EFFECTS OF FEEDING VARYING LEVELS OF PEELED AND COOKED WHITE SWEET POTATO MEAL ON HEN-DAY EGG PRODUCTION EXTERNAL AND INTERNAL EGG QUALITIES OF JAPANESE QUAILS

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Abstract

A feeding trial lasting six months was carried out to investigate the effect of feeding peeled cooked sundried sweet potato tuber on hen-day egg production, external and internal egg qualities of Japanese quails. Five isonitrogenous (20%CP) diets were compounded to contain 25, 50, 75 and 100% of peeled cooked sundried sweet potato tuber at the expense of maize and designated B, C, D and E respectively. The control diet (A) had zero sweet potato tuber meal. Three hundred point-of-lay female Japanese quails were randomly assigned the diets in a completely randomized design with feed and water provided *ad libitum*. Each diet was allocated to 60 quail chicks which were further divided into three replicates of 20 birds each. Feed intake, body weight change, age at first eggs, age at 50% egg production, age at 75% egg production, hen-day egg production and feed per dozen eggs were similar ($p > 0.05$) across the diets. Water intake was significantly higher ($p < 0.05$) by birds on diet D (51.93ml/bird/day) than by those on diets A (42.60) and C (46.68 ml/bird/day). Water intake by birds on diet A was significantly lower ($p < 0.05$) than by birds on the sweet potato diets. Egg weight, shell thickness, egg length, egg diameter and egg shape index were not significantly affected ($p > 0.05$) by the diets. Albumin height, yolk height, yolk width, yolk index, haugh unit and yolk colour score were similar across the diets from the control. Albumin width was significantly higher on the control than on diet D only. Albumin width on diet B was significantly higher than on diets D and E. Albumin index was significantly lower on diets B and C than on diet D. Results showed that peeled cooked sundried sweet potato can completely replace maize in the diet of laying quails without adverse effects on performance or on internal and external egg qualities. This is because the haugh unit values were similar across the diets.

Keywords: Feed intake, water intake, hen-day egg production, internal egg and external egg qualities.

Introduction

Japanese quails are early maturing and come to egg production early in life, (Martins, 1987). They are small-sized, with meat and eggs low in body fat and cholesterol (Schwartz and Allen, 1981) which is of public health importance. The eggs are small and weigh about 10g each (Edache *et al.,* 2003[a], Musa *et al.,* 2008). Eighteen to twenty percent crude protein diet was recommended for acceptable performance for laying Japanese quail, (Edache *et al.*, 2003[b]). Sweet potato belongs to the family convulvulaceae. The edible tuberous root is long, enlarged and tapered, with a smooth skin whose colour ranges between red, purple, brown and white (Woolfe, 1992). It is widely cultivated in the tropics and the warmer temperate regions. Neild, (1992) reported that the solid root consists largely of starch and that the orangefleshed varieties are high in carotene, vitamin A and B_6 or pyridoxine. Maphosa *et al*. (2003) and Afolayan *et al*. (2012) indicated that only 50% of maize should be replaced with sweet potato meal in finisher diet to avoid deleterous effect on performance. Ladokun *et al*. (2007) reported that to maintain profitable performance not more than 50% of maize be replaced by sweet potato meal in laying chicken diet. Aina and Fanimo (1997) showed that hen-day egg production, egg weight, feed intake and shell thickness did not differ significantly between birds fed maize-based diets and those fed sweet potato diets. 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 determine the effect of replacing maize with peeled and cooked sweet potato meal on hen-day egg production, internal and external egg quality parameters of Japanese 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 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 chemical components according to procedures outlined by AOAC (2000).

Experimental birds: Three hundred point - of- lay Japanese quail birds obtained from Poultry Division of National Veterinary Research Institute (NVRI), Vom were used in this study. They were healthy and uniform in body weight and size.

