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Effect of Pawpaw Leaf Meal on Laying Performance and Egg Quality of Japanese Quails

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ABSTRACT

Background and Objective: The problem of feed shortages caused by rising costs of conventional feed ingredients has affected animal protein supply. A possible solution to this problem could be increased use of cheaper alternative feed ingredients, such as leaf meals. The study evaluated the effect of Pawpaw Leaf Meal on laying performance and egg quality of Japanese quail eggs. **Materials and Methods:** A total of 120 quail hens were allotted to five dietary treatments with three replicates of 8 birds each in a Completely Randomized Design. Five experimental diets were formulated in which diet 1 served as control (0% PLM) while diets 2, 3, 4 and 5 contained 5, 10, 15 and 20% Pawpaw Leaf Meal, respectively. Water and feed were offered *ad-libitum*. Data collected were subjected to analysis of variance using the general linear model of SAS. **Results:** Results showed that laying performance parameters were all significantly ($p<0.05$) better in birds fed a 5% PLM-based diet and were comparable to the control group. Internal egg quality traits differed significantly ($p<0.05$) across treatment groups except for egg shape index and yolk percentage. Eggs from birds on a 5% PLM-based diet had higher egg weight, egg length, egg width, eggshell weight, albumen length, albumen diameter, albumen weight, yolk height, yolk diameter, yolk weight, albumen index and shell percentage that were comparable to the control group. **Conclusion:** It was concluded that the inclusion of PLM at a 5% level helps improve the laying performance of Japanese quails.

KEYWORDS

Pawpaw, leafmeal, quails, laying, performance, egg, quality

INTRODUCTION

The problem of feed shortages caused by rising costs of conventional protein and energy feed ingredients (such as groundnut cake, soybean, maize and sorghum), has negatively impacted animal protein supply and created a large gap between the demand and supply of animal protein in Nigeria and many other developing countries around the world. As a result, the average animal protein consumption of people in the majority of these countries is substantially below the required daily requirement[1].

A feasible step toward increasing the supply and consumption of animal protein in Nigeria is the growth and expansion of the poultry sector. As a result, scientists and researchers have focused their attention on the rearing of poultry species with short generation intervals like the Japanese quails[2].

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Quails are small in size, occupy less space, mature quickly, are hardy and are very prolific[3]. They reach sexual maturity and egg production at 5-6 weeks of age and reach market weight of 150-180 g at around the same age[3]. The meat and eggs include high-quality protein with low levels of body fat and cholesterol, making them an excellent alternative for people who are predisposed to cardiovascular disease[4]. They only require 20-25 g of feed per day. Furthermore, they are fairly resistant to diseases and the hens can lay between 200 and 350 eggs in their first year if properly cared for[3].

However, the main impediment to the expansion of the poultry business in Nigeria and, by extension, Africa is the scarcity and high cost of feed ingredients. Protein sources for poultry feed are expensive and they make up roughly 30-35% of their diet. The over-reliance on soybeans and groundnut cake as main protein sources in poultry feed has resulted in strong competition between man and livestock and consequently expensive poultry feed prices[5,6].

A possible solution to the high cost of feeds could be increased use of potentially cheaper alternative feed ingredients, such as leaf meals in place of the more expensive soybean cake/meal and fish meal[7-10].

Pawpaw (*Carica papaya* L.) leaves have the potential to supply dietary proteins required by quail birds. This is because they have a high Crude Protein (CP) content (30%) with low (5%) crude fibre levels[10]. Additionally, pawpaw leaves contain papain (5.3%), a natural enzyme that helps in the digestion of proteins in the digestive tract[11], vitamin C (286 mg/100 g), as well as vitamin E (30 mg/100 mg)[12]. The leaf also contains high levels of base metals (potassium, sodium, calcium and magnesium) and appreciable levels of iron[13]. As a result, Pawpaw Leaf Meal (PLM) may not only offer quails with dietary proteins but also herbal proteolytic enzymes to improve the digestibility of ingested feed in the digestive tract, thereby promoting their growth.

Even though Pawpaw Leaf Meal has the potential to reduce the cost of feeding quails by partially replacing soybean, its impact on laying performance and egg quality traits of Japanese quail birds has to remain unestablished and grossly understudied. This study, therefore, investigated the effect of partially replacing soybean meal with graded levels of Pawpaw Leaf Meal on laying performance and external and internal egg quality traits of Japanese quails (*Coturnix coturnix japonica*).

MATERIALS AND METHODS

Experimental site: The research was carried out at the Poultry Unit of the Department of Animal Science Teaching and Research Farm, Ahmadu Bello University, Zaria, Kaduna State, Nigeria from September, 2019 to April, 2022. It is situated at latitude 11009'01.78"N and longitude 7039'14.79"E, 671 m above sea level, in Nigeria's Northern Guinea Savanna Zone. The climate is marked by distinct dry and rainy seasons, with annual rainfall varying from 700-1400 mm on average. The highest temperature fluctuates from 26-40°C depending on the season, with a relative humidity of 21 and 72% in the dry and wet seasons, respectively[14].

Source and processing of Pawpaw Leaf: Fresh pawpaw leaves were collected from Mallam Shehu Pawpaw plantation at Hayin Gada, along Shika Road, Sabon Gari Local Government area of Kaduna State and dried under the shade to a crispy feel for 7 days. It was then ground in a hammer mill (1 mm) to produce Pawpaw Leave Meal (PLM).

