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*)

*****Francisco Kanyinji and Chionile Zulu

Natural Resources Development College, Animal Sciences Department, Great East Road, Chelston, Lusaka, ZAMBIA.

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*Corresponding author: Francisco Kanyinji (Dr.),

Natural Resources Development College,

Animal Sciences Department,

P.O. BOX 310099, Chelstone, Lusaka, Zambia.

Tel: +260963884674 or +260971582990.

E-mail : fkanyinji@yahoo.com or Kanyinji@zambia.co.zm

Abstract;

This study assessed nutrient digestibility and growth performance in Japanese quails (*Cortunix japonica*) fed diets with 0, 2, 4 and 6% of pawpaw (*Carica papaya*) leaf meal (PLM) as a protein sources. Fresh pawpaw leaves were collected, dried under a shade to a crispy feel, pounded into a fine PLM. The PLM was used to formulate diets in which it replaced soybean meal at 0, 2, 4 and 6%. Thereafter, 108 three-weeks-old quails were individually weighed, divided into four groups based on body weights, and groups randomly assigned 0, 2, 4 and 6% PLM-diets. These diets and cleaning drinking water were supplied to birds *ad libitum* until 42d of age. Feed intake, weight gain, body weights, feed conversion ratios (FCR), and digestibility of dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and nitrogen free extract (NFE) were assessed. Feed intake, weight gain, body weights, FCR, and digestibility of DM, CP, CF, EE, and NFE significantly improved with increase in PLM content in the diets. Birds fed 6% PLM-diet were superior ($p < 0.05$) in all these parameters, followed by those in 4% PLM group. No significant differences were observed between control and 2% PLM-diet fed birds. Thus, partially replacing soybean meal with PLM improved nutrient digestibility and growth performance of quails, and optimal results were achieved at 6% PLM replacement level.

Key words: Pawpaw leaf meal; papain enzyme; nutrient digestibility.

INTRODUCTION

For a long time, the poultry industry in Zambia has been dominated largely by broiler and egg layer chicken production. In the recent past, however, rearing of Japanese quail (*Cortunix japonica*) for meat has been fast-gaining prominence in the poultry sector of the country. These birds have a shorter generation interval (Odunsi et al. 2007), lower feed requirement, and a lower production cost (Ojo et al., 2011) than chickens. However, the major constraint to expand quail production in Zambia is the high cost of feed protein ingredients such as soybean cake/meal and fish meal. Their prices negatively affect the cost of compounded quail feeds, reducing the profit margin farmers. This, therefore, discourages many would-be-quail farmers from taking it up.

A possible solution to escalating cost of feeds that has been suggested is greater utilization of potential alternative feed ingredients, such as leaf meals (Odunsi et al., 1999; Nworgu et al., 2007; Iheukwumere et al., 2008; Onyimonyi et al., 2009), as replacement for the more expensive soybean cake/meal and fish meal. Incorporating leaf meals in poultry diets would not only serve as a protein source, but also provide some vitamins, minerals and oxycarotenoids which may improve egg and carcass quality of quails as observed in chickens by D'Mello et al. (1987) and Opara (1996).

Pawpaw (*Carica papaya*) leaves have the potential to supply dietary proteins required by quails. This is because they have high crude protein (CP) content of at least 30% and low (~5%) crude fiber contents (Opara, 1996; Onyimonyi and Onu, 2009). Additionally, they contain papain, a natural enzyme that aids in the digestion of proteins (Singh et al., 2011) in the digestive tract. Thus, pawpaw leaf meal (PLM) may not only supply dietary proteins required by quails, but also provide herbal proteolytic enzymes to enhance digestibility of ingested feed in the tract, and accelerate their growth. However, leaf meals are known to negatively affect nutrient utilization in monogastric animals such as birds, by diluting macronutrients (Longe and Ogedengbe, 1989;

Sobayo et al., 2012). Thus, while replacement of soybean meal with PLM may be able to obviate the cost of feeding quails, the same may not be said of its impact on nutrient utilization and their growth performance.

Therefore, the aim of this study was to determine the effects of partially replacing soybean meal in quail diets with graded levels of PLM on nutrient digestibility and growth performance of Japanese quails (*Cortunix japonica*).

