total (Kg)	100	100	100	100	100	100	100	100
Metabolizable energy (kcal/ kg)	2913.6	2750.3	2587	2423.6	3041.9	2878.5	2715.2	22251.9
Crude protein (%)	25.109	24.91	24.71	24.52	18.856	18.65	18.45	18.25
Crude fiber (%)	3.83	4.14	4.46	4.77	3.45	3.76	4.07	4.39

Control; T 5%: batch 5%; T 10%: batch 10% and T 15%: batch 15%.

Data collection method and measured parameters

Weekly Food Consumption (WFC)

It is expressed in grams per day per subject and is obtained from the following formula:

$$\text{WFC} = \frac{\text{TFC (g)}}{\text{Total number of birds}} \quad (1)$$

TFC: Total Food Consumption per week

The live weight of the quail (LW), expressed in grams per bird.

$$\text{LW} = \frac{\text{Sum of live weight of quails (g)}}{\text{Number of quails}} \quad (2)$$

Average Weekly Gain (AWG), expressed in grams per week per subject

$$\text{AWG (g)} = \frac{\text{Average weight of nw (g)} - \text{Average weight of lw (g)}}{\text{Time interval (weeks)}} \quad (3)$$

nw = new week and lw = last week

Consumption Index (CI)

Consumption Index (CI) is the ratio that measures the amount of feed consumed to produce one kg of egg or meat in poultry.

$$\text{IC} = \frac{\text{WFC (g)}}{\text{AWG (g)}} \quad (4)$$

Feed cost of Japanese quail in F CFA per kg of weight gain (FC)

$$FC = \frac{\text{Price per kilogram of feed (FCFA)} \times \text{WFC (g)}}{\text{AWG (g)}} \quad (5)$$

FC: feed cost of Japanese quail expressed in F CFA/kg of weight gain.

TFC: Total food consumption expressed in grams per week per subject.

AWG: Average Weekly Gain, expressed in grams per week per subject.

Statistical analysis of data

Data were entered using Excel 2013 spreadsheet software. Statistical analyses were performed by Graph Pad Prism 8.0.0 software and results were presented in graphical or tabular form and were expressed as mean $\pm$ Standard Error

of the Mean (SEM) of three samples of *P. biglobosa* pulp and three replicates for the zootechnical parameters of the quail individuals considered. Differences were considered significant at the 5% level.

RESULTS AND DISCUSSION

The analysis of the *P. biglobosa* pulp used in this study showed that for 100 g ms, 359.072 Kcal of energy; 5.04 g of protein and 9.81 g of fiber with a mineral and vitamin complex concentrate (Table 2). The comparative bromatological profile of corn flour and *P. biglobosa* pulp revealed that corn flour is richer in energy, protein and less fibrous than *P. biglobosa* pulp. In terms of minerals and vitamins, *P. biglobosa* pulp is much richer than corn flour (Table 3).

Table 2. Nutritional composition of *Parkia biglobosa* pulp in 100 g of dry matter (ms).

Elements analyzed	Values
Energy (kcal/100 g of dry matter)	359.10 $\pm$ 6.33
Moisture content (% of dry matter)	15.38 $\pm$ 0.67
Protein (g/100 g of dry matter)	5.04 $\pm$ 0.05
Carbohydrates (g/100 g of dry matter)	82.52 $\pm$ 0.53
Fat (g/100 g of dry matter)	0.91 $\pm$ 0.01
Ash (g/100 g of dry matter)	4.17 $\pm$ 0.01
Fiber (g/100 g of dry matter)	9.81 $\pm$ 0.03
Ca (mg/100 g of dry matter)	171.50 $\pm$ 5.35
Iron (mg/100 g of dry matter)	8.04 $\pm$ 1.05
Mg (mg/100 g of dry matter)	90.06 $\pm$ 2.02
P (mg/100 g of dry matter)	131.30 $\pm$ 6.28
Zn (mg/100 g of dry matter)	5.56 $\pm$ 0.05
K (mg/100 g of dry matter)	1571.70 $\pm$ 20.07
Vitamin C (mg/100 g of dry matter)	70.25 $\pm$ 2.44

Values were expressed as mean $\pm$ ESM (n = 3).