Experimental design and housing: The three hundred quails were randomly allotted to five dietary treatments in a completely randomized design. Each treatment group had sixty (60) quail birds and was replicated thrice. Each replicate had twenty quail birds. The birds were housed in a standard deep litter poultry house spaced 150 sq cm per bird as recommended by Musa *et al*. (2008).

Experimental diets: Peeled and cooked sweet potato meal was used to replace maize in a isonitrogenous (20% CP) diets. Diet A without peeled cooked sundried sweet potato served as the control. In diets B, C, D and E, 25%, 50%, 75% and 100% of maize was replaced by peeled and cooked sweet potato tuber meal, respectively. The diets were fortified with vitamins and minerals (see table 1).

Table 1: Percent ingredient composition of experimental diets for laying quails

	Diets				
Ingredients	A	B	C	D	E
Maize	40.23	29.26	18.27	7.25	0
Sweet potato meal	0	10.06	20.11	30.22	40.23
Ground nut cake	25.57	26.48	27.41	28.33	30.31
Wheat offal	10.00	10.00	10.00	10.00	10.00
Fish meal	1.00	1.00	1.00	1.00	1.00
Palm kernel cake	14.00	14.00	14.00	14.00	14.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Limestone	6.50	6.50	6.50	6.50	6.50
*Vit. 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
Calculated composition:					
C.P. %	20.00	20.00	20.00	20.00	20.00
M.E. (Kcal/kg)	2575.83	2521.79	2467.57	2413.24	2377.48
Ca. (%)	3.17	3.18	3.18	3.18	3.19
P (%)	0.47	0.47	0.47	0.46	0.45
C.F. (%)	4.63	5.05	5.48	6.90	6.17
Cost/kg Diet (₦)	63.72	62.99	62.26	61.53	61.04

* Bio Mix Layer premix supplied the following per 100kg of diet: Vitamin A, 850,000 I.U; Vitamin D_3, 150,000 I.U; Vitamin E, 1,000 I.U; Vitamin K, 1000 mg; Thiamin (B_1), 150 mg; Riboflavin (B_2), 450mg; Pyridoxine (B_6), 300mg; Niacin, 1500mg; Vitamin B_{12}, 1.5mg; Pantothenic acid, 450mg; Folic acid, 60mg; Biotin, 50mg; Choline chloride, 17,500mg; Anti oxidant, 125mg; Manganese, 4000mg;, Zinc, 3000mg; Iron, 2000mg; Copper, 300mg; Iodine, 100mg; Selenium, 20mg; Cobalt, 20mg. Key: C.P, crude protein; M.E, metabolizable energy; Ca, calcium; P, phosphorus; C.F, crude fibre.

Table 1 is the nutrient composition of the ingredients used in the experiment where maize is replaced by sweet potatoes at varying levels. The protein content of the diet is held at 20% while the energy content decreased slightly.

Table 2 presents results of analyzed composition of nutrients in experimental diets. Dry matter of the diets was between 94.70 (diet A) and 94.04 (diet D). Crude protein of the diets was between 20.11 (diet D) and 20.08 (diet C). Ash, Ether extract, crude fibre and nitrogen free extract values ranged from 10.06 (highest) to 6.09 (lowest), 5.54 (highest) to 4.78 (lowest), 9.06 (highest) to 8.01 (lowest) and 53.86 (highest) to 51.46 (lowest) respectively. All the figures were in percentage. However, the differences were not significant (p> 0.05).

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

Parameters (%)	**A**	**B**	**C**	**D**	**E**	**SEM**
Dry matter	94.70	94.50	94.39	94.04	94.22	±0.43NS
Crude Protein	20.10	20.10	20.08	20.11	20.10	±0.06NS
Ash	10.06	8.00	6.40	6.09	7.02	±4.11NS
Ether extract	5.07	4.78	5.54	4.92	4.98	±0.49NS
Crude fibre	8.01	8.06	8.70	9.06	8.53	±0.71NS
Nitrogen Free Extract	51.46	53.06	53.67	53.86	53.59	±2.23NS

Key: A = Diet (with no cooked sweet potato tuber), B = Diet with 25% of maize replaced by peeled cooked sundried sweet potato meal, C = Diet with 50% of maize replaced by peeled cooked sundried sweet potato meal, D = Diet with 75% of maize replaced by peeled cooked sundried sweet potato meal, E = Diet with 100% of maize replaced by peeled cooked sundried sweet potato meal, SEM - Standard error of mean, N.S – not significant (P >0.05).

