OPEN ACCESS

J. Adv. Vet. Anim. Res., 1(3): 100-106.
Available at- *http://bdvets.org/JAVAR*

ORIGINAL ARTICLE

Volume 1 Issue 3 (September 2014)

DOI: 10.5455/javar.2014.a19

Effects of replacing maize meal with rumen filtrate-fermented cassava meal on growth and egg production performance in Japanese quails (*Cortunix japonica*)

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ABSTRACT

This study was conducted to evaluate the effects of replacing maize in quail diets with graded levels of rumen filtrate-fermented cassava meal (FCM) on growth and egg production performances. Cassava meal (CM) was mixed with dried manure of layer at 75 g/kg CM, which was mixed with freshly collected rumen filtrate (at 1 L/5 kg CM), and finally fermented in sealed bags for 14 days. It was then sun-dried and added in grower or finisher diets at 0, 50, 75 and 100%. Then, 84 three weeks-old Japanese quails (*Cortunix japonica*) were divided into four equal groups; the birds were randomly assigned to 0, 50, 75 and 100% FCM grower/layers diets, and were reared until 56 days of age. Daily feed consumption, weekly body weights, weight gains, feed conversion ratios (FCR), hen-day, and egg weights were monitored. The quails fed with 75% FCM were found to be superior ($p<0.05$) for body weight, feed intake, weight gain, and egg weights. However, birds fed control diets had higher ($p<0.05$) hen-day, but lower ($p<0.05$) in egg weights. Complete replacement of maize with FCM (100%) had similar ($p>0.05$) effect on feed intake, body weight, and weight gain, as compared to those of fed control diets. Thus, replacing maize with FCM had no deleterious effects on growth performance, but depressed hen-day. However, better growth performance was obtained when maize was replaced at 75% FCM.

Keywords

Cortunix japonica, Fermented cassava meal, Layers' manure, Rumen filtrate, Quails

Received : 13 May 2014, **Revised**: 18 June 2014,
Accepted : 18 June 2014, **Published online**: 18 June 2014.

INTRODUCTION

One of the major limiting factors to expand the poultry sector in Zambia is the high cost of feed ingredients such as maize, which constitutes 45-60% of finished feeds (Dairo et al., 2001; Bratte, 2011). Domestic price of maize is very high because it is a staple food for humans in the country, and it is also used in industrial purposes. Recent developments, where maize is now used for ethanol and biofuel production, in other countries have further affected to its availability and price in the country. Thus, the high cost of maize made the poultry industry an expensive sector in Zambia. As a result, farmers are losing interests in many cases. Therefore, finding cheaper alternatives compared to maize as an ingredient of poultry diets is crucial.

Cassava (*Manihot esculenta*) is a widely cultivated crop in Zambia (FAO, 2010). It is a rich source of carbohydrate (Silva et al., 2000; Agwunobi and Okeke, 2000; Gomez et al., 2005; Promthong, 2005). Annual production of cassava in Zambia was 1,114,583 metric tons in 2013 (MAL, 2013). Use of cassava as an energy source in poultry diets has been reported by many researchers (Aderemi et al., 2000; Akinfala et al., 2002; Balagopalan, 2002; Eruvbetine et al., 2003; Tewe and Egbunike, 2005; Aderemi et al., 2006; Adeyemi et al., 2008); however, its merits are not completely known. Protein content in cassava is much lower than that of maize. Additionally, cassava lacks sulphur containing amino acids such as methionine (Balagopalan, 2002), which limits the extent to which it can be included in poultry diets. Thus, there is in need to identify means of improving the protein quality of cassava, especially those that can be easily adapted in the farm.

Fermentation technology has been used for many years in the modification of biological materials into useful products, and as a method of reducing anti-nutrient and fiber contents in feed (Campbell-Platt, 1994; Dhilon and Skirvaram, 1999; Oboh and Akindahunsi, 2003; Aro et al., 2008). According to Noomhorm et al. (1992), part of the starch in cassava meal (CM) could be converted to protein by microbes during solid-state fermentation. Adeyemi and Sipe (2004) reported an improvement in crude protein concentration of cassava root meal when fermented with rumen filtrate with or without ammonium sulphate as the source of nitrogen. Adeyemi et al. (2004) obtained a 237.8% increase in crude protein of whole cassava root meal when CM was fermented with rumen filtrate using caged layer waste as a source of nitrogen. These reports suggested that fermentation could have great potentials as a means of improving the feed value of CM in poultry. However, few works have been conducted to assess growth and egg production performances in which CM has been enriched after fermentation of rumen filtrates. Therefore, the purpose of this study was to assess growth and egg production performance of quails fed with the diets in which maize had been replaced with graded levels (0, 50, 75, and 100%) of a rumen filtrate fermented CM.

