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ORIGINAL RESEARCH ARTICLE

Growth performance and digestibility of nutrients by Japanese quail (*Coturnix coturnix japonica*) chicks on processed sweet potato (*Ipomea batatas*) meal diets

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ABSTRACT

A six –week feeding trial was set up to investigate the effect of processing of sweet potato tuber on growth parameters and digestibility of nutrients by Japanese quail chicks. Five isonitrogenous (25%CP) diets were compounded. The control diet (A) had zero sweet potato tuber meal. The other four diets (B, C, D and E) contained sweet potato tuber meal processed in different ways (unpeeled, peeled, unpeeled and cooked and peeled and cooked) replacing maize at 15.60% of the diet. 300 day-old Japanese quail birds were randomly assigned the diets in a completely randomized design with feed and water given ad libitum. Each diet had 60 quail chicks and the diets were replicated thrice. None of the parameters (feed intake, water intake, weight gain, feed conversion ratio and feed cost/gain) measured differed significantly (p <0.05) from the control. Digestibility of dry matter was significantly better by birds on diets C (peeled sundried) and D (unpeeled cooked sundried sweet potato) than on diet A. Digestibility of crude protein was significantly better on diet E (peeled cooked sundried) than on the other diets. No significant differences were observed in ether extract digestibility across the diets. Results show that processed sweet potato can replace maize at 15.60% of the diet of quail chicks without adverse effects on performance or on digestibility of nutrients.

Key words: Feed intake, dry matter digestibility

Introduction

Japanese quails are small-bodied birds, weighing about 180 grams at maturity. The quail belongs to the class Aves, order Galiformes, family Phasianide and kingdom Animalia (Thear, 1998; Mizutani, 2003). They are prolific (Robbins, 1981) and hardy birds (ANON, 1991) are low in body fat and cholesterol but high in body protein content (Garwood and Diehl, 1987). The eggs weigh on average 10 grams (Edache *et al*., 2003b; Musa *et al.*, 2008) and usually hatch by the 17th day of incubation (Edache *et al*.,2003b). This fast growing nature of this bird makes it a possible way out for increasing animal protein intake for developing nations.

There is increasing competition between man and livestock for available feedstuff for food. Cheaper and emerging feed resources seem to be the panacea for rising feed cost. According to Chauynarong *et al*. (2009) there is a need to exploit cheaper energy sources in order to replace expensive cereals (maize) for animal feed production.

Agwunobi (1999) reported that sweet potato meal can substitute for maize in diets for broiler starter and finisher at 27 and 30% respectively and that higher level resulted in wet droppings. Gerpacio *et al*. (1978) replaced 100% of the maize with sweet potato in diets for broiler chicks and recommended that not more than 75% of maize should be replaced by sweet potato meal.

Ayuk and Essien, (2009) reported a consistent drop in weight gain as the quantities of sweet potato increased in the diet for broilers. The feed became increasingly dusty with increasing sweet potato content and this may be responsible for the drop in weight gain of broilers but birds were not predisposed to anaemia or any health threat (Ayuk and Essien, 2009). However, data on use of sweet potato for non-ruminant animals are limited (Apata and Babalola, 2012). Cooking did not significantly affect the utilization of energy (Oyenuga and Fetuga, 1975), but increased the digestibility of the nutrients (Oyenuga and Fetuga, 1975, Canope *et al*., 1977). The objective of this study is to investigate the effect of feeding sweet potato tuber processed in various ways on the growth performance and digestibility of nutrients by Japanese quail chicks.

Table 1. PERCENT COMPOSITION OF EXPERIMENTAL DIETS FOR QUAIL CHICKS

Ingredients	A	B	C	D	E
Maize	32.65	15.60	15.60	15.60	15.60
Sweet potato meal	0	15.60	15.60	15.60	15.60
Ground nut cake	36.65	38.10	38.10	38.10	38.10
Wheat offal	10.00	10.00	10.00	10.00	10.00
Fish meal	2.00	2.00	2.00	2.00	2.00
Palm kernel cake	15.00	15.00	15.00	15.00	15.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Limestone	1.50	1.50	1.50	1.50	1.50
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
C. P. (%)	25.13	25.13	25.13	25.13	25.13
M.E. (Kcal/kg)	2658.58	2450.88	2450.88	2450.88	2450.88
Ca (%)	1.33	1.33	1.33	1.33	1.33
P (%)	0.48	0.48	0.48	0.48	0.48
C.F. (%)	5.14	5.79	5.79	5.79	5.79
Cost/kg Diet (₦)	74.04	72.92	72.92	72.92	72.92