Management of birds and data collection:

Each treatment group of birds was fed one of five experimental diets in which 0, 25, 50, 75 and 100% of maize was replaced by peeled and cooked sweet potato tuber meal, respectively. The birds were fed the experimental diets daily and corresponding leftover weighed to determine feed intake over time. Water intake was measured daily using a calibrated cylinder. All birds were given feed and water *ad libitum* throughout the experimental period of 6 months. All recommended routine medications and other routine management practices were strictly adhered to as outlined by Musa *et al.* (2008). Constant administration of vitamins and antibiotics as required keeping birds fit was carried out. All birds in each replicate were weighed at the start of the feeding trial and once a week for the period of the feeding trial. Daily egg collection was carried and sample of eggs from each replicate weighed weekly to record mean egg weight.

Parameters measured:

The initial weight of birds at point-of-lay (POL) and the final weight of the birds at the end of the experiment were taken.

Body weight change: - measured by the difference between the final weight and the initial weight of the quail birds multiplied by 100.

Feed intake: - The birds were offered weighed amount of feed daily and the corresponding left over was weighed and recorded. The difference between the amount fed and the corresponding leftover divided by the specified period was the daily feed intake.

Water consumption: Daily water consumption was determined accounting for evaporative loss using the procedure outlined by Shoremi *et al.* (2001).

Production parameters measured:

b) **Feed conversion ratio-** this was measured as the gram feed consumed per gram of dozen eggs produced.
c) Egg weight; five eggs per replicate were weighed and the average weight

of one recorded weekly using a sensitive electronic balance.

d) Shell thickness; three eggs per replicate were assessed forthnightly. The shells were dried within 48 hours and the shell thickness (sharp point thickness + equator thickness + broad-end thickness/3) measured by micrometer screw gauge and recorded.

e) Egg length; three eggs per replicate were measured fortnightly in the last two months of the study period for egg length or long axis with a vernier caliper and the average egg length recorded.

f) Egg width; the short axis of three eggs per replicate measured fortnightly using a vernier caliper and the mean egg width recorded in the last two months of the study period.

g) Shape index; the long axis and the short axis of eggs measured earlier were used to determine the shape index by the formula given thus; SI = d/D*100, where SI is the shape index, d is the short axis, D the long axis of the egg as described by Genchev (2012).

Internal egg quality;

1) Yolk width; this was measured using three eggs per replicate fortnightly using the vernier caliper. The two points of the vernier caliper were fixed on either side of the short axis of the yolk and the measurement on the caliper taken as yolk width.

2) Yolk height; the height was measured using three eggs per replicate forthnightly using the point of the vernier caliper. The sharp point of the vernier caliper was used to pierce the fresh yolk at the mid-point. Then the space covered by the wet yolk measured on a rule.

3) Yolk index: Records on yolk index which is the ratio of yolk height to the diameter of yolk was kept fortnightly.

4) Yolk colour; the yolk colour was scored for individual egg yolk (using three eggs per replicate forthnightly) by comparing the colour of the egg yolk with the colour of the chips of a Hoffman-La-Roche Yolk Colour Fan.

5) Albumen height was measured every two weeks using three eggs per replicate with the vernier caliper at the point the yolk joins the albumen. The sharp point of the vernier caliper was used to pierce the albumen at the point it joins the yolk and the space covered by the wetness read on a rule.

6) Albumen width was determined every two weeks using three eggs per replicate using a vernier caliper and recorded. The two points of the vernier caliper were placed on either side of the short axis of the albumen and the distance between the two read as the albumen width.