MATERIALS AND METHODS

The CM was purchased from local market, and was mixed with dried layer manure at 75 g/kg CM. Freshly disemboweled rumen contents of cattle carcasses were collected from local commercial abattoir (Kings Meat Quality Ltd, Lusaka, Zambia), and manually squeezed to obtain the liquid, which was later filtered through a cloth into a clean plastic container. Then, the prepared CM was wetted with tap water, and fine-sprayed with rumen filtrate at 1 L/5 kg, and was mixed thoroughly. The mixture was put into a 20 L black polythene plastic bag and was fermented for 14 days in air tight condition. The fermented mixture (FCM) was then sun-dried and used to formulate diets where FCM replaced maize at 0, 50, 75, and 100% in the grower/layer diets. Prior to feeding trial, a sample of FCM, unfermented CM (UFCM), and formulated diets were taken for laboratory analysis for dry matter [(DM) 105°C for 24 h], ash by weight loss upon heating at 450°C for 8h (AOAC, 1990, I.D. No 942.05), ether extract [(EE) AOAC, 1990, I.D. No 920.39], and nitrogen (AOAC, 1990, I.D. No 984.13). The proximate composition of FCM and UFCM are shown in **Table 1**, and the nutrients composition of formulated diets is tabulated in **Table 2**.

A total of 84 newly-hatched unsexed Japanese quails (*Cortunix japonica*) were housed in a brooder box with electric bulb, and were fed together for the first 20 days with commercial starter diet collected from a local feed manufacturer (Novatek Animal Feeds Ltd, Lusaka, Zambia). On the 21st day, all birds were individually weighed, and 72 quails were selected based on body weights and were divided into four equal groups. The treatment groups were randomly assigned to experimental diets containing 0 (control), 50, 75 or 100% FCM as a replacement for maize in the diets. Fresh clean drinking water and trial diets were supplied to the quails *ad libitum* for 8 weeks.

Body weights of the quails were recorded prior to commencement of the study, and at 4-, 5-, 6-, 7-, and 8-week-age. Feed leftover by the birds of each group was measured daily before putting in fresh feed and weekly weight gain, and FCRs were also monitored. FCR was calculated as the amount of feed (kg/week) consumed for one kg of weight gained (kg/week). Egg production was determined on daily-basis as the number of eggs laid by the birds. At the end of each week, 10 eggs were randomly sampled from each treatment group for the measurement of egg weight. All data were analyzed by the general linear model (GLM) procedure of SAS (2002), with treatment and level of inclusion as factors based on the mathematical model;

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

Where; Y_{ijk} is the observation; μ is the overall mean, T_i is the fixed effect of treatment, L_j is the random effect of inclusion level within T_i, P_j is the random effect of animal within T_i, and ε_{ijk} is the random error. Means were compared using Turkey test (SAS, 2002). A p value less than 0.05 was considered as statistically significant. However, differences among means with

0.05<p<0.10 were accepted as representing statistical tendency to differ.

Table 1: Proximate nutrient composition (%) of unfermented cassava meal (UFCM) and fermented cassava meal-layers manure mixture (FCM) used in the study.

Parameter	Maize	UFCM	FCM
DM	91.9	87.8	87.3
CP	8.6	1.7	7.6
CF	2.2	1.6	8.5
EE	3.7	6.6	5.4
Ash	1.7	1.9	3.6
ME (Kcal/kg)	3637	3350	3220

UFCM: unfermented cassava meal; FCM: fermented cassava meal; DM: dry matter; CP: crude protein; CF: crude fiber; EE: ether extract; ME: metabolizable energy

RESULTS AND DISCUSSION

All the birds remained healthy throughout the experiment, implying that consumption of diets with FCM had no adverse effect on their health. Data on proximate analysis of UFCM and FCM were presented in **Table 1**. There was no change in DM and EE content when CM was fermented with rumen filtrate. However, in the FCM, the CP level was increased from 1.7% to 7.6%, which was close to maize (**Table 1**). These findings supported the reports of Adeyemi and Sipe (2004), Adeyemi et al. (2004), Adeyemi et al. (2007) and Dairo et al. (2011) who observed an increase in CP in cassava root meal that was fermented with rumen filtrate and a nitrogen source. However, the magnitude of increase in CP in the present study differed to that of Adeyemi et al. (2004), Adeyemi et al. (2007) and Dairo et al. (2011), who used caged layer manure as a source of nitrogen.

