Performance and economics of production of Japanese quails (*Coturnix coturnix japonica*) fed varying levels of peeled cooked sun-dried sweet potato (*Ipomoea batatas*) meal diets

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Abstract

A six-week feeding trial was carried out to investigate the effect of feeding peeled cooked sundried sweet potato tuber on growth parameters and economics of production of Japanese quails. Five isonitrogenous (25%CP) diets were compounded. The control diet (1) had no sweet potato tuber meal while 2, 3, 4 and 5 had maize replaced at 25, 50, 75 and 100% by peeled and cooked sundried sweet potato tuber meal respectively. Three hundred day-old Japanese quails of mixed sexes were randomly assigned the diets in a completely randomized design with feed and water provided ad libitum for six weeks. Each diet was allocated to 60 quail chicks which were further divided into three replicates of 20 birds each. Feed intake was significantly ($p < 0.05$) lower for birds on diet 3 (14.05g/b/d) than for those on diets 4 (14.87g/b/d) and 5 (14.79g/b/d). Water intake was however significantly ($p < 0.05$) higher for birds on diet 4 (27.40ml/b/d) than for those on diets 1 (23.77ml/b/d), 2 (24.01ml/b/d) and 3 (24.66ml/b/d). Protein intake was significantly ($p < 0.05$) higher for birds on diet 4 (3.72g/b/d) than for those on diets 1 (3.55g/b/d), 2 (3.54g/b/d) and 3 (3.51g/b/d). Energy efficiency ratio was significantly ($p < 0.05$) better on diet 5 (0.29) than on diet 1 (0.24) only. However, weight gain, feed conversion ratio, feed cost/gain, energy intake and protein efficiency ratio did not differ significantly ($p > 0.05$) from the control. Total cost of production per bird was significantly ($p < 0.05$) higher on diet 3 than on diets 4 and 5. Revenue per bird was significantly ($p < 0.05$) lower on diet 2 than on diets 1 and 4 only. Gross margin per bird was significantly ($p < 0.05$) lower on diet 2 than on diets 1 and 3 only. Total feed intake and feed cost/kg gain were not affected by the diets ($p > 0.05$) and diet 5 has a cost saving of 3.00% over the control diet. Results showed that peeled cooked sundried sweet potato can completely replace maize in the diet of quail chicks without adverse effects on performance or on economics of production of Japanese quails.

Key words: Feed intake, water intake, body weight changes, economics of production

Introduction

Sweet potato is cheaper, easier to cultivate than maize and also has less pressure of competition for human use. However, report on the use of sweet potato in quail diet is scanty in literature Agwunobi (1999) reported that sweet potato meal can substitute for maize in the diets of 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 reported that not more than 75% of maize should be replaced by sweet potato meal. The crude protein and gross energy content of sweet potato roots are given as 6.40% and 16.50 M.J/kg respectively, (Dominguez, 1990)

Ayuk and Essien (2009) reported a consistent drop in weight gain as the quantities of sweet potato increased in the diet for broilers. The drop in weight gain of

broilers, as reported, may be due to the increasing dustiness of the feed with increasing content of sweet potato. However, the birds were not predisposed to anaemia or any health threat (Ayuk and Essien, 2009). However, as observed by Apata and Babalola (2012) use of sweet potato for non-ruminant animals are limited. Trypsin inhibitors in sweet potato (Woolfe, 1992) have also been established and these can inhibit the digestibility of the protein when eaten raw. In raw sweet potato, inhibition of trypsin can be up to 78.8% while in the cooked it is as low as 16.70% (Dominguez, 1990). Cooking did not significantly affect the utilization of energy of sweet potato by pigs (Oyenuga and Fetuga, 1975), but increased the digestibility of the nutrients (Oyenuga and Fetuga, 1975, Canope *et al.*, 1977). Afolayan *et al.* (2012) reported that feed cost per kg gain was higher for broilers on the sweet potato diets than on the control. Contrarily, Mohammad *et al.* (2012) showed that feed cost per gain was higher on the control diet than on the sweet potato meal diets for broilers