Proximate composition of Pawpaw Leaf Meal: The proximate composition (dry matter, crude protein, crude fibre, ether extract, ash and nitrogen-free extract) of the samples of Pawpaw Leaf Meal were determined using the standard methods described by AOAC[15] in the Biochemical Laboratory, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. To determine the Dry Matter

Table 1: Ingredient composition of quail layer diets containing graded levels of Pawpaw Leaf Meal

	Inclusion levels of Pawpaw Leaf Meal (%)				
Ingredients (%)	0	5	10	15	20
Maize	43.00	41.20	40.20	38.00	36.00
SBC	34.00	31.00	27.00	25.00	22.00
PLM	0.00	5.00	10.00	15.00	20.00
Groundnut cake	15.00	15.00	15.00	15.00	15.00
Bone meal	3.20	3.00	3.00	3.00	3.00
Limestone	4.00	4.00	4.00	4.00	4.00
Common salt	0.25	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30	0.30
Vit/Min premix**	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Metabolizable energy (kcal kg^{-1})	2840	2826	2810	2813	2806
Crude protein (%)	25.42	25.41	25.39	25.43	25.40
Crude fibre (%)	4.45	4.51	4.51	4.64	4.70
Ether extracts (%)	5.81	5.84	5.83	5.92	5.95
Calcium (%)	2.68	2.60	2.59	2.58	2.57
Available phosphorus (%)	1.03	0.84	0.81	0.79	0.77
Lysine (%)	1.32	1.23	1.12	1.10	1.00
Methionine (%)	0.65	0.63	0.60	0.60	0.57
Cysteine (%)	0.36	0.34	0.32	0.31	0.29
Cost per kg diet (N)	122.67	118.60	113.58	111.09	107.05

**Vitamin-mineral premix provided per kg the following: Vitamin A, 10,000 iu, Vitamin D_3: 2,200,000 iu, Vitamin E: 10,000 mg, Vitamin K_3: 2,000 mg, Vitamin B_1: 1,500 mg, Vitamin B_2: 5000 mg, Vitamin B_6: 1,500 mg, Vitamin B_{12}: 10 mg, Folic acid: 500 mg, Niacin: 15,00 mg, Calpan: 5000 mg, Biotin: 20 mg, Antioxidant: 125,000 mg, Cobalt: 200 mg, Selenium: 200 mg, Iodine: 1,000 mg, Iron: 40,000 mg, Manganese: 70,000 mg, Copper: 4,000 mg, Zinc: 50,000 mg, Choline chloride: 150,000 mg, SBC: Soyabean cake and PLM: Pawpaw Leaf Meal

(DM) content weighed samples were put into an oven at 105°C for 16 hrs. The DM was then determined based on weight loss. Macro Kjeldahl Method was used in determining the Nitrogen (N) content of the leaf meal sample and the crude protein was calculated as N×6.25. The ash content was determined as residue remaining after incinerating the sample at 600°C for 3 hrs in a muffle furnace.

Experimental diets: Five experimental diets were formulated for this experiment. Diet 1 served as control (0% PLM) while diets 2, 3, 4 and 5 contained 5, 10, 15 and 20% Pawpaw Leaf Meal, respectively. The composition of the experimental diets is shown in Table 1.

Experimental design and management of birds: One hundred and twenty, 6 weeks old Japanese quail birds were randomly allotted five dietary treatments with three replicates of 8 birds each in a Completely Randomized Design (CRD). All routine management practices and necessary biosecurity measures were carried out. Water and feed were administered *ad-libitum* throughout the experiment. The birds were housed in wooden cages with the floors covered with wood shavings as litter materials.

Data collection

Laying performance: The hens were weighed and allotted five dietary treatments and fed a quail layers diet containing graded levels of Pawpaw Leaf Meal. Egg production was recorded daily and pooled weekly to calculate Hen-Day Production (HDP) and Hen-Housed Production (HHP). Other eggs laying performance parameters measured include the average initial weight of the birds, the final weight, change in body weight, daily feed intake, total feed intake, FCR, the average weight of eggs, total number of egg production per bird, age at peak and percent egg production at peak. Analysis of the cost-benefit of using

Pawpaw Leaf Meal in the diet of quails was also carried out. Feed cost per dozen eggs, feed cost per crate of eggs, kg of feed/dozen eggs and income above feed cost were calculated for each dietary treatment:

$$\text{HDEP} = \frac{\text{Total number of eggs produced on a day}}{\text{Total number of hens present on that day}} \times 100$$

The average for the whole egg laying period of hen-day percent lay was calculated and termed as percent lay:

$$\text{HHEP} = \frac{\text{Total number of eggs produced by a flock}}{\text{Total number of hens housed}} \times 100$$

Egg quality: Eggs were collected twice daily (8:00 am and 5:00 pm), counted, weighed and recorded for each replicate. Three freshly laid eggs representing the average weight of eggs per replicate were used fortnightly to determine the egg quality parameters throughout the study. Egg weights were recorded after which they were carefully broken into a flat plate to assess the internal and external quality traits. The external egg quality parameters include the following: Eggs shape index, shell thickness, egg breadth, egg weight and egg length. The shell was washed with distilled water to remove adhering albumen and then dried at room temperature and subsequently weighed. Egg length and diameter were measured with vernier calliper and egg shape index was calculated as egg diameter divided by the length. The egg length was calculated as the distance between the two extreme points while the egg width was calculated as the diameter of the egg at its widest circumference to the nearest 0.01 mm. Eggshell weight and thickness were also measured using a digital electronic scale and micrometre screw gauge respectively. The yolk index was calculated as yolk diameter divided by yolk height. The Haugh unit which is the unit for describing the egg freshness, based on the thickness of the albumen was calculated from the measured height of the albumen and weight of the egg using the following formula proposed by Haugh[16]:

$$\text{HU} = 100 \log10 \text{ (h-1.7W 0.37+7.6)}$$

Where:
HU = Haugh unit
H = Observed height of the albumen in mm
W = Weight of egg in grams

Yolk Index: Egg yolk height and width were measured using a Vernier Calliper and the value so obtained was used to calculate the Yolk Index[17]:

$$\text{YI} = \frac{\text{YH}}{\text{YD}}$$

Where:
YI = Yolk index
YH = Yolk height
YD = Yolk diameter

Yolk colour: Yolk colour was determined using the Roche Yolk colour fan.