Fermentation is known to improve protein levels in feed (Dairo et al., 2011). The CM added the required fermentative microbes with readily digestible energy, and the layer manure supplied nitrogen for microbial growth and proliferation. Thus, growth and proliferation of rumen microbes might account for the apparent increase in the protein content of FCM, as suggested by Nguyen and Nguyen (1992), Antai and Mbongo (1994) and Oboh (2002). Surprisingly, CF content in FCM increased from 1.6% to 8.5%, which was contrary to the findings of Adeyemi et al. (2007) and Dairo et al. (2011) who observed a decline in CF after fermentation of cassava root meal. The rumen fluid used in the present study was manually squeezed out of rumen contents and filtered using a cloth. This might not be adequate to filter out finer feed particles from the liquid. Thus, the increase in CF content in FCM might be due to contamination with fine feed particles.

Results of the performance of quails fed with experimental diets were shown in Table 3. Data showed that the effects of graded levels of FCM on feed intake, weight gain, final body weights and FCR were significant (p<0.05). Feed intake, body weights, and weight gains were improved with the increase of FCM level. Specifically, the quails fed diets supplemented with 75% FCM showed superiority among these parameters. Feed intake for these birds was 21.5 g/b/d, which was significantly higher than 18.9, 20.4, and 20.7 g/b/d recorded for those fed as control, 50 and 100% FCM diets. Birds fed control diets had the least (p<0.05) feed intake of all groups. Increase in intake with increase in FCM inclusion levels was agreement with the report of Ijaiya et al. (2002), who recorded higher intake with increasing levels of fermented cassava peel meal fed to rabbits.

Usually, animals intake more low-energy diet as compared to high-energy diet (Ojewola and Longe, 1999). In the current study, proximate analysis of the formulated diets showed that crude fiber content increased with the increase of FCM levels (**Table 2**). Thus, high feed intake by birds fed diets with 75% FCM might be attributed to high fiber content in the feed which diluted the metabolisable energy concentration. This prompted the birds to intake more feed to meet their requirements.

Palatability is one of the factors that could determine the extent to which an animal consumed a particular feed (Cherry and Jones, 1982; Lyayi et al., 2005). Aro et al. (2008) reported that swine fed fermented cassava meal based diets had high feed intake due to improved palatability of the feed. Therefore, it was likely that the high feed intake by the birds in the 75% FCM treatment group might be due to better palatability of the feeds caused by high FCM levels. In this view, birds fed diets with 100% FCM were expected to consume more because it had the highest crude fiber content, but this was not so. It was thus, evidenced that birds showed aversion to complete replacement of maize, probably due to dusty and powdery nature of the feed, as suggested by Onyimonyi and Ugwu (2007) and Salami and Odunsi (2003).

Table 2: Composition (%) of diets fed to Japanese quails (*Cortunix japonica*) during growing and laying periods.

Ingredient	Inclusion percentages of FCM							
	Grower diet				Laying Diet			
	0	50	75	100	0	50	75	100
Maize meal	54.5	27.25	13.7	-	50.0	25.0	12.5	-
FCM	-	27.25	40.9	54.5	-	25.0	37.5	50
Soybean Meal	40.0	40.0	40.0	40.0	36.0	36.0	36.0	36.0
Meat and bone meal	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5
Limestone flour	1.5	1.5	1.5	1.5	10.0	10.0	10.0	10.0
DCP	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5
DL-Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Lysine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Salt	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Broiler Premix*	0.3	0.3	0.3	0.3	-	-	-	-
Layer premix	-	-	-	-	0.2	0.2	0.2	0.2
Total	100	100	100	100	100	100	100	100
Determine analysis								
CP (%)	23.3	23.0	22.8	22.7	20.9	20.6	20.5	20.3
CF (%)	3.7	5.5	6.4	7.2	3.4	5.0	5.8	6.6
EE (%)	3.0	3.8	4.2	4.6	2.7	3.4	3.8	4.2
ME (Kcal/Kg)	2737	2704	2691	2671	2487	2457	2442	2427

*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.
FCM: fermented cassava meal; DCP: dicalcium phosphate; CP: crude protein; CF: crude fiber; EE: ether extract; ME: metabolizable energy

Table 3: Performance characteristics of quails fed diets containing graded levels (0, 50, 75 and 100%) of cassava-layer mixture fermented in rumen filtrate.