Japanese quails of the class Aves, order Galiformes, family Phasianide and kingdom Animalia (Thear, 1998; Mizutani, 2003).are small-sized, weighing about 180 grams at maturity. They are prolific (Robbins, 1981) and hardy birds (ANON, 1991) and have low body fat and cholesterol but high in body protein content (Garwood and Diehl, 1987). This fast growing nature makes it a panacea for making available animal protein to growing human population. It is therefore important to establish an alternative energy source that can adequately support the performance of this bird. Sweet potato is cheaper, easier to cultivate than maize and also has less

pressure of competition for human use. This study was therefore conducted to assess the performance and economics of production of peeled cooked sundried sweet potato roots in the diets of quails.

Materials and methods

Source and processing method of sweet potato tuber

The white-fleshed 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 and processed as follows:

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

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

The processed sweet potato tubers were milled using a hammer mill fitted with an 8 mm sieve for incorporation into experimental diets. The diets were analyzed for proximate composition by procedures outlined by AOAC (2000). Metabolizable energy was calculated from the result of analysis using this formular; $ME = 432 + 27.91 (CP + EE \times 2.25 + NFE)$.

Experimental diets and birds

Five isonitrogenous (25% CP) diets were formulated. The first diet contains 0% of sweet potato and tagged 1 (control). In each of the other four diets, 25, 50, 75 and 100% of maize was replaced by peeled cooked sundried sweet potato tuber meal and tagged 2, 3, 4 and 5 respectively. The ingredients and calculated nutrient composition of the diets are presented in Table 2 while the formulated feed samples were analyzed for proximate composition by the AOAC methods (Table 1). 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

Table 1: Nutrient composition of quail chick diet used in the experiment

Parameters	1	2	3	4	5	SEM
Dry matter	91.54	91.93	91.42	92.07	91.77	±1.20NS
Crude protein	25.06	25.06	25.11	25.05	25.10	±0.08NS
Ash	7.55	7.23	8.58	10.81	9.97	±2.69NS
Ether extract	6.76	7.15	8.54	6.65	10.35	±2.74NS
Crude fibre	3.91	5.22	4.47	5.33	6.75	±1.51NS
Nitrogen free extract	48.26	47.27	44.72	44.23	39.60	±4.10NS

Key: a, b, means bearing letters with same superscripts within the same row are not significantly ($p > 0.05$) different. SEM= standard error of mean. N.S = not significant, 1= control (no sweet potato tuber meal); 2= diet with 7.80% peeled cooked sweet potato tuber meal; 3= diet with 15.60% peeled cooked sweet potato tuber meal; 4= diet with 23.40% peeled cooked sweet potato tuber meal; 5= diet with 31.20% peeled cooked sweet potato tuber meal; FCR, Feed conversion ratio.

Housing and experimental procedure

The birds were housed on deep litter in a standard poultry brooding house. The house was partitioned using wire mesh to allow for adequate ventilation. A floor space of 75 cm² per bird as recommended (Musa *et al.*, 2008) was used. 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 on a daily basis in the course of the study. From the feed intake and weight gain, feed conversion ratio was calculated. Feed cost per kilogram feed and feed cost/gain were calculated using the prevailing market prices around Jos. From the weight gain, energy intake, protein intake, energy efficiency ratio and protein

efficiency ratio were derived. Feed conversion ratio was determined as the ratio of feed intake to weight gain. Protein intake was calculated by multiplying feed consumed by the protein content of the diet. Feed cost/gain was calculated by multiplying values for feed conversion ratio by the unit cost of the diet. Energy intake was calculated by multiplying feed consumed by the energy content of the diet. Data collected were subjected to one-way analysis of variance (ANOVA) as described (Steel and Torrie, 1980) and means were separated using Duncan's Multiple Range Test (Duncan's, 1950) at ($p < 0.05$).