Shell percentage: Shell percentage was determined using the formula below[17]:

$$\text{Shell (\%)} = \frac{\text{Shell weight}}{\text{Egg weight}} \times 100$$

Yolk percentage: The yolk percentage was calculated using the formula below[17]:

$$\text{Yolk (\%)} = \frac{\text{Yolk weight}}{\text{Egg white}} \times 100$$

Egg shape index: The egg shape index was calculated as the percentage of the egg width to the length using the formula below[17]:

$$\text{Egg shape index (mm)} = \frac{\text{Width of egg}}{\text{Length of egg}} \times 100$$

Albumen index: Albumen index was calculated as follows[17]:

$$\text{Albumen index} = \frac{\text{H}}{0.5\ \text{D}}$$

Where:
H = Height of the thickness of albumen at the boundary with the Yolk
D = Average long and short diameters of albumen, measured on a smooth surface

Data analysis: Data generated were subjected to Analysis of Variance (ANOVA) using the general linear model procedure of Statistical Analysis System (SAS, Version 9.00 TS Level 00M0, XP_PRO Platform Licensed to SUNY AT STONY BROOK., Site 0013402001 https://www.sas.com/en_us/home.html). Significant differences between treatment means were separated using the Duncan Multiple Range Test in the SAS package.

RESULTS

Proximate and anti-nutritional factor composition of Pawpaw Leaf Meal: The result of proximate and anti-nutritional factor composition of Pawpaw Leaf Meal is presented in Table 2. The result showed that pawpaw leaves have high crude protein (26.78%), crude fibre (10.22%) carbohydrates (49.01%) and mineral (12.93%) content. The leaves have high content of saponins (17.80 mg/100 g) and oxalate (1.62 mg/100 g) compared to tannins (0.07 mg/100 g) and phytate (0.30 mg/100 g).

Laying performance and economic benefits of Japanese quails raised with diets containing a graded level of Pawpaw Leaf Meal: The result of the effects of diets containing Pawpaw Leaf Meal (PLM) on the laying performance of Japanese quails is presented in Table 3. The result showed that there were significant ($p<0.05$) differences in all the parameters measured across all treatment groups. The final weight was significantly ($p<0.05$) higher in birds fed a diet containing a 5% PLM-based diet but similar to those in the control group. Other treatment groups were similar in the final weight. Birds on a 5% PLM-based diet recorded a significant ($p<0.05$) positive change in body weight while other treatment groups had negative body weight changes. Average daily feed intake was significantly ($p<0.05$) higher in birds fed a 5% PLM-based diet when compared to that of birds fed a 15% and 20% PLM-based diet. Average Daily Feed Intake was however similar among birds fed 0, 5 and 10% PLM-based diet. Feed Conversion Ratio was significantly ($p<0.05$) lower and better in birds fed a 5% PLM-based diet and in the control group when compared to birds on 10 and 15% PLM-based diets. Birds on 20% PLM-based diets had the highest value of FCR. Age At Peak Lay (AAPL) was significantly ($p<0.05$) lower in other treatment groups except for the control group which attained peak production lately.

Hen housed egg production and hen day egg production were significantly ($p<0.05$) higher in birds fed the control diet and 5% PLM-based diet followed by those fed a 10% PLM-based diet. Birds fed 15 and 20% PLM-based diets had the least percentage of HHEP and HDEP.

Table 2: Proximate and anti-nutritional factor composition of Pawpaw Leaf Meal

Parameters	Pawpaw Leaf composition (%)
Proximate composition (%)	
Dry matter	92.65
Crude protein	26.78
Crude fibre	10.22
Ether extract	1.06
Nitrogen free extract	49.01
Ash	12.93
Anti-nutrient factors (mg 100 g^{-1})	
Tannins	0.07
Saponins	17.80
Oxalate	1.62
Phytate	0.30

Values are means of two separate laboratory determinations

Table 3: Laying performance and economic benefits of Japanese quails raised with diets containing the graded level of Pawpaw Leaf Meal