The vitamin – mineral premix supplied the following per 100kg of diet: Vitamin A 1,200,000 I.U, Vitamin D_3 250,000 I.U., Vitamin E 3,000 I.U., Vitamin K 200mg, Thiamin, (B_1) 225mg, Riboflavin (B_2) 600mg, Pyridoxine (B_6) 450mg, Niacin 4000mg, Vitamin B_{12} 2mg, Pantothenic acid 1,500mg, Folic acid, 150mg, Biotin 8mg, Choline chloride 30,000mg, Anti oxidant 12,500mg, Manganese 8,000mg, Zinc 5,000mg, Iron 2,000mg, Copper 500mg, Iodine 100mg, Selenium 20mg, Cobalt 50mg (Hi Nutrient international Ltd (HNIL).

MATERIALS AND METHODS

Source and processing methods of sweet potato tuber

The white-flesh sweet potato tuber used in this study was purchased from Jos and from a border market between Plateau and Kaduna States. The sweet potato tubers were cleaned of dirt and subjected to various processing methods as follows:

1) Unpeeled sweet potato tubers were, sliced (3mm) and sun-dried for seven days during the harmattan to about 10% moisture.

2) Peeled sweet potato tubers were sliced (3mm) and sun-dried for seven days during the harmattan.

3) Unpeeled sweet potato tubers were sliced (3mm), cooked (20 minutes) and sun-dried for seven days during the harmattan.

4) Peeled sweet potato tubers were sliced (3mm), cooked (20 minutes) and sun-dried for seven days during the harmattan.

The cooking was done by pouring the sliced sweet potato tuber into boiling water and left boiling for 20 minutes.

The variously processed sweet potato tubers were milled using a hammermill fitted with an 8 mm sieve for incorporation into experimental diets. The diets were analyzed for proximate chemical components by procedures outlined by AOAC (2000).

Diets.

Five isonitrogenous (25.13% CP) diets were formulated. The first diet contains 0% of sweet potato and tagged A (control). In each of the other four diets, 47.80% of maize (i.e 15.60% of the diet) was replaced by sundried sweet potato tuber meal that have been produced as described earlier; viz, unpeeled and raw (B), peeled and raw (C), unpeeled and cooked (D) and peeled and cooked (E). The ingredients and calculated nutrient composition of the diets are presented in Table 1.

Experimental birds: Three hundred unsexed day-old quail chicks were purchased from the Poultry Department of the National Veterinary Research Institute, Vom. They were healthy, uniform in weight and size.

Housing and experimental procedure

The birds were housed in a standard poultry brooding house with deep litter partitions using wire mesh to allow for adequate ventilation and spaced 75 sq cm per bird as recommended (Musa *et al*., 2008). The birds were randomly allotted to five (5) dietary treatment groups at sixty (60) chicks each in a completely randomized design. The treatments were replicated thrice with twenty (20) chicks each. Each replicate group of chicks was weighed at the start of the feeding trial and thereafter weighed weekly to monitor the growth response over time. Cool drinking water and experimental diets were provided *ad libitum* for the study period of six weeks.

Data collection

Feed intake, water intake, body weight gain, energy intake and protein intake were measured in the course of the study. From the feed intake and weight gain, feed conversion ratio was calculated. Feed cost/gain and feed cost/kg feed were calculated using the prevailing market prices around Jos. From the weight gain, energy intake and protein intake, energy efficiency ratio and protein efficiency ratio were determined. Data collected were subjected to one-way analysis of variance as described by Steel and Torrie (1980) and where significant differences ($P<0.05$) were observed, means were separated using Duncan's Multiple Range Test (Duncan, 1955).

Apparent nutrient digestibility study:

At the end of the fifth week of experiment 1, four birds (4) per replicate whose live weight were as close as possible to the mean live weight for the treatment were used for digestibility trial. Four birds from each replicate were placed in a digestibility crate and given a known quantity of feed that they consumed per day. They were fasted over- night and placed on the experimental diets for seven days. Fecal collection was carried out for the seven days. The feces collected were oven-dried for a period of 18 hours at a temperature of 105^0C and weighed daily. At the end of the collection period, the fecal samples collected from each replicate group were bulked, milled and thoroughly mixed to obtain a homogenous mixture. Samples were then taken and analyzed for proximate composition according to the methods outlined by AOAC (2000).