7) Albumen index was computed as the ratio of albumen height to the width of albumen also recorded.

8) Haugh unit computed every two weeks and as described by Neisheim (1979) and Yannakopoulos and Tserveni-Gousi (1986) was also included. Haugh unit is computed using the formular: 100 x Log (albumen height + 7.57 – 1.7 x egg weight$^{0.37}$).

Statistical Analysis

Data obtained were subjected to One Way Analysis of Variance (ANOVA) and where significant differences were observed, means were separated using Duncan's Multiple Range Test (Duncan, 1955) as described by Steel and Torrie (1980).

Results

Data on performance characteristics of laying quails are presented in Table 3. The final body weight seemed to decrease from 197.75g/bird for birds on the control diet to 194.43g/bird on the sweet potato diets. However, the differences were not significant (P> 0.05).

Feed intake ranged from 28.88g/bird/day (diet A) to 29.98g/bird/day (diet D) but was not significantly affected by the diets (P> 0.05). Hen –day egg production decreased from 78.11 (diet A) to 73.09 % (diet E) but did not differ significantly between the diets. Water intake of birds on the test diets was significantly higher (p< 0.05) than those on the control (42.60ml/bird). Significant differences also exist between water intake of birds on diets C and D (51.93ml/bird) only.

Feed per dozen eggs increased linearly from control (0.45kg; diet A) to 0.49kg (diet D) but did not differ significantly (P> 0.05). Egg weight varied slightly between 11.15 grams (diet D) and 10.91 grams (diet E) but differences were not significant (P> 0.05). Egg length varied between 1.62 cm (diet A) and 1.46cm (diet C) but the differences were not significant (P> 0.05). Egg diameter as reported in the current study ranged from 0.93cm (diet B) to 0.78cm (diet E) but the variations were not significant (P> 0.05)

Feed cost/dozen eggs was between N28.89 (diet A) and N30.15 (diet D) but did not differ significantly (P> 0.05) across the diets.

Egg shape index varied between 0.61 (diet B) and 0.51 (diet E) but the differences were not significant (P> 0.05). Shell thickness of quail eggs varied between 0.25 mm (diet C) and 0.22 mm (diet D) but did not differ significantly (P> 0.05). Albumen height varied between 0.41 (diet A) and 0.39 cm (diet E) but did not differ significantly across the diets from the control (P> 0.05).

Albumen width showed variations between 1.48 cm (diet D) and 1.66 cm (diet B) and these variations differed significantly. Actual significant differences exist between diet D and diets A (1.64 cm), B (1.66 cm) and C (1.64cm) only. Diet E (1.50 cm) did not differ significantly (P> 0.05) from diets A, C and D. Records of albumen index (0.25, 0.24, 0.24, 0.27, 0.26) and yolk index (1.39, 1.41, 1.46, 1.46, 1.50) obtained from the present study showed that albumen index differed significantly (p< 0.05) between diet C and diet D only.

Table 3: Effects of replacement levels of peeled cooked sundried sweet potato tuber meal for maize on performance of laying Japanese quails

	Diets					
Parameters	**1**	**2**	**3**	**4**	**5**	**SEM**
Initial weight (g)	155.00	155.67	155.33	155.00	155.00	$0.58^{N.S}$
Final weight (g/bird)	197.75	187.38	192.85	194.43	187.48	6.32^{NS}
Weight change (%)	27.57	20.39	24.15	25.44	20.96	3.94^{NS}
Feed intake (g/bird/day)	28.88	29.39	29.22	29.98	29.11	1.23^{NS}
Water intake (ml/bird/day)	42.60^{a}	48.32^{bc}	46.68^{b}	51.93^{c}	49.19^{bc}	1.81*
Hen-day egg prodn (%)	78.73	76.68	73.83	74.73	73.09	3.75^{NS}
Hen-housed egg prodn (%)	69.02	66.73	73.44	73.00	72.12	5.48^{NS}
Feed/doz eggs	0.45	0.47	0.48	0.49	0.48	0.03^{NS}