Estimation of economics of production

The following parameters were used to estimate economics of production:

Cost of feed per kilogram (N/kg) - This was computed using the prevailing market prices of ingredients and it's indicated in the formula (Table 2).

Cost of feed per unit weight gain- This was computed as the feed conversion ratio multiplied by the unit price of feed.

Cost of production/bird: The cost of production was estimated as sum of cost of

birds, feed, medications, kerosene, charcoal, wood shaving, electric bulbs, measuring cylinder, labour and housing divided by the number of birds in a treatment.

Revenue/bird: The revenue/bird was

calculated as price per mature bird plus the manure harvested divided by the number of birds in that treatment.

Gross margin/bird: This was calculated as the total revenue generated minus the total cost of production.

Table 2: Composition of experimental diets containing peeled cooked sundried sweet potato meal as a replacement for maize in growing quail diet

Ingredients	Diets				
	1	2	3	4	5
Maize	31.20	22.71	14.19	5.67	0
Sweet potato meal	0.00	7.80	15.60	23.40	31.20
Ground nut cake	38.10	38.79	39.51	40.22	38.10
Wheat offal	10.00	10.00	10.00	10.00	10.00
Fish meal	1.50	1.50	1.50	1.50	1.50
Palm kernel cake	15.00	15.00	15.00	15.00	15.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50	1.50
*Vitamin Premix	0.25	0.25	0.25	0.25	0.25
Table Salt	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.10	0.10	0.10	0.10	0.10
DL-Methionine	0.10	0.10	0.10	0.10	0.10
	100	100	100	100	100
C. P. (%)	25.00	25.00	25.00	25.00	25.00
M.E. (Kcal/kg)	2618.51	2576.66	2534.62	2492.65	2464.67
Ca. (%)	1.73	1.73	1.73	1.74	1.74
P (%)	0.60	0.59	0.58	0.58	0.57
C.F. (%)	5.18	5.51	5.84	6.16	6.39
Cost/Kg					
Diet (N)	68.98	68.41	67.84	67.28	66.91

* Premix supplied the following per 100kg of diet: Vitamin A, 1,200,000 I.U.; Vitamin D₃ 250,000 I.U.; Vitamin E, 3,000 I.U.; Vitamin K, 200mg; Thiamin (B₁), 225mg; Riboflavin (B₂), 600mg; Pyridoxine (B₆), 450mg; Niacin, 4000mg; Vitamin B₁₂, 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. Key: C.P, crude protein; M.E, metabolizable energy; Ca, calcium; P, phosphorus; C.F, crude fibre.

Results and Discussion

The result of analysis of peeled cooked sundried sweet potato tuber meal (%) showed that it contained crude protein, 5.45; fat, 6.43; ash, 4.99; crude fibre, 6.43; moisture, 4.52; nitrogen free extract, 72.20 and dry matter, 95.50. as against raw peeled sundried sweet potato which was analyzed to contain; crude protein, 6.08; fat, 4.68;

ash, 5.08; crude fibre, 5.13; moisture, 5.69; nitrogen free extract, 73.45 and dry matter, 94.42%. There were minimal differences between values for the raw as against those for the cooked. The protein level compare closely to the 5.54% reported by Aina and Fanimio (1997) 5.00% by Manfredini *et al.* (1990). The fat content is higher than the 2.31% reported by Aina and Fanimio (1997)

and 0.80% by Manfredini *et al.* (1990). The crude fibre content of the processed sweet potato is higher than 3.20% reported by Manfredini (1990) and 3.00% by Devendra (1992). The NFE content is lower than the

90.60% by Oyenuga (1968) and 81.00% by Aina and Fanimo (1997). Variations between values in this study and that of other authors may be due to differences in climate, variety and soil nutrient conditions.