Table 2: Nutrient composition of quail chick diets (%) used in the experiment

	A	B	C	D	E	SEM
Dry matter	93.78	92.69	93.78	92.14	91.74	±4.61NS
Protein	24.99	25.03	25.05	25.04	25.01	±0.04NS
Ash	4.10	3.41	3.82	4.56	3.59	±1.08NS
Fat	4.66	4.02	4.36	4.56	4.84	±0.43NS
Crude fibre	3.81	4.12	4.09	4.32	4.22	±0.51NS
NFE	56.22	56.11	56.46	54.04	54.08	±4.50NS

Key: A = Control (no sweet potato root meal), B = Diet with 47.80% unpeeled sundried sweet potato root meal, C = Diet with 47.80% peeled sundried sweet potato root meal, D = Diet with 47.80% unpeeled cooked sundried sweet potato root meal, E = Diet with 47.80% peeled cooked sundried sweet potato root meal, SEM; standard error of mean, N.S. not significant.

Table 3: **Effects of sweet potato root meal diets processed in various ways on performance of quail birds.**

Parameters	A	B	C	D	E	SEM
Initial weight (g)	7.71	8.00	7.62	7.82	7.73	±0.43$^{N.S}$
Final weight (g)	150.11	148.95	145.35	163.44	154.72	±10.95$^{N.S}$
Feed intake (g/bird/day)	14.96	14.31	14.13	14.69	14.71	±0.50$^{N.S}$
Water intake (ml/bird/day)	28.93	34.26	30.93	33.21	29.74	±2.93$^{N.S}$
Weight gain (g/bird/day)	3.39	3.36	3.22	3.71	3.50	±0.26$^{N.S}$
Feed/gain ratio	5.05	4.82	4.88	4.78	4.28	±0.71$^{N.S}$
Feed cost/gain (₦)	0.37	0.35	0.36	0.35	0.31	0.05 n.s
Mortality (%)	12.50	12.38	11.78	13.36	12.50	±7.14$^{N.S}$

a, b, letters with common superscript letters within rows are not significantly ($p > 0.05$) different.SEM = standard error of mean, N.S = not significant, A; control (no sweet potato root meal) B; Diet with 47.80% unpeeled, sundried sweet potato root meal, C; Diet with 47.80% peeled, sundried sweet potato root meal, D; Diet with 47.80% unpeeled, cooked sundried sweet potato root meal, E; Diet with 47.80% peeled, cooked sundried sweet potato root meal. * = significant ($p<0.05$)

RESULTS AND DISCUSSION

The ash content was between 3.41 to 4.10% and was higher than the 2.6 to 2.8% reported by Maphosa *et al*. (2003) but lower than the level (5.39 -6.07%) in the diet for broilers by Panigrahi *et al*. (1996). The crude fibre level of the feed (3.81 – 4.32%) is higher than 2.94 – 3.00% reported by Maphosa *et al*. (2003) but compared favourably to that (4.45%) reported by Panigrahi *et al*. (1996). The ether extract content (4.02 – 4.84%) is higher than 1.50 – 1.90% reported by Maphosa *et al*. (2003) and 0.52 – 0.67% by Panigrahi *et al*. (1996). The dry matter content of the diet was between 91.74 to 93.78% and comparable to the 90.64 to 91.48% reported by Ladokun *et al*. (2007) and 90.95 to 92.12% by Panigrahi *et al*. (1996). The crude protein content of between 24.99 to 25.05% corresponds to the level recommended for growing quail (Akpan and Nsa, 2009) though understandably higher than the 22.3 to 22.8% for starter broilers (Maphosa *et al*., 2003). The differences in the values reported may be due to different diets formulated and types of feed materials used.

The initial weight of day old quail chicks at the onset of the experiment compared favourably with 7.50-8.05g/bird by Bawa (2010) but was higher than the body weight at day old reported by Ani *et al*. (2009) which was between 6.50-6.54g/bird. The final body weight (145.35- 163.44g/bird) in this work was higher than the final body weight (125.65-141.47g/bird) reported by Bawa (2010) and higher than 137.80-140.80g/bird reported by Odunsi *et al*. (2007).

This may be due to differences in the bird's response to the nutrient content of the feed fed and the source of the birds.