MATERIALS AND METHODS

Preparation of PLM and experimental diets

Fresh tender pawpaw leaves were collected, dried in the shade to a crispy feel, pounded and sieved to a fine PLM. The PLM was used to formulate four quail diets that contained 0, 2, 4 and 6% PLM as partial replacement for soybean meal. Thereafter, 150d-old unsexed Japanese quails (*Cortunix japonica*) were housed in a ventilated card box with an electric bulb and fed a commercial starter diet (Novatek Animal Feeds Ltd, Lusaka, Zambia) for 21d. On the 22nd d, the birds were individually weighed, and 108 of them were selected based on body weights and divided into four treatment groups of 27 quails (n = 27) each. These groups were randomly allotted to grower diets with 0 (control), 2, 4 or 6% PLM. Clean drinking water and the trial diets were supplied to the birds *ad libitum* until 42d of age.

Data collection and analysis

Body weights of the birds were recorded at 21, 28, 35 and 42d of age. Total feed leftover by birds in each group was measured daily before putting in fresh feed to determine intake. Weight gains and feed conversion ratios (FCR) were also assessed. FCR were calculated as amount of feed (kg/week) consumed for one kg of weight gained (kg/week). At 42d of age, 5 birds per treatment were randomly chosen and put in individual metabolic cages for a digestibility trial. Total fecal output and orts for each bird were measured daily for 5d (after a 4d acclimatization period), and a representative sample of feces and orts were taken for laboratory analysis. Dried samples of orts and feces were ground through a 1mm mesh sieve, pooled per treatment on a 5d basis and analyzed for dry matter (DM; 105^{o}C for 24 hrs), crude fiber (CF), ether extract (EE), and nitrogen, as outlined by AOAC, (1990), I.D. No 962.09, 920.39, and 984.13, respectively. Data collected was analyzed by the general linear model (GLM) procedure of SAS (2002), with treatment and level of PLM inclusion as factors based on the mathematical model;

$$Y_{ijk} = \mu + Ti + L_j + P_j + \varepsilon_{ijk}$$

where: $Y_{ijk}$is the observation; μ is the overall mean, T_i the fixed effect of treatment, L_i is the random effect of inclusion level within T_i, and ε_{ijk} is the random error. Means were compared using Tukey test (SAS, 2002).

RESULTS AND DISCUSSION

The results of proximate composition of the PLM used in the study are shown in Table 1. Its CP content was 298.9g/kg DM, which was comparable to 301.2g/kg DM reported by Onyimonyi and Onu (2009), but higher than other types of leaf meals evaluated by Esonu et al. (2002), Iheukwumere et al. (2008), and Onyimonyi et al. (2009). The CF content of PLM was 53.6g/kg DM which was also close to 56g/kg DM determined by Onyomonyi and Onu (2009). The relatively high CP content and low CF levels compared to other leaf meals indicate the suitability potential of PLM to be used as a protein source in diets for monogastric animals such as quails.

Data on the performance characteristics of quails fed diets with 0 (control), 2, 4 and 6% PLM are shown in Table 3. Generally, there were significant improvements in body weights, feed consumption, weight gains and FCR with increase in the level of PLM in the diets. Quails fed diets with 6% PLM exhibited superiority ($p < 0.05$) in all the parameters assessed, followed by those in the 4% PLM treatment group, while birds fed control and 2% PLM-diets were similar ($p > 0.05$) in terms of body weights, feed intake, weight gain and FCR. Body weights, daily feed intake, and weight gains for quails fed 6% PLM diets were 173.8, 21.9, and 3.0g/b/d, respectively, which were significantly lower than 159.5, 16.1, and 2.1g/b/d for birds fed 0 (control), 2, and 4% PLM diets, respectively. The same birds on 6% PLM diets had an FCR of 7.3, which was better ($p < 0.05$) than 7.7, 7.4 and 7.6 for those fed diets with 0, 2 and 4% PLM. Feed cost per kg weight gain of quails fed 6% PLM diets was K14.59, which was significantly cheaper than K15.39, K14.73 and K15.40 calculated for birds on control, 2 and 4% diets.