	Inclusion levels of Pawpaw Leaf Meal (%)					
Parameters	0	5	10	15	20	SEM
Initial weight (g/bird)	159.33^{a}	158.71^{a}	155.42^{bc}	158.25^{ab}	153.63^{c}	1.48
Final weight (g/bird)	140.04^{ab}	174.67^{a}	128.08^{b}	104.21^{b}	115.63^{b}	18.26
Change in BW (g/bird)	-19.29^{b}	15.96^{a}	-27.33^{b}	-54.04^{b}	-38.00^{b}	18.38
ADFI (g/b)	29.40^{ab}	31.03^{a}	30.03^{ab}	26.10^{c}	28.67^{b}	1.02
FCR	5.98^{a}	5.63^{a}	8.24^{b}	8.82^{b}	12.93^{c}	0.44
AAPL (days)	67.67^{a}	66.00^{ab}	54.67^{ab}	53.33^{ab}	52.33^{b}	7.63
AEW (g)	10.00^{a}	10.00^{a}	9.00^{ab}	9.00^{ab}	8.66^{b}	0.30
HHEP (%)	63.33^{a}	70.29^{a}	51.08^{b}	41.71^{c}	32.50^{c}	4.64
HDEP (%)	85.88^{a}	80.53^{a}	68.11^{b}	66.73^{b}	43.46^{c}	3.70
Total egg number	63.33^{a}	70.29^{a}	51.08^{b}	41.71^{c}	32.50^{c}	4.64
Total egg weight (g/bird)	633.33^{a}	702.92^{a}	459.75^{b}	374.17^{b}	281.13^{c}	46.07
Feed/12 egg (kg)	0.72^{a}	0.68^{a}	0.89^{b}	0.95^{b}	1.34^{c}	0.05
Cost/kg feed (₦)	122.67	118.60	113.58	111.09	107.06	0.87
Cost/12 egg (₦)	113.87^{a}	106.22^{a}	140.67^{b}	154.56^{b}	214.60^{c}	8.23
Cost/30 egg (₦)	284.67^{a}	265.54^{a}	351.68^{b}	386.41^{b}	536.51^{c}	20.58

a,ab,b,c: Means with different superscripts on the same row are significantly different ($p<0.05$), ADFI: Average daily feed intake, FCR: Feed conversion ratio, AAPL: Age at peak lay, AEW: Average egg weight, HHEP: Hen housed egg production, HDEP: Hen day egg production, SEM: Standard error of means

Total egg number and total egg weight were significantly ($p<0.05$) lower in birds fed 15 and 20% PLM-based diets but highest in birds fed the control diet and 5% PLM-based diets. Birds fed 10% PLM-based diets differed from all other treatment groups. The quantity of feed required to produce a dozen eggs (feed/12 eggs) was significantly ($p<0.05$) lower in birds fed a 5% PLM-based diet and the control diet but highest in birds fed 20% PLM-based diets. Feed cost per dozen eggs and feed cost per crate of eggs were significantly ($p<0.05$) lower in birds fed the control diet and 5% PLM-based diet when compared to other treatment groups. Birds fed a 20% PLM-based diet had the highest feed cost/12 egg and feed cost/30 eggs.

Effect of diets containing a graded level of Pawpaw Leaf Meal on external and internal quality of Japanese quail eggs: The result of the effects of diets containing Pawpaw Leaf Meal (PLM) on the external and internal quality of Japanese quail eggs is presented in Table 4. Egg weight and length were significantly ($p<0.05$) higher in birds fed the control diet and diets containing 5% PLM than those birds on 10, 15 and 20% PLM-based diets which were similar.

Egg width (24.67 mm) was significantly ($p<0.05$) highest in birds on a 5% PLM-based diet compared to those of birds on diets containing 10, 15 and 20% PLM but similar to that of birds on the control diet (24.37 mm). Eggshell weight was significantly ($p<0.05$) higher in birds on 0 and 5% PLM-based diets

Table 4: Effect of diets containing a graded level of Pawpaw Leaf Meal on external and internal quality of Japanese quail eggs

	Inclusion levels of Pawpaw Leaf Meal (%)					
Parameters	0	5	10	15	20	SEM
Egg weight (g)	10.00[a]	10.00[a]	8.67[b]	9.00[b]	8.67[b]	0.21
Egg length (mm)	31.63[a]	32.17[a]	30.30[b]	29.80[b]	29.93[b]	0.35
Egg width (mm)	24.37[ab]	24.67[a]	23.87[b]	23.50[b]	23.60[b]	0.27
Eggshell weight (g)	0.89[a]	0.86[a]	0.80[b]	0.67[c]	0.67[c]	0.02
Eggshell thickness	0.29[a]	0.25[c]	0.28[ab]	0.27[b]	0.26[bc]	0.01
Albumen length	42.10[ab]	42.63[a]	38.33[c]	39.97[bc]	37.33[c]	1.23
Albumen diameter	31.13[ab]	31.90[a]	29.83[bc]	30.23[bc]	29.60[c]	0.65
Albumen weight	5.76[a]	5.92[a]	4.83[c]	5.32[b]	5.37[b]	0.19
Albumen height	0.43[a]	0.41[c]	0.43[a]	0.43[a]	0.42[b]	0.01
Yolk height	10.70[ab]	10.43[ab]	10.27[b]	10.37[ab]	10.77[a]	0.24
Yolk diameter	22.97[ab]	23.70[a]	22.67[b]	22.87[ab]	22.57[b]	0.47
Yolk weight	2.96[ab]	3.08[a]	2.71[bc]	2.61[c]	2.46[c]	0.14
Egg shape index	0.77	0.77	0.79	0.79	0.79	0.58
Yolk index	0.47[ab]	0.44[c]	0.45[bc]	0.45[bc]	0.48[a]	0.01
Albumen index	2.66[a]	2.60[ab]	2.60[ab]	2.60[ab]	2.51[b]	0.08
Shell (%)	8.80[a]	8.57[a]	9.23[c]	7.44[c]	7.76[bc]	0.27
Yolk (%)	51.45	52.13	54.26	49.16	48.16	3.14
Yolk colour	5.11[c]	9.78[b]	11.00[ab]	11.44[a]	12.11[a]	0.62
Haugh unit	86.30[b]	86.08[c]	86.50[a]	86.44[a]	86.49[a]	0.04

[a,ab,b,bc,c]: Means with different superscripts on the same row are significantly different ($p<0.05$) and SEM: Standard error of means

followed by birds on 10% PLM-based diets. Birds on 15 and 20% PLM-based diets recorded similar eggshell weights which were the least. Eggshell thickness was significantly ($p<0.05$) higher in eggs from birds fed the control diet compared to other treatments but comparable to those on a 10% PLM-based diet.