No significant effect of the different processing methods for sweet potato root on feed intake was observed. However, compared to the control, birds on the first two levels of processing recorded apparent decrease in feed intake but this improved slightly in the birds fed the other two levels (unpeeled, cooked sun-dried and peeled, cooked sun-dried). According to Maphosa *et al*. (2003), feed intake was significantly depressed by increasing content of sweet potato meal for broiler chickens which disagrees with the result of this study. Results similar to what was obtained in the present study were obtained by Lee and Yang (1979) when they substituted maize with sweet potato meal at 24% for broilers and by Orunmuyi *et al*. (2006) for rabbits fed sweet potato meal up to 40% of the diet. The levels of inclusion of sweet potato meal by these authors were; however, lower than the level of inclusion in the present study. However, Afolayan *et al*. (2011) reported that feed intake of broilers decreased significantly as the level of sweet potato meal increased in the diets. This was not found in this study and may probably be due to differences in species. Japanese quails are known to be hardy (ANNON, 1991) and more tolerant of nutrient changes (such as energy and crude fibre levels) than chickens.

Mean daily water intake increased numerically from control; 28.93ml/bird/day (diet A) to 34.26ml/bird/day; diet B but reduced again to 29.74ml/bird/day diet E but the differences were not significant. Watery feces had been reported for broilers on sweet potato meals above 30% of the diet (Agwunobi, 1999). This was not observed in this study. The daily water consumption (28.93-34.26ml/bird) recorded in this study was much similar to the 33.07ml/bird reported by Rajput (2006) but lower than the range of 38.93-44.28ml/bird reported by Tuleun *et al*. (2009). The higher range of water intake reported by Tuleun *et al*. (2009) may be due to the higher ambient temperature (25 - 37^{o} C, Makurdi) where their studies were carried out. The similarity between the water intake reported by Rajput (2006) and the current study may be as a result of the closeness of the ambient temperature (12^{o} C) of Pakistan and that of Vom (13.9^{o} C) in

Plateau State, Nigeria. In the current study, the water to feed ratio was approximately 2.39, which is quite close to the 2.03 reported by Rajput (2006).

The non- significant effect of the diets on weight gain is contrary to the depressive effect of sweet potato meal on weight gain of broilers reported by Maphosa *et al*. (2003), Afolayan *et al*. (2012) and Gonzalez (2002) with pigs. However, the finding agrees with the report of Dominguez (1990) who worked on pigs and Orunmuyi *et al*. (2006) for rabbits fed sweet potato meal. Manfredini *et al*. (1990) also reported that replacing maize with not more than 50% sweet potato chips gave acceptable performance for pigs.

Feed conversion ratio of quail birds fed the various diets was not different between the diets. However, there was a slight but insignificant improvement in efficiency of feed conversion as compared to the control, as birds on the sweet potato diets performed numerically better. This trend had been attested to by Gerpacio *et al*. (1978) who suggested a replacement of maize with sweet potato meal at not more than 75% granted that a proper adjustment had been made for other nutrients like protein and energy. This lack of significant difference agrees with the report of Dominguez (1990) who fed cooked sweet potato chips to pigs in place of maize and also with the report of Orunmuyi *et al*. (2006) who fed rabbits with sundried sweet potato meal. However, according to Afolayan *et al*. (2012), broiler chicks on the sweet potato meal diets were significantly better feed converters and this in disagreement with the observations in this study. The similarity of feed conversion between the test diets and the control in this study is in disagreement with earlier reports (Maphosa *et al*., 2003, Ayuk; 2004) and may be due to the ability of Japanese quail to adjust feed intake across different dietary energy levels as has been indicated by Weber and Reid (1967).

Table 4: Apparent nutrient digestibility of growing japanese quails fed differently processed sweet potato meal (%)

	Diets					
Parameters	A	B	C	D	E	SEM
Dry matter	70.21 [b]	70.67[ab]	72.85 [a]	72.58 [a]	71.34[ab]	±1.04*
Crude protein	56.11 [b]	56.26 [b]	54.30 [b]	54.64 [b]	59.99 [a]	±1.49*
Ether extract	74.67	74.55	74.93	70.13	75.04	±3.82[N.S]

a, b, means separated by distinct letters within rows are significantly different at 5% level ($P > 0.05$). Key: SEM, standard error of mean. A; control (no sweet potato tuber meal) B; Diet with 47.80% unpeeled, sundried sweet potato tuber meal, C; Diet with 47.80% peeled, sundried sweet potato tuber meal, D; Diet with 47.80% unpeeled, cooked sundried sweet potato tuber meal, E; Diet with 47.80% peeled, cooked sundried sweet potato tuber meal.