Parameter	Control	Fermented cassava meal			SE*
		50%	75%	100%	
Initial weight (g/b)	118.2	116.2	114.3	119.3	1.1
Final weight (g/b)	220.4^a	235.2^b	247.9^c	222.2^a	6.4
Weight gained (g/b)	102.2^a	119.0^b	133.6^c	102.9^a	4.8
Daily Feed intake (g/b/d)	18.9^a	20.4^b	21.5^c	20.7^b	0.3
Feed conversion ratios	5.4^a	5.8^a	6.2^b	4.6^b	0.2
Average hen-day (%)	74.6^a	68.9^b	67.5^b	67.7^b	0.3
Average egg weight (g/egg)	12.4^a	13.0^a	13.3^b	12.9^a	0.2

Values are means (n = 18); SE*: standard error
Means within the same row with different superscripts (a-c) differ significantly ($p<0.05$)

Replacing maize with FCM had a positive effect on daily weight gain. Birds in the 75% FCM treatment group had the highest weight gain at 133.6 g/b, followed by 119.0 g/b for those fed diets with 50% FCM. Quails fed control and 100% FCM based diets gained similar weights ($p>0.05$) at 102.2 and 102.9 g/b, respectively. This similarity implied that quails could tolerate with the diet that was completely replaced with maize. Fermentation process helps in production of several kinds of essential nutrients such as oligosaccharides, vitamins, and small-size peptides (Kim et al., 1999; Feng et al., 2007; Chen et al 2010). Probably, these substances enhanced the utilization of ingested feed. This view is supported by the data on final body weights of the birds. Birds fed diets with 75% FCM weighed heaviest ($p<0.05$) at 247.9 g/b, followed by those fed diets with 50% FCM at 235.2 g/b. Those fed control or 100% FCM diets were similar in weights at 220.4 and 222.2 g/b, respectively, but lower ($p<0.05$) than 247.9 g/b that was recorded for birds fed 75% FCM-diets. It has been reported that fiber levels higher than 5% negatively affected growth rate and feed efficiency (Ochetim, 1993). The complete replacement of maize with FCM resulted into diets with more than 5% CF (**Table 2**). Relative to the 75% FCM diet, this could account for the lower weight gains and body weights recorded for birds in the 100% FCM treatment group.

The FCR values were generally high. This might be due to the quails wasted feed more as compared to chickens. However, these values showed an improvement when FCM was included at 100% in the diets. FCR was 6.4 for quails fed diets with 75% FCM, which was lower than 4.9 that were recorded for birds fed diets with 100% FCM. No significant difference was observed between 5.4 and 5.8 for birds fed diets with 0 and 50% FCM. Better FCR in the 100% FCM treatment group was due to lower feed intake caused by the dusty and powdery nature of the feed, as well as the high crude fiber content. Ijaiya et al. (2002) observed that a high dietary crude fiber level due to cassava peel meal reduced feed conversion efficiency in the rabbits.

Replacing maize in the diets with FCM had significant (p<0.05) effect on mean hen-day production and egg weights of quails. Hen-day (%) of quails fed diets with FCM (50, 75 and 100%) were 68.9, 67.5 and 67.7%, respectively, which were similar (p>0.05), but significantly lower as compared to those fed control diets. However, the weights of eggs from the birds fed diets with 75% FCM were 13.3 g/egg, which were heavier (p<0.05) than 12.4, 13.0 and 12.9 g for those from 0, 50 and 100% FCM treatment groups, respectively. It is worthy to mention that quails fed FCM based diets started laying a week later than those in the control diets. Reasons for these observations were not clear. Since egg weight was increased with the age of birds (Adegbola and Olatoke, (1988), higher egg weight in the FCM treatment groups could be attributed to their bigger body sizes which resulted into laying of bigger eggs.

CONCLUSIONS

Fermented cassava meal mixed with layer manure increased its CP content close to that of maize, and replacing maize with FCM had no significant deleterious effects on the growth performance and egg weights of quails, apart from the hen-day. However, it appears that optimal growth performance can be achieved when FCM replaces maize at 75%.

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