These performance data indicate potential for replacing soybean meal with a cheap and non-competed for protein source like PLM. If pawpaw trees could be established around homesteads, there would be double benefits for farmers, i.e., fruits for human consumption and PLM as protein ingredient in poultry diets in place of the much expensive soybeans. Previously, Widjastuti et al. (2009) and Onyimonyi and Onu (2009) had reported that incorporation of PLM in diets for chickens improved their growth performance and carcass quality. The present results agree with these observations. Leaf meals usually have high CF contents. Therefore, it was expected that high inclusion levels of PLM in the diets would depress growth of the birds as suggested by Opara (1996) and Iheukwumere et al. (2008) because monogastric animals lack appropriate enzymes to degrade CF (Danicke et al. 1999; Babalola et al., 2006). However, quails fed diets with 6% PLM had better ($p < 0.05$) performance in terms of feed intake, weight gain, body weights, and FCR. Analysis of their diet showed a CF content of 38.5g/kg (Table 2), which was within the acceptable limits of 50g/kg for monogastric animals (Ochetim, 1993). According to Yadava et al. (1990) and Onyimonyi and Onu (2009), pawpaw leaves contain identifiable proteolytic enzymes (papain, chymopapain A, chymopapain B, and papaya peptidase A) which help in the digestion of nutrients. Papain is a protease enzyme that hydrolyzes proteins to short peptides, a key factor to increase protein digestibility and absorption, as well as growth of animals

(Wong et al., 1996). Thus, the observed improvements in growth performance with increase in the level of PLM may be due to increase in the presence of papain enzyme in the diets supplied by the leaf meal, which enhanced digestion and release of free amino acids required for growth. This view is in agreement with that of Poulter and Caygill (1985) who earlier reported that papain enzyme is an effective natural digestive aid that breaks down proteins and cleans the digestive system. Additionally, this opinion was also supported by the data on nutrient digestibility shown in Table 4. Increase in nutrient utilization resulted in better weight gain, body weights and FCR observed in birds fed diets with 6% PLM.

Feed related costs are widely recognized as representing the major part (60-80%) of the total costs of production in poultry. In view of this, D'Mello (1995), Odunsi et al. (1999), Nworgu et al. (2007), and Onyimonyi et al. (2009) suggested use of leaf meals in poultry diets as a way to reduce feed costs. Theferore, an attempt was made in this study to evaluate the economics of replacing soybean meal with PLM. Indeed, feed cost per weight gain reduced when PLM replaced soybean meal at 6%. Feed cost per kg weight gain of the 6% PLM feed was K14.59 which was significantly lower than K15.39, K14.73, and K15.40 calculated for the control, 2 and 4% PLM diets. Thus, these results concured with the suggestions of D'Mello (1995), Odunsi et al. (1999), Nworgu et al. (2007), and Onyimonyi et al. (2009), and imply that a quail farmer stands to have more returns to his/her investments by incorporating PLM in the rations for his/her quail flock than one raising them on a 100% soybean meal.

It has been observed that fibrous feed ingredients negatively affect nutrient utilization in birds by diluting macronutrients (Longe and Ogedengbe, 1989; Sobayo et al., 2012), modifying gut characteristics and intestinal morphology (Wu et al., 2004; Sobayo et al., 2012), as well as altering the upper and lower part of the digestive tract (Gabriel et al., 2003; Hetland et al., 2003; Sobayo et al., 2012). Thus, it was expected that increasing PLM level in the diets would reduce digestibility of nutrients. However, results in this study showed progressive increase in digestibility of all the nutrients assessed with increase in the level of PLM in the diet. Quails that received diets with 6% PLM had the highest ($p < 0.05$) digestibility among the treatments, followed by those fed diet with 4% PLM, while digestibility in birds fed control and 2% PLM diets was similar ($p > 0.05$). The reason for is could be attributed to low CF content of the leaf meal and increase in the amount of papain enzyme supplied by PLM. Thus, 6% PLM availed higher amounts of the enzyme than other inclusion levels, hence the high digestibility.

In conclusion, this study demonstrated that PLM has potential to be used as a protein source quail diets because it improved their growth performance. Improvement in growth performance was due to PLM increased digestibility of the ingested feed as it also contains proteolytic enzymes, and optimal results were obtained when PLM replaced soybean meal at 6%.

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Competing interests

Both authors declare that they have no competing interests.

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Table 1: Proximate composition of pawpaw (*Carica papaya*) leaf meal (PLM) incorporated in quail diets at 0 (control), 2, 4 and 6%.