Table 3. Comparative bromatological profile of corn and *Parkia biglobosa* pulp.

Elements analyzed	<i>Parkia biglobosa</i> pulp	White corn flour (FAO, 2012)
Moisture content (% of dry matter)	15.38 $\pm$ 0.67	11.5
Energy (kcal/100 g of dry matter)	3.59 $\pm$ 6.33	351
Carbohydrates (g/100 g of dry matter)	82.52 $\pm$ 0.53	64.5
Fats (g/100 g of dry matter)	0.91 $\pm$ 0.01	4.0
Protein (g/100 g of dry matter)	5.4 $\pm$ 0.05	9.7
Fibers (g/100 g of dry matter)	9.81 $\pm$ 0.03	9.0
Ash (g/100 g of dry matter)	4.17 $\pm$ 0.01	1.4
P (mg/100 g of dry matter)	131.30 $\pm$ 6.28	198
Ca (mg/100 g of dry matter)	171.5 $\pm$ 5.35	18
K (mg/100 g of dry matter)	1571.70 $\pm$ 20.07	315
Mg (mg/100 g of dry matter)	90.06 $\pm$ 2.02	93
Zn (mg/100 g of dry matter)	5.56 $\pm$ 0.05	1.73
Iron (mg/100 g of dry matter)	8.04 $\pm$ 1.05	3.8
Vitamin C (mg/100 g of dry matter)	70.25 $\pm$ 2.44	Traces

Values were expressed as mean $\pm$ ESM (n = 3).

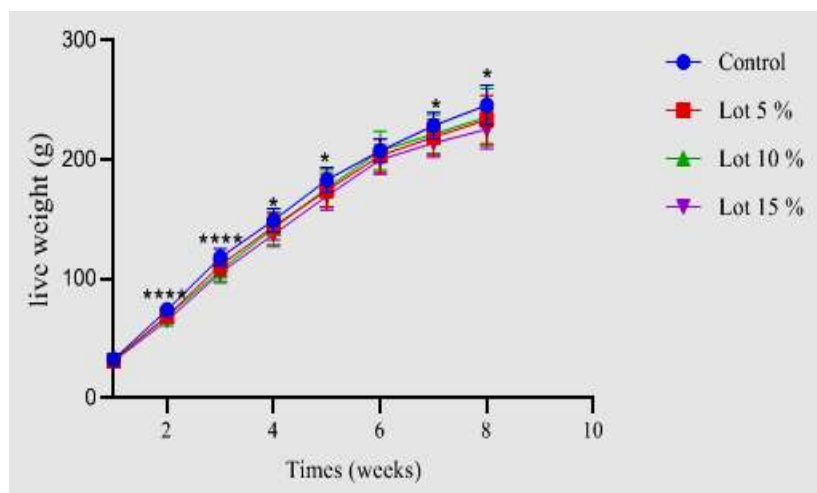


Figure 1. Evolution of the live weight Evolution of the birds following the time.

Control: feed without *P. biglobosa* pulp (T 0%); Batch 5%: feed with 5% *P. biglobosa* pulp (T 5%); Batch 10%: feed with 10% *P. biglobosa* pulp (T 10%) and Batch 15%: feed with 15% *P. biglobosa* pulp (T 15%). Values are presented as mean $\pm$ SEM (n = 3). Significantly different between all batches, *: p < 0.05; ****: p < 0.0001.

Table 4. Average weekly gain of birds according to rearing phase.

Breeding phases	Control	T 5%	T 10%	T 15%	p value
Start-up	36.96 $\pm$ 0,73 ^a	34.8 $\pm$ 0,23 ^b	33.34 $\pm$ 0.74 ^{bc}	32.15 $\pm$ 1,27 ^c	0.0001 (****)
Growth	25.53 $\pm$ 0,65 ^a	24.4 $\pm$ 0,34 ^a	25.72 $\pm$ 0.75 ^a	24.12 $\pm$ 0,75 ^a	0.0511

Control: feed without *P. biglobosa* pulp (T 0%); Batch 5%: feed with 5% *P. biglobosa* pulp (T 5%); Batch 10%: feed with 10% *P. biglobosa* pulp (T 10%) and Batch 15%: feed with 15% *P. biglobosa* pulp (T 15%). Values are presented as mean $\pm$ SEM (n = 3). Values with the same letter on the same line are not significantly different at the 5% level. Significantly different between all batches: ****: p < 0.0001.