Feed cost/gain decreased linearly from the control to the last test diet but the differences were not significant. This may be due to the lower cost of sweet potato as compared to maize. It seems to confirm the report of Muhammad *et al*. (2012), Afolayan *et al*. (2012) for broilers and Orunmuyi *et al*. (2006) for rabbits fed sweet potato meal. The fact that similar results were obtained for diets containing 50% sweet potato at the expense of maize when compared to maize-based diets in this study attest to the ability of Japanese quail to utilize high fibre feedstuff.

Dry matter digestibility was significantly higher on diets C and D than on diet A. In the report of Gerpacio *et al*. (1978), dry matter digestibility was similar between the control and the test diets which was different from the observations in this study. However, figures obtained in the current study which ranged between 70.21 - 72.85% seem quite similar to the figures (64.30 – 72.0%) obtained by Gerpacio *et al*. (1978) in studies with broilers on sweet potato root meal. However, the figures obtained in this study are lower than the figures (90.40 - 93.50%) reported by Canope *et al*. (1977) and 85.50% reported by Dominguez (1990) for pigs on cooked sweet potato diets. The higher figures reported may be due to different animal species involved. Moreover, Dominguez (1990) had reported the presence of non-identified factors which inhibit the digestive and metabolic processes in sweet potato – based diets. These may be responsible for the lower dry matter digestibility.

Protein digestibility in the present study was significantly better on diet E (59.99%), the cooked sweet potato diet than on the other processed sweet potato meals. However, the values which is between 54.30 (diet C) and 59.99% (diet E) is lower than 61.80 – 72.60% for broilers reported by Gerpacio *et al*. (1978) but similar to the protein digestibility for cooked sweet potato meal (52.80) for pigs reported by Canope *et al*. (1977), higher than the protein digestibility (49.80%) of raw sweet potato for pigs reported by Rose and White (1980) and higher than the protein digestibility (32 %) for ensiled sweet potato meal for pigs reported by Tomita *et al*. (1985).

Ether extract digestibility varied between 70.13 (diet D) and 75.04 % (diet E) with figures for other diets within this range. However, the differences were not significant. Similar results have been reported for rabbits fed sweet potato peal meal (Malik *et al*., 2011). The digestibility of ether extract (79.18 – 89.90 %) and crude protein (85.29 – 87.78 %) reported by Malik *et al*. (2011) is much higher than that reported in the present study and may be responsible to differences in species and diets employed in the study. Whereas the crude protein digestibility in the report of Malik *et al*. (2011) was not significant across the diets, in the present report, crude protein digestibility was significantly superior on the diet with peeled, cooked sundried sweet potato root meal than on the other diets. This seems to confirm the report that cooking did not significantly affect the utilization of energy (Oyenuga and Fetuga, 1975), but increased the digestibility of the nutrients (Oyenuga and Fetuga, 1975, Canope *et al*., 1977). Dominguez (1990) had suggested that the presence of trypsin inhibitors in raw sweet potato roots could decrease protein digestibility in mixed feed and this may be responsible for the higher crude protein digestibility in diets containing the cooked sweet potato meal.

According to Gerpacio *et al*. (1978), the presence of non-identified factors which inhibits the digestive and metabolic processes is suggested in sweet potato-based rations. These factors caused low dry matter digestibility and low metabolizable protein and energy values, even when the ration contained adequate and high quality proteins which may be what is being observed in this study. According to Oyenuga and Fetuga (1975) peeling of sweet potato significantly increased digestibility of crude protein, ether extract and crude fibre. Furuya (1986) has reported that digestible energy of sweet potato for pigs depended on processing methods with values increasing progressively for freeze-dried, sundried, oven dried and boiled tubers. This was not strictly observed in this study.

CONCLUSION

Sweet potato is well suited to our climate and does well particularly in the savannah regions and has been known to be cheaper to produce than cereals. Parameters measured to determine the effect of feeding processed sweet potato tubers at 50% of the diet for quail chicks showed that only energy intake was significantly higher on the control diet than on the unpeeled and the peeled tubers. Other differences were not significant. Therefore, inclusion level of 47.80 to 50% sweet potato tubers in the diet of quail chicks and probably other growing poultry is recommended.

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CONFLICT OF INTEREST

The authors declare that there is no known conflict of interest as regards the conduct of this study and the data reported in this work.

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