Egg albumen length and diameter from birds on a 5% PLM-based diet were significantly ($p<0.05$) higher when compared to those on other treatments but similar to that of the control group. The weight of albumen was significantly ($p<0.05$) lower than eggs of birds on the control diet and 5% PLM-based diet compared to other treatments. Height of albumen was significantly ($p<0.05$) higher in eggs of birds on 0, 10 and 15% PLM-based diets than those on 20 and 5% PLM which also varied. Yolk height was significantly higher in T_5 (20% PLM) but similar in T_1 (0% PLM), T_2 (5% PLM) and T_4 (15% PLM). The least value was recorded in T_3 (10% PLM). Yolk diameter was significantly ($p<0.05$) higher in birds on a 5% PLM-based diet and is comparable to those on 0 and 15% PLM but varied from that of 10 and 20% PLM-based diets. Yolk weight was significantly ($p<0.05$) lower and comparable in eggs of birds fed a 10, 15 and 20% PLM-based diet when compared to those on 5 and 0% PLM which gave the highest yolk weight. Pawpaw Leaf Meal had no significant ($p>0.05$) effect on the egg shape index of Japanese quail eggs. Yolk index was significantly ($p<0.05$) higher in birds fed a 20% PLM-based diet compared to other treatments but similar to that of the control group PLM. Birds on a 10 and 15% PLM-based diet recorded a yolk index that was comparable to that of the control group and a 5% PLM inclusion level. Albumen index was significantly ($p<0.05$) higher in eggs from the control group compared to those of birds on a 20% PLM-based diet but similar to eggs from birds on 5, 10 and 15% PLM-based diets. Shell percentage was significantly ($p<0.05$) higher in eggs from birds on the control diets and those fed diets containing 5% PLM compared to the other treatments.

Yolk percentage was not significantly ($p>0.05$) affected by the inclusion of PLM in the diet of Japanese quails. The Haugh unit computed to determine albumen quality was significantly ($p<0.05$) higher in birds fed 10, 15 and 20% PLM-based diets when compared to birds on the control diet and 5%, PLM-based diet. The least value was observed in birds fed diet containing 5% PLM.

DISCUSSION

The result of the proximate composition of Pawpaw Leaf Meal showed that pawpaw leaves have high crude protein (26.78%), crude fibre (10.22%) carbohydrates (49.01%) and mineral (12.93%) content. The crude protein content obtained for pawpaw leaf is 26.78% which is lower than the 30.12% reported by Onyimonyi and Ernest[18] 28.20% by Ebenebe *et al.*[19], 29.8% by Kanyinji *et al.*[20] and 32.6% by Oloruntola *et al.*[21]. It was however comparable to the value of 25.30% reported by Unigwe *et al.*[22], 26.14% by Oloruntola *et al.*[21]. The variation could be attributed to the difference in geographical location, season and nutrient status of the soil. The high protein content of PLM suggests its suitability and utilization as a protein supplement in diets for birds[18].

The Crude Fibre (CF) content of 10.22% obtained in this study is high when compared to 5.60% reported by Onyimonyi and Ernest[18] 8.86% by Unigwe *et al.*[22] but lower than 11.40, 12.00 and 12.93% observed for cassava, neem and mucuna leaves, respectively[9,23,24]. The relatively low fibre of PLM is indicative of its potential as feedstuff for poultry birds when included at the optimum level. The ash content of 12.93% obtained in this study is higher than the value of 8.88% reported by Unigwe *et al.*[22], but lower than 16.05% reported by Oloruntola *et al.*[21]. The relatively high content of ash is a reflection of its deposit of mineral elements[25]. These various reports may arise from the natural variability of plant secondary metabolite and chemical compositions[22,26].

The result of anti-nutrient composition revealed that PLM contains Tannin (0.07 mg/100 g), Saponin (17.80 mg/100 g), Oxalate (1.62 mg/100 g), Phytate (0.30 mg/100 g). Oloruntola *et al.*[21] also reported that PLM contain saponin (16.90 g kg^{-1}), tannin (0.01 g kg^{-1}), phytate (20.18 g kg^{-1}), oxalate (6.11 g kg^{-1}). The presence of ANF in PLM was also reported by Oche *et al.*[27] with the leaf having saponin (3.84 mg/100 g), phytate (6.98 mg/100 g), Oxalate (0.18 mg/100 g), tannin (0.55 mg/100 g). From this finding, the Pawpaw is reported to contain an appreciable amount of saponin as suggested by other researchers. However, the variation in concentration could be due to the type of leaves analysed or the stage of harvesting of the leaves since younger leaves are known to contain lower ANF contents compared to older leaves.

The significantly higher final weight and percent change in body weights observed in birds fed a diet containing 5% PLM may be due to good nutrient utilization as protein in PLM complemented that of soybean without considerable fibre increase leading to improved weight gain. It also showed that incorporating PLM at a lower level resulted in higher nutrient utilization and improved weight gain. This result conforms with the findings of Onyimonyi and Ernest[18] who fed diets containing 4% PLM to broilers birds and observed a significant increase in final weight as compared to the control. However, feeding a higher percentage of PLM tends to negatively affect growth as observed in this study. This could be attributed to the increased fibre level in the diet of birds fed a higher percentage of PLM as fibre is known to be poorly digested by poultry species and thus its higher percentage in the diet interferes with nutrient digestion and absorption which leads to depressed growth as suggested by Iheukwumere *et al.*[9].