Table 5. Food consumption of quails according to the rearing phase.

Breeding phases	Control	T 5%	T 10%	T 15%	p value
Star-up	60.17 $\pm$ 1.08 ^c	64.66 $\pm$ 1.55 ^{ab}	67.22 $\pm$ 2.66 ^a	68.62 $\pm$ 0.89 ^a	0.0001 (****)
Growth	131.1 $\pm$ 0.49 ^c	133.6 $\pm$ 0.74 ^{bc}	136.2 $\pm$ 0.38 ^b	140.7 $\pm$ 0.58 ^a	0.0011 (***)

Control : feed without *P. biglobosa* pulp (T 0%) ; Batch 5%: feed with 5% *P. biglobosa* pulp (T 5%) ; Batch 10%: feed with 10% *P. biglobosa* pulp (T 10%) and Batch 15%: feed with 15% *P. biglobosa* pulp (T 15%). Values are presented as mean $\pm$ SEM of three repetitions (n = 3). Values with the same letter on the same line are not significantly different at the 5 % level. Significantly different between all batches: *** p < 0.001; **** p < 0.0001.

Table 6. Food consumption index according to rearing phase.

Breeding phases	Control	Lot 5%	Lot 10%	Lot 15%	p value
Start-up	1.53 $\pm$ 0.03 ^a	1.68 $\pm$ 0.05 ^a	1.77 $\pm$ 0.07 ^a	1.87 $\pm$ 0.51 ^a	0.0501
Growth	5.62 $\pm$ 0.16 ^a	6.36 $\pm$ 0.17 ^b	6.05 $\pm$ 0.45 ^b	7.41 $\pm$ 0.76 ^c	0.0001 (****)

Control: feed without *P. biglobosa* pulp (T 0%); Batch 5%: feed with 5% *P. biglobosa* pulp (T 5%) ; Batch 10%: feed with 10% *P. biglobosa* pulp (T 10%) and Batch 15%: feed with 15% *P. biglobosa* pulp (T 15%). Values are presented as mean $\pm$ SEM of three repetitions (n = 3). Values with the same letter on the same line are not significantly different at the 5% level. Significantly different between all batches: **** p < 0.0001.

The average hatching weight of quail in our study was 7 ± 0.02 g. At the eighth week, the average weight of quails was 245.8 ± 16.79 g; 233.7 ± 20.3 g; 235.9 ± 23.74 g and 225.7 ± 16.26 g respectively for the control and treated batches in the order of increasing substitution rate of maize for *P. biglobosa* pulp. The results showed that from 0 to 4 weeks of age, growth was similar for all treated lots compared to the control batch (Figure 1). After this age, weight growth was better for quails fed with the ration containing 10% *P. biglobosa* pulp and those of the control lot compared to quails fed with the rations of 5% and 15% *P. biglobosa* pulp respectively. This observation was very remarkable in the sixth week of age of Japanese quails.

The evolution of the cumulative weekly average gain during the two phases of quail rearing was represented in table 3. The statistical analysis showed that in the start-up phase, the control lot gained more weight followed by the 5% and 10% batches ($p < 0.0001$). On one hand, the average weekly gain cumulative in the growth phase showed no significant difference between the control and treated batches. On the other hand, the incorporation of 15% *P. biglobosa* pulp altered the weight growth of the quails without the weekly average gains of the four rations being significantly different ($p > 0.05$).