Table 3: Effects of different inclusion levels of peeled and cooked sundried sweet potato tuber meal diets on performance of growing Japanese quail birds

Parameters	Diets					SEM
	1	2	3	4	5	
Initial wt (g/bird)	7.00	7.00	6.80	6.98	7.03	±0.14NS
Final wt (g/bird)	143.33	141.67	142.58	148.83	147.17	±3.25NS
Feed intake(g/b/d)	14.21 ^{ab}	14.17 ^{ab}	14.05 ^b	14.87 ^a	14.79 ^a	±0.34*
Water intake(ml/b/d)	23.77 ^b	24.01 ^b	24.66 ^b	27.40 ^a	26.21 ^{ab}	±1.24*
Weight gain(g/b/d)	3.89	3.85	3.88	4.06	4.00	±0.09NS
FCR	3.29	3.60	3.46	3.54	3.61	±0.21NS
Energy intake (kcal/g)	37.23	36.57	35.61	37.02	36.38	±0.84NS
Protein intake (g)	3.55 ^a	3.54 ^a	3.51 ^a	3.72 ^b	3.69 ^{ab}	±0.04*

Key: a, b, means bearing letters with same superscripts within the same row are not significantly ($p > 0.05$) different. SEM= standard error of mean. N.S = not significant, 1= control (no sweet potato tuber meal); 2= diet with 7.80% peeled cooked sweet potato tuber meal; 3= diet with 15.60% peeled cooked sweet potato tuber meal; 4= diet with 23.40% peeled cooked sweet potato tuber meal; 5= diet with 31.20% peeled cooked sweet potato tuber meal; FCR, Feed conversion ratio.

Table 4: Economics of production of quails fed varying levels of peeled cooked sundried sweet potato tuber meal diets

Parameters	Diets					SEM
	1	2	3	4	5	
Total feed intake (kg)	29.84	29.76	29.51	31.23	31.06	±1.41NS
Total cost of prodn. (N)	119.97	119.60	119.03	120.69	120.30	±0.55NS
Feed cost/gain (N)	240.00	240.00	240.00	240.00	240.00	±0.00NS
Cost of feed/kg (N)	68.98	68.41	67.84	67.28	66.91	
Revenue/bird (N)	266.67	265.00	265.83	266.67	266.33	±0.63NS
Gross margin/bird (N)	146.69	145.40	146.80	145.98	146.03	±0.51NS

Key: a, b, means with same superscripts letters within rows are not significant ($P > 0.05$). SEM = standard error of mean. N.S = not significant. 1 = Control (no sweet potato tuber meal), 2 = Diet with 7.80% peeled cooked sundried sweet potato tuber meal, 3 = Diet with 15.60% peeled cooked sundried sweet potato tuber meal, 4 = Diet with 23.40% peeled cooked sundried sweet potato tuber meal, 5 = Diet with 31.20% peeled cooked sundried sweet potato tuber meal

Data on the various parameters measured are presented on Table 4. Feed intake decreased significantly from control (diet 1) to diet 3 and thereafter increased significantly from diets 4 to 5. This may be due to the fact that birds eat to satisfy energy requirement (NRC, 1994) and because the energy levels of the test diets were decreasing with increasing levels of sweet potato root meal. Similar results have been reported by Mohammad *et al.* (2012) for broilers. But Maphosa *et al.* (2003) reported that feed intake was not significantly

affected by increasing content of sweet potato meal for broilers which disagrees with this result. Agwunobi (1999) also reported no adverse effect on feed intake when sweet potato meal was fed at 27 and 30 % levels respectively in broiler starter and finisher diets. Lee and Yang (1979) reported that feed intake was not affected when they substituted maize with sweet potato meal at 24% for broilers. The difference between the present report and that of Lee and Yang (1979) and Agwunobi (1999) may be due to different species used

in these studies.