The higher average daily feed intake observed in birds fed diets containing 5% PLM could be attributed to optimum fibre level which did not affect digestion time and thus resulted in more intake. Forbes[28] observed that the composition and availability of nutrients, the concentration of protein, fibre level, the balance of amino acids and deficiency or excess of minerals or vitamins can all affect feed intake. It is, therefore, possible that components in PLM such as proteolytic enzymes (Papain, Chymopapain A and B and Papaya Peptidase) may have created an enabling gut environment suitable for the release and absorption of digestible nutrients, hence the increased feed intake observed in this study when PLM was not high. The poor feed intake observed in birds fed higher levels of PLM agrees with the findings of Herbert[29] and Onwudike[30], who reported that feed intake was depressed with increasing dietary levels of various leaf meals. The significantly better feed conversion ratio observed in birds fed the control diet and those on a 5% PLM-based diet implies that feed was converted more efficiently into gains in terms of tissue and eggs produced by birds in these treatment groups. Good nutrient utilization facilitated by the optimum fibre level and proteolytic enzymes in PLM may have produced an enabling gut environment fitting for the digestion and absorption of nutrients required for egg production. However, the feed conversion ratio observed in this study did not compare favourably with the values reported for laying quails fed varying levels of protein by Bawa *et al.*[31]. This variation could be attributed to the management system and age of the birds. The comparable values of age at peak lay and average egg weights obtained in birds fed the control diet and diets containing 5% PLM and those on 10 and 15% PLM-based diets suggested balanced and efficient feed nutrient utilization by birds across the treatments. Hen housed egg production and hen day egg production was highest and comparable among birds fed the control diet and 5% PLM-based diet. This is closely in agreement with the report of Setu *et al.*[32], who fed papaya leave suspension to Japanese quails. This shows that the inclusion of PLM at 5% in the diet of Japanese quails is capable of supporting egg production. The least values obtained in birds fed a 20% PLM-based diet show that higher fibre and saponin levels might cause poor performance and/or deleterious effects on egg production. The significantly higher egg number and egg weight recorded in birds fed the control diet and 5% PLM-based diet further corroborate the observation that PLM when included at optimum level facilitates egg production and good eight weight as observed in this study and the findings of Setu *et al.*[32], who fed diets containing papaya leave suspension in quails.

Feed cost per dozen eggs (FC/12 Egg) was significantly lower and better in birds fed 5% PLM-based diets. This observation could be an indication of cost-effectiveness and may be attributed to a reduction in the cost of feed required to produce a dozen eggs and crate of eggs, respectively. This was further substantiated by the cost of feed required to produce 12 and 30 eggs which were significantly lower in birds fed diets containing 5% PLM. It was, therefore, more economical to produce a dozen and a crate of eggs with a diet containing 5% PLM compared to diets containing 10, 15 and 20% PLM.

The significant differences in egg weight, egg length and egg width observed from birds on the control diet and those fed a 5% PLM-based diet suggest that optimum inclusion of PLM in the diet of laying quails enhances egg weight. This agrees with the findings of Setu *et al.*[32], who reported improved egg weight in a group of birds supplied with papaya leaf suspension than the group with a normal diet. Albumen length, diameter, weight and eggshell weight were all significantly higher in birds fed 5% PLM which implies that when PLM is fed at an optimum level it does have a positive effect on these parameters as observed in this study. This finding disagrees with the report of Akintunde *et al.*[33], who reported no significant differences in internal egg quality traits of quails fed differently processed pigeon pea meal. The variation could be attributed to differences in diet composition. This finding however agreed with the report of Olayinka *et al.*[34], who reported significant differences across internal egg quality traits of quails fed garlic meal. Albumen height, yolk height, yolk weight, yolk index, albumen index and Haugh unit were all significantly affected by the inclusion of PLM. This corroborates with the report of Akande *et al.*[35] also observed improvement in egg characteristics of birds fed diets containing up to 7.5% *Tephrosia bracteolate* leaf meal. This however does not agree with the reports of Odunsi[36] and Akkaya *et al.*[37] that supplementations with *Lablab purpureum* and peppermint leaf meal had no significant effect on the internal egg characteristics of laying birds. This implies that the production ability to lay birds and internal egg quality traits could vary due to the active components present in the different leaf meals.

However, egg shape index and yolk percentage were not significantly affected by the inclusion of PLM in the diet of laying Japanese quails. Yolk colour was significantly affected by the inclusion of PLM in the diet of quails. The colour score increases as the level of PLM increases. This corroborates with the findings of Esonu *et al.*[23], who reported that leaf meal inclusion in diets of layer birds could positively affect the colour of egg yolk. Muhammad *et al.*[38] also reported an increase in colouration with an increase in the level of neem leaf meal.

Based on the above discussion, the inclusion of PLM at 5% in the diet of growing and laying Japanese quails is recommended for better growth and laying performance, farmers should include PLM at 5% in the diet of Japanese quails as it is cost and energy saving and poses no deleterious threat to performance and health status of quail birds.

The research was able to establish that the inclusion of Pawpaw Leaf Meal at 5% in the diet of Japanese quails helped improve laying performance by 10.99% when compared to the control. This suggests that Pawpaw Leaf Meal can be incorporated into the diet of quails to optimize production and enhance farmer profit.