The average food consumption of the control and 15% batches was respectively, 60.17 g and 68.62 g at start-up and 131.1 g and 140.7 g at growth. Indeed, the 15% batch

consumed more feed than the 10% and 5% batches (Table 4). Statistical analysis showed that this consumption increased with age but remained different between the different treatment batches. The feed conversion ratio of the control and 15% batches was 1.53 and 1.87 at start-up and 5.62 and 7.41 at growth, respectively. Indeed, the 15% lot recorded a higher consumption index compared to the 10% and 5% treated batches (Table 5). Statistical analysis shows that there was no significant difference in feed conversion between the four batches in the starting phase. However, in the growth phase, there was a significant difference ($p < 0.0001$) between the four batches. The 15% lot was the lot that converted the least feed during both rearing phases compared to the other batches. The use of *P. biglobosa* pulp reduced the price of feed for quails from 2.75 to 8.25 FCFA/kg in the start-up phase and from 2.55 to 8.05 FCFA/kg compared to the control ration. The feeding cost in quails fed with the *P. biglobosa* pulp-based feed rations showed no significant difference ($p > 0.05$) between the treated batches compared to the control batch during the two rearing phases of the Japanese quail. Indeed, compared to the control ration, the rations based on 5%, 10% and 15% of *P. biglobosa* pulp resulted in an increasing in feed cost from 13.20% to 27.06% in the start-up phase and 0.79% to 9.64% in the growth phase respectively. From an economic point of view, the three incorporation rates of *P. biglobosa* pulp did not reduce the feed cost compared to the control.

Table 7. Feed prices and feed costs for Japanese quail fed with cowpea pulp rations.

	Breeding phases	Control	T 5%	T 10%	T 15%	p value
Price of feed (FCFA/kg of feed)	Start-up	268,25	265,5	262,75	260	
	Growth	234,6	231,85	229,1	226,35	
Feed cost (F CFA/kg of weight gain)	Start-up	436 ^a	493 ^a	529 ^a	554 ^a	0,050
	Growth	1203 ^a	1269 ^a	1213 ^a	1320 ^a	0,050
	Global	819,5 ^a	881 ^a	871 ^a	937 ^a	0,050

Control: feed without *P. biglobosa* pulp (T 0%); Batch 5%: feed with 5% *P. biglobosa* pulp (T 5%) ; Batch 10%: feed with 10% *P. biglobosa* pulp (T 10%) and Batch 15%: feed with 15% *P. biglobosa* pulp (T 15%). Values are presented as mean $\pm$ SEM (n = 3). Significantly different between all batches, *: $p < 0.05$.

The bromatological profile which was obtained showed that the *P. biglobosa* pulp meets the criteria of choice of a food ingredient by its energy, protein and mineral and vitamin complex. This confirms previous work in this area by other authors such as (Ouedraogo, 1987) and (Gernah *et al.*, 2007), on the fact that *P. biglobosa* pulp is a very nutritious flour. From 0 to 4 weeks of age, the growth was similar for all treated lots compared to the control batch (Figure 1). After this age, weight growth was better for quails fed with the ration containing 10% *P. biglobosa* pulp and those of the control lot compared to quails fed with the rations of 5% and 15% *P. biglobosa* pulp respectively. This observation was very remarkable in the sixth week of age of Japanese quails. This can be explained by the fact that the birds adapted better and better to the substitution of

corn by *P. biglobosa* pulp in their diet. Several authors have reported the same growth pattern in the quail *Coturnix japonica* (Ikaya *et al.*, 2005; Kizilkaya *et al.*, 2006; Vatsalya & Arora, 2012). The average weekly gain evolved in a decreasing way with the age of the birds. It was very high during the first three weeks of age of the birds, which corresponded to the start-up phase of the Japanese quail. This difference in weight gain observed between birds of all batches during the start-up phase, explained why the growth rate of birds in the control batch was higher than that of the treated batches during the first three weeks of rearing. However, this weight gain was small during the growth phase of the birds and showed no significant difference between batches during this phase of quail development. This explained the fact that the

incorporation of 15% *P. biglobosa* pulp altered the weight growth of the quails without the weekly average gains of the four rations being significantly different in the growth phase.