Mean daily water intake increased numerically from control; 23.77ml/bird/day (diet 1) to 24.66ml/bird/day; diet 3 but birds on diet 4 consumed significantly more water; 27.40ml/bird/day than those on the preceding diets. However, no significant differences exist between water intake on diets 4 and 5 (26.21ml/bird/day). This is far lower than the mean daily water (164ml/bird) consumed by broilers (Feddes *et al.*, 2002). Moreover, the differences in water intake between diet 5 and diets 1, 2 and 3 were not significant. The daily water consumption recorded in this study was close to the 33.07ml/bird reported by Rajput (2006) for growing quail but much lower than the range of 38.93 - 44.28ml/bird reported by Tuleun *et al.* (2009) for growing quail. This higher range reported by Tuleun *et al.* (2009) may be due to the higher ambient temperature (25 – 37° C) where their study was carried out. Ezieshi *et al.* (2003) had also reported increased water intake for birds in warmer environments compared to colder ones obviously to regulate body temperature. The increase in water intake with increasing content of sweet potato may be as a result of the "sweet" in sweet potato especially at the 75 and 100% replacement of maize with sweet potato root meal which has a tendency to make birds drink more. According to Panigrahi *et al.* (1996), roasting, a common traditional method of preparing sweet potato tubers for human consumption imparts sweetness to the feedstuff by activating the amylases present such that some starch is hydrolyzed to sugars. This is probably what happened since the sweet potato was cooked; some starch must have been hydrolyzed to sugars. It is however, interesting that at the complete (100%) replacement of maize with sweet potato meal, there were only numerical but not

significant differences when compared to diets 1, 2 and 3 and may be due to some adjustments made by the quail birds that kept the feces hard and not watery. Watery feces had been reported for broilers on sweet potato meals above 30% of the diet (Agwunobi, 1999).

Mean daily weight gain of quail chicks improved from birds on diet 2 (3.85g/bird/day) to those on diet 4 (4.06g/bird/day) but did not vary significantly between the diets. This was in agreement with the report of Muhammad *et al.* (2012) even at 80% level of replacement of maize with sweet potato meal for broilers. This was, however, contrary to the report of Maphosa *et al.* (2003); Ayuk (2004) and Afolayan *et al.* (2012) who both reported depressed weight gain for broilers and Gonzalez (2002) working with pigs and this may be due differences in species used. The non significant effect of the inclusion of sweet potato meal in the diets on weight gain in this work agreed with the report of Dominguez (1990) who worked on pigs and Garba *et al.* (2006) and reported no significant effect of sweet potato meal on performance of broilers and adduced that the inactivation of trypsin inhibitors by cooking was responsible.

Feed conversion ratio of quail birds fed the various diets did not vary significantly. This had been attested to by Marrero, (1975) for pigs and Muhammad *et al.* (2012) in the overall performance of broilers. The reports of Maphosa *et al.* (2003); Ayuk (2004); Afolayan *et al.* (2012) however, disagree with this finding. According to Afolayan *et al.* (2012) broiler chicks on the sweet potato meal diets were significantly better feed converters. This was not observed in this study with growing Japanese quail.

The cost of feed per unit of gain (N240/kg) was interestingly similar for each of the diet

even though the cost of feed per kilogram was decreasing as the level of sweet potato was increasing. This is in disagreement with the observations of Afolayan *et al.* (2012) for broilers and Edache *et al.* (2009) for quail chicks. The feed cost per gain did not increase because the sweet potato meal used in this study was cheaper than maize. Also feed cost per kilogram of feed reduced from the control (N68.98/kg) to the complete (100%) replacement with sweet potato meal (N66.91/kg). The disparity between this report and that of previous authors may be as a result of different market prices of various feedstuffs used in the studies reported. The similarity between the diets in terms of feed cost per gain is in agreement with the report of Muhammad *et al.* (2012) where cooked sweet potato was included in the diets of broilers.