One of the few limitations of this research includes the lack of prior research studies on the topic and due date which could not allow devoting more time to further collect data over a long period. However, despite this, the research will serve as one of the few pilot studies that will help form a foundation for understanding the use of Pawpaw Leaf Meal on laying Japanese quails.

CONCLUSION

From the results obtained in this study, it can be concluded that the inclusion of PLM at 5% helps improve laying performance and internal quality traits of quail eggs while 20% PLM inclusion can affect laying performance negatively. Also, the inclusion of PLM at 5% can help scale down cost while improving performance concurrently for laying birds.

SIGNIFICANCE STATEMENT

This study discovers the optimum level (5%) of Pawpaw Leaf Meal to be used in enhancing the laying performance of Japanese quails. The study will also serve as one of the foundational research on the use of Pawpaw Leaf Meal on laying Japanese quails. The study was also able to establish Pawpaw Leaf as a good source of unconventional plant protein for livestock feed which can help reduce the cost of feed and enhance farmers' profit by partially replacing soybean.

REFERENCES

1. Yisa, A.G., B. Yakubu, J.A. Edache, M.N. Danjuma and H.I. Deme, 2013. Effect of graded levels of toasted pigeon pea [*Cajanus cajan* (L.) Millsp] seed meal diets on growth performance and carcass characteristics of japanese quails (*Coturnix coturnix japonica*). Int. J. Poult. Sci., 12: 121-125.
2. Edache, J.A., U. Musa, E.S. Haruna, J.O. Esilonu, I. Jibrin, E.J. Okpala and I.G. Dogo, 2005. Replacement value of guinea corn for maize in practical diet fed to quail (*Coturnix coturnix japonica*) chicks. Anim. Res. Int., 2: 311-313.
3. Oluyemi, J.A. and F.A. Roberts, 1979. Poultry Production in Warm Wet Climates. Macmillan, London, ISBN: 9780333253120, Pages: 197.
4. Olubamiwa, O., E.S. Haruna, U. Musa, T.O. Akinwale, I.H. Lombin and O.G. Longe, 1999. Effects of different energy levels of cocoa based diets on the productive performance of Japanese Quail. Niger. J. Anim. Prod., 26: 88-92.
5. Abubakar, A., H.M. Tukur, A.A. Sekoni and W.A. Hassan, 2007. Performance and egg quality characteristics of laying birds fed diets containing rice bran with and without yeast supplementation. Asian J. Anim. Sci., 1: 1-9.
6. Agbede, J.O. and V.A. Aletor, 2003. Evaluation of fish meal replaced with leaf protein concentrate from glyricidia in diets for broiler-chicks: Effect on performance, muscle growth, haematology and serum metabolites. Int. J. Poult. Sci., 2: 242-250.
7. Farinu, G.O., A.A. Odunsi, J.O. Akinola and V.A. Togun, 1999. Yield and chemical composition of wild sunflower (*Tithonia diversifolia hemsl A. Gray*) and the feeding value of wild sunflower forage meal in broiler chicken diets. Trop. J. Anim. Sci., 2: 31-37.

8. Nworgu, F.C., S.A. Ogungbenro and K.S. Solesi, 2007. Performance and some blood chemistry indices of broiler chicken served fluted pumpkin (*Telfaria occidentalis*) leaves extract supplement. Am.-Eurasian J. Agric. Environ. Sci., 2: 90-98.
9. Iheukwumere, F.C., E.C. Ndubuisi, E.A. Mazi and M.U. Onyekwere, 2008. Performance, nutrient utilization and organ characteristics of broilers fed cassava leaf meal (*Manihot esculenta* Crantz). Pak. J. Nutr., 7: 13-16.
10. Onyimonyi, A.E., A. Olabode and G.C. Okeke, 2009. Performance and economic characteristics of broilers fed varying dietary levels of neem leaf meal (*Azadirachta indica*). Int. J. Poult. Sci., 8: 256-259.
11. Singh, P., S. Maqsood, M.H. Samoon, V. Phulia, M. Danish and R.S. Chalal, 2011. Exogenous supplementation of papain as growth promoter in diet of fingerlings of *Cyprinus carpio*. Int. Aquat. Res., 3: 1-9.
12. Ampode, K.M.B., 2019. Papaya (*Carica papaya* Linn.) leaf meal as phytobiotic feed supplement improves the production performance of growing Japanese quails. Int. J. Biosci., 14: 533-540.
13. Maisarah, A.M., R. Asmah and O. Fauziah, 2014. Proximate analysis, antioxidant and antiproliferative activities of different parts of *Carica papaya*. J. Nutr. Food Sci., Vol. 4.
14. Dada, B.M., E.C. Okogbue, V.O. Ajayi, S.O. Agele and A.M. Yamusa, 2021. Inter-annual variation of weather pattern in the semi arid region of Nigeria and its implication on sorghum production. Int. Res. J. Innovations Eng. Technol., 5: 51-66.
15. Aurand, L.W., A.E. Woods and M.R. Wells, 1987. Sampling and Proximate Analysis. In: Food Composition and Analysis, Aurand, L.W., A.E. Woods and M.R. Wells (Eds.), Springer, Dordrecht, Netherlands, ISBN: 978-94-015-7400-6, pp: 19-34.
16. Eisen, E.J., B.B. Bohren and H.E. McKean, 1962. The Haugh unit as a measure of egg albumen quality. Poult. Sci., 41: 1461-1468.
17. Nuhu, B.T., M.A. Adelanwa, M.R. Hassan and S. Duru, 2018. Egg quality parameters and blood biochemical profile of six strains of poultry under extensive management system in Nigerian Savanna. Niger. J. Anim. Sci., 20: 72-80.
18. Onyimonyi, A.E. and O. Ernest, 2009. An assessment of pawpaw leaf meal as protein ingredient for finishing broiler. Int. J. Poult. Sci., 8: 995-998.
19. Ebenebe, C.I., O. Itefue, T.C. Ebere-Ohameje and J.C. Okonkwo, 2011. Fortification of the nutritive value of mushroom (*Termitomyces microcarpus*) with paw-paw leaf meal for broiler chicks diet. Pak. J. Nutr., 10: 155-158.
20. Kanyinji, Francisco, Zulu and Chionile, 2014. Effects of partially replacing soybean meal in grower diets with pawpaw (*Carica papaya*) leaf meal on nutrient digestibility and growth performance of Japanese quails (*Cortunix japonica*). Int. J. Livest. Res., 4: 7-14.
21. Oloruntola, O.D., S.O. Ayodele and D.A. Oloruntola, 2018. Effect of pawpaw (*Carica papaya*) leaf meal and dietary enzymes on broiler performance, digestibility, carcass and blood composition. (French) Rev. d`elevage Med. Vet. Pays Trop., 71: 121-129.
22. Unigwe, C.R., U.P. Okorafor, U.M. Ogbu and O.C. Nwufoh, 2014. The nutritive profile of sun-dried paw-paw (*Carica papaya*) leaf meal and its effect on the growth performance of broiler chickens. Int. J. Pure Appl. Sci. Technol., 20: 72-78.
23. Esonu, B.O. and I.C. Okoli, N.M. Opara, H.O. Obikaonu, C. Udedibie and O.O.M. Iheshiulor, 2006. Physiological response of laying birds to neem (*Azadirachta indica*) leaf meal-based diets: Body weight organ characteristics and haematology. Online J. Health Allied Sci., Vol. 5.
24. Emenalom, O.O., E.B. Etuk, B.O. Esonu and C. Anaba, 2009. Effect of *Mucuna pruriens* (velvet bean) leaf meal on performance and blood composition of finisher broiler chickens. Niger. J. Anim. Prod., 36: 52-60.
25. Antia, B.S., E.J. Akpan, P.A. Okon and I.U. Umoren, 2006. Nutritive and anti-nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. Pak. J. Nutr., 5: 166-168.
26. Nahak, G., M. Suar and R.K. Sahu, 2014. Antioxidant potential and nutritional values of vegetables: A review. Res. J. Med. Plant, 8: 50-81.