In the light of these results, we can say that the fattening performance of Japanese quail (*Coturnix japonica*) is noticeable in the first three weeks of rearing. Some authors like (Aryeetey, 2011; Sezer & Tarhan, 2005) also reported this fast fattening performance of this Japanese quail. Some authors like (Sezer & Tarhan, 2005) also reported this rapid fattening performance of quail. The feed consumption of the quails increased with age and the increasing level of substitution of corn by *P. biglobosa* pulp. This is explained by the fact that the increasing level of substitution with *P. biglobosa* pulp led to a decrease in the energy level of the feed ration of the 5%, 10% and 15% batches. Indeed, according to (Swennen *et al.*, 2007), good performance of poultry in breeding depends on the characteristics of the feed such as composition, feed intake, digestion and absorption processes.

The decrease in the energy level of the quail ration in the treated lots resulted in a slight increase in food consumption compared to the control batch. (Baransaka, 1998) obtained a mean feed intake that increased ($p < 0.05$) with increasing levels of *P. biglobosa* pulp in laying hens in the pullet phase. This confirmed the energy imbalance between the two ingredients (corn and cowpea pulp). Our results corroborate with the results reported by some authors such as (Berrama *et al.*, 2011; Djouvinov & Mihailov, 2005). Bromatological analysis of *P. biglobosa* pulp has shown that beyond its nutritional qualities, it is very rich in dietary fiber. Ouedraogo, (1987) and (Gernah *et al.*, 2007) reported a crude dietary fiber content of 11 and 19% respectively, much higher than in our study. The increment in feed consumption of quail with the increasing level of substitution of corn by pulp has resulted in an increasing intake of dietary fiber. This explained the low feed conversion and growth rate of the quails in the 15 % treated batch compared to the other two treated batches and the control. Moreover, due to their less developed digestive system in microflora, the poultry do not have the capacity to better valorize these fibers, as an additional source of energy. Dietary fiber is much feared to have adverse effects on growth performance of birds especially monogastrics due to its low digestibility (Musamba *et al.*, 2011). The fiber levels in our different formulated feeds increased with the increasing level of substitution of *P. biglobosa* pulp. The 15 % batch feed had the highest fiber level compared to the other two treated batches. Recommended fiber levels of 3 to 3.88% in the quail feed. The availability of *P. biglobosa* pulp at low cost in some localities of our country and its good nutritional value made it possible to reduce the food, the rate of corn between 3.5% to 20.28% and 3.72% to 15.92% respectively for the phases of starting and growth of the Japanese quail. This resulted in a reduction in the price per kilogram of feed of the 5%, 10% and 15% lot rations compared to the control lot. The 5% to 15% batches rations which in combination with the similarity in average weekly gain (AWG) did not result in a

significant decrease in feed cost per kg live weight of Japanese quail. The feed costs obtained with the 5%, 10%, and 15% rations compared to the control lot showed that there was no reduction in feed cost. (Houndonougbo *et al.*, 2012) reported a decrease in price per kilogram of feed and feed cost per kilogram of weight gain with the incorporation of dried cassava leaves in the diet of laying hens in the chick and pullet phases. Our results could be explained by the fact that our food rations were not iso-energetic and iso-proteinic, which led to the increasing in food consumption and its low valorization by the birds because of the dietary fibers. We also obtained a low weight gain of the birds in the start-up phase but which improved for the batches treated in the growth phase. So we can say that the *P. biglobosa* pulp was better valued in the growth phase of the Japanese quail.

CONCLUSION

In this study considered as preliminary, the substitution of corn by cowpea pulp was a presumptive test in order to conduct further studies on the valorization of this nutritious meal in Japanese quail feeding. The possibilities for improvement in energy balance are very important as the two raw materials differ both in quantity and quality. This pulp can, in fact according to the data of the present study, substitute corn at rates of 5 to 15% in the feed of the quail while maintaining its growth performance. The results show that cowpea pulp has an interesting nutritional value and its concentration in vitamins and minerals could contribute to stimulate the immune system in quail without affecting the growth performance. Faced with the high cost of cereals and the uncertainty of their sustainable supply as a source of energy, a maize-pulp associated would help poultry farmers not only to reduce the cost of food, but also to promote coturniculture, as an income-generating activity to vulnerable social classes.

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