Daily protein intake decreased but inconsistently from 3.55g/bird (diet 1) to 3.51g/bird (diet 3) and increased again to 3.72g/bird (diet 4). Protein intake on diet 4 was significantly higher than intakes on diets 1, 2, and 3. Differences between diet 4 and 5 were not significant. The higher protein intake on diet 4 may be due to higher feed intake by birds on that diet. The range of protein intake of 1.96-1.80g reported by Tuleun *et al.* (2009) for growing Japanese quail was lower than the 3.72- 3.51g/bird reported in the present study and may be due to differences in diets used and the higher environmental temperature (25 – 37° C) where their study was conducted since birds consume less feed at higher temperature as compared to lower ones (Ezieshi *et al.*, 2003).

The daily metabolizable energy intake in this study range from 37.23 to 35.61kcal/g/bird which was lower than reported for Japanese quail in the work of Farrell *et al.* (1982). They reported that daily metabolizable energy intake for quail

was 57, 48 and 52 kcal/kg body weight at 12, 19 and 26 days of age which was much higher than reported in this present work probably because of the differences in the climate where the works were carried out. British ambient temperature range between 6 – 18° C as against 13.9 – 28.6° C for the location of the present study. Therefore, increased consumption of energy to satisfy body requirement became mandatory for birds reared under such conditions.

Economics production (Table 4) of raising birds in this study showed that gross margin from birds on diets 3 (146.80) and 1 (146.69) was significantly ($P > 0.05$) better than for those on diet 2 (145.40). Other differences were not significant. In the present study, gross margin for raising growing quails was higher on the diets where 50% of maize was replaced by sweet potato meal diets than on the diet where 25% of maize was replaced which in part supported earlier report of Akinmutimi and Anakebe, 2008). Feed cost per gain was similar for all the diets. This is contrary to the report of Afolayan *et al.* (2012) for broilers. They reported that feed cost per kg gain was higher on the sweet potato diets than on the control. But the report of Mohammad *et al.* (2012) showed that feed cost per gain was higher on the control diet than on the sweet potato meal diets which showed interplay of feed cost, species involved and cost of test materials employed. Total cost of production was significantly higher ($P > 0.05$) for birds on diets 4 (120.69) and 5 (120.30) than on diet 3 (119.03). In the report of Afolayan *et al.* (2012), total cost of production was higher on the control diet than on the sweet potato diet which is contrary to the current report. In the current report, total cost of production was similar between birds on the control and diets 4 and 5 respectively. Feed cost per kg feed was higher on the control than on the

sweet potato diets and this agreed with Akinmutimi and Anakebe (2008) for rabbits fed yam and sweet potato peels mixture and the report of Mohammad *et al.* (2012) for broiler chicken fed cooked sweet potato meal diets. Whereas in the current report, revenue was significantly higher for birds on diets 1 (266.67) and 4 (266.67) than for those on diet 2 (265.00), in the report of Akinmutimi and Anakebe (2008), revenue was lower on the control diet than on the test diets probably because of differences in species and diets in the two reports. Moreover, the sweet potato tuber meal diet has a cost savings of 3% over the maize-based diet.

Conclusion

Sweet potato is commonly available in the savannah regions. It is less costly in terms of farm input and labour when compared to cereals. Parameters measured to determine the effect of replacing maize with peeled cooked sundried sweet potato in the diet for quail chicks showed that feed intake was significantly lower on diet 3 than on diets 4 and 5. Water intake was significantly higher on diet 4 than on diets 1, 2 and 3. Protein intake was significantly higher on diet 4 than on diets 1, 2 and 3. Energy efficiency ratio was significantly better on diet 5 than on diet 1. Other differences were not significant. Gross margin for birds on diets 1 and 3 was significantly better than on the other diets and the other parameters did not follow any particular trend. Therefore, for growing Japanese quails, peeled and cooked sweet potato could completely replace maize without adverse effect on performance or on gross margin.

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