Component	**g/kg DM**
CP	298.9
CF	53.6
EE	6.9
NFE	431.2

CP: crude protein; CF: crude fiber; EE: ether extract; NFE: nitrogen free extract

Table 2: Composition (g/kg) of formulated diets with 0 (control), 2, 4 and 6% PLM fed to Japanese quails (*Cortunix japonica*).

Diet composition (g/kg)		Level of PLM		
	Control	**2%**	**4%**	**6%**
Maize	490	490	490	490
Soya meal	280	274.4	268.8	264
Meat & bone meal	12	12	12	12
PLM	-	5.6	11.2	16
No 3 Maize meal	170	170	170	170
DL-Methionine	4	4	4	4
Lysine	11	11	11	11
Salt	4	4	4	4
DCP	12	12	12	12
Premix	4	4	4	4
Limestone flour	12	12	12	12
Zinc Bacitracin	1	1	1	1
Total	1000	1000	1000	1000
Calculated composition				
CP (g/kg)	237.6	238.0	238.8	239.4
CF (g/kg)	38.7	38.6	38.6	38.5
ME (MJ/Kg)	11.84	11.72	11.77	11.94

*Broiler Premix provided the following (per kg of complete diets): 1400 IU Vit. A, 3000 IU Vit. D3, 50 mg Vit. E, 4mg Vit. K, 3mg Vit. B_6, 6mg Vit. B_{12}, 60 mg niacin, 20 mg pantothenic acid, 0.2 mg folic acid, 150 mg choline, 4.8 mg Ca, 3.18 mg P,100 mg Mn, 50 mg Fe, 80 mg Zn, 10 mg Cu, 0.25 mg Co and 1.5 mg Iodine

CP: crude protein; CF: crude fiber; ME: Metabolizable energy; PLM: pawpaw leaf meal; DCP: dicalcium phosphate

Table 3: Performance characteristics of Japanese quails (*Cortunix japonica*) fed diets containing 0 (control), 2, 4 and 6% pawpaw (*Carica papaya*) leaf meal (PLM) as protein source.

Parameter		**Level of PLM**			
	Control	**2%**	**4%**	**6%**	**SE**
Initial body weight (g/b)	114.9	112.7	113.8	111.7	0.69
Final body weight (g/b)	159.5 ^{a}	163.7^{ab}	167.8^{b}	173.8^{c}	3.05
Daily feed intake (g/b/d	16.1^{a}	17.8^{ab}	19.9^{c}	21.9^{d}	2.51
Total weight gained (g/b)	44.6^{a}	51.0^{b}	54.0^{b}	62.1^{c}	3.63
Daily weight gain (g/b/d)	2.1^{a}	2.4^{ab}	2.6^{b}	3.0^{c}	0.38
Feed conversion ratios (g:g)	7.7^{a}	7.4^{a}	7.6^{a}	7.3^{b}	0.06
Feed cost per kg (ZMW*)	2.08	2.06	2.04	2.02	0.02
Feed cost/kg gain (ZMW)	15.39^{a}	14.73^{b}	15.40^{a}	14.59^{c}	0.21

Means within the same row with different superscripts (a-c) differ significantly ($p < 0.05$).

*Zambian currency called Kwacha (At the time of the study, 1 ZMW was equivalent to USD 5.50)

Table 4: **N**utrient digestibility (g/kg) in Japanese quails (*Cortunix japonica*) fed diets containing 0 (control), 2, 4, and 6% pawpaw leaf (*Carica papaya*) meal (PLM) as protein source.

Parameter		**Level of PLM**			
	Control	**2%**	**4%**	**6%**	**SE**
DM	814^{a}	835^{ab}	869^{b}	884^{c}	141
CP	759^{a}	807^{a}	825^{b}	923^{c}	292
CF	714^{a}	732^{ab}	761^{b}	792^{c}	152
EE	827^{a}	841^{ab}	906^{b}	977^{c}	344
NFE	834^{a}	859^{ab}	883^{c}	937^{d}	220

Means within the same row with different superscripts (a-d) differ significantly ($p < 0.05$).

DM: dry matter; CP: crude protein; CF: crude fiber; EE: ether extract; NFE: nitrogen free extract.