27. Oche, O., A. Rosemary, O. John, E. Chidi, S.M. Rebecca and U.A. Vincent, 2017. Chemical constituents and nutrient composition of *Carica papaya* and *Vernonia amygdalina* leaf extracts. J. Complementary Altern. Med. Res., Vol. 2. 10.9734/JOCAMR/2017/29402.
28. Forbes, J.M., 1986. The Voluntary Food Intake of Farm Animals. Butterworth-Heinemann, United Kingdom, ISBN: 978-0-408-11154-6, Pages: 206.
29. Herbert, U., 1998. Reproductive performance of rabbit does fed diets containing gliricidia leaf meal from conception through weaning of kits. Niger. J. Anim. Prod., 25: 163-168.
30. Onwudike, O.C., 1995. Use of the legume tree crops *Gliricidia sepium* and *Leucaena leucocephala* as green feeds for growing rabbits. Anim. Feed Sci. Technol., 51: 153-163.
31. Bawa, G.S., L.H. Lombin, P. Musa, U. Payi and D. Shamaki, 2021. Response of Japanese breeder quails to varying dietary protein levels in the tropics. Niger. J. Anim. Prod., 38: 43-54.
32. Setu, S.A., R. Islam, M.M. Hasan, F.B. Aziz and A.S.M.A. Saeed, 2018. Effect of papaya leaves (*Carica papaya*) suspension on Japanese quail (*Coturnix japonica*). Indian J. Pharm. Pharmacol., 5: 141-145.
33. Akintunde, A.R., J.J. Omage, G.S. Bawa, M.O. Oguntoye and A.O. Atanda, 2017. Effect of diets containing raw and processed pigeon pea seed meal on external and internal egg quality characteristics of laying quails (*Coturnix coturnix japonica*) Ke. Niger. J. Anim. Prod., 44: 70-77.
34. Olayinka, O.I., G.S. Bawa, F.O. Abeke and M. Afolayan, 2022. Comparative evaluation of garlic (*Allium sativum*) meal as natural feed additives on egg production and egg quality of laying Japanese quails. Niger. J. Anim. Sci. Technol., 5: 47-55.
35. Akande, T.O., M.K. Adeyeri and O.G. Longe, 2008. Nutritional and economic value of leaf meal (*Tephrosia bracteolata*) in diet of laying hens. J. Anim. Vet. Adv., 7: 784-788.
36. Odunsi, A.A., 2003. Assessment of lablab (*Lablab purpureus*) leaf meal as a feed ingredient and Yolk colouring agent in the diet of layers. Int. J. Poult. Sci., 2: 71-74.
37. Akkaya, A.B., C. Uyarlar, I.S. Cetingul, I. Bayram and M. Yardimci, 2008. Effect of peppermint (*Mentha piperita*) on performance, hatchability and egg quality parameters of laying quails (*Coturnix coturnix japonica*). J. Anim. Vet. Adv., 7: 1489-1494.
38. Muhammad, M., S. Peter, G. James and A. Wosilat, 2015. Growth performance of growing quails (*Coturnix japonica*) fed graded levels of neem. Int. J. Appl. Res., 1: 4-7.