Age at 1st egg (days)	35.00	35.00	35.33	35.33	35.00	0.37NS
Age at 50% egg (wks)	5.43	5.48	5.43	5.58	5.52	0.14NS
Age at 75% egg (wks)	6.00	5.86	5.95	5.90	6.19	0.25NS
Feed cost/doz eggs (₦)	28.89	29.90	30.09	30.15	29.50	1.88NS
Energy intake (kcal/g/bird)	74.49	73.97	72.19	72.24	69.20	3.09NS
Protein intake (g/bird/day)	5.78	5.88	5.85	6.00	5.79	0.26NS
Energy Efficiency Ratio	0.15	0.15	0.16	0.15	0.16	0.007NS
Protein Efficiency Rartio	2.03	1.86	1.89	1.86	1.87	0.099NS
Mortality (%)	2.20	2.49	0.28	0.55	0.54	1.40NS

a, b, means with same superscripts letters within rows 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 10.06% peeled cooked sweet potatotuber meal; 3, diet with 20.11% peeled cooked sweet potato tuber meal; 4, diet with 30.22% peeled cooked sweet potato tuber meal; 5, diet with 40.23% peeled cooked sweet potato tuber meal.

Table 4: Effects of different levels of peeled cooked sundried sweet potato tuber meal on external egg quality parameters of laying Japanese quails

	Diets					
Parameters	**A**	**B**	**C**	**D**	**E**	**SEM**
Shell thickness (mm)	0.24	0.23	0.25	0.22	0.23	0.02NS
Egg weight (g/egg)	11.12	10.95	11.03	11.15	10.91	0.25NS
Egg length (cm)	1.62	1.52	1.46	1.54	1.53	0.06 NS
Egg diameter (cm)	0.84	0.93	0.85	0.86	0.78	0.09 NS
Shape index	0.52	0.61	0.58	0.56	0.51	0.05 NS

Key: a, b, means with same superscripts letters within rows are not significantly ($P > 0.05$) different. SEM, standard error of mean. N.S = not significant, A, control (no sweet potato tuber meal); B, diet with 25% peeled cooked sweet potato tuber meal; C, diet with 50% peeled cooked sweet potato tuber meal; D, diet with 75% peeled cooked sweet potato tuber meal; E, diet with 96.45% peeled cooked sweet potato tuber meal.

Yolk height recorded in the present study showed some slight reduction from control (0.94 cm) to 0.92 cm (diet E) but these differences were not significant ($P> 0.05$) across the diets from the control. Yolk width records from the current study ranged from 0.69 cm (diet A) to 0.62 cm (diet E) but the differences were not significant ($P> 0.05$). Records of yolk index did not differ significantly ($P> 0.05$) from the control to the 100 % replacement of maize with cooked sweet potato meal.

Haugh unit scores were similar across the dietary treatments. It was highest for diet A (68.09%) and lowest 67.68% foe diet E. Yolk colour fan score recorded in the present work varied between 3.00 (diet E) and 4.00 (diet B).

However, such differences were not significant (P> 0.05).

Energy intake of the birds varied between 74.49 (diet A) and 69.20kcal/gram (diet E) respectively but did not differ significantly (P> 0.05). Similarly, protein intake varied between 5.78 (diet A) and 6.00g/bird (diet D) respectively but did not differ significantly (P> 0.05).

Table 5: Effects of different levels of peeled cooked sundried sweet potato tuber meal on internal egg quality parameters of laying Japanese quails

	Diets					
Parameters	**A**	**B**	**C**	**D**	**E**	**SEM**
Albumin index	0.25^{ab}	0.24^{b}	0.24^{b}	0.27^{a}	0.26^{ab}	0.02*
Yolk index	0.86	0.87	0.83	0.87	0.88	0.03^{NS}
Albumin height.(cm)	0.41	0.40	0.40	0.40	0.39	0.14^{NS}
Albumin width.(cm)	1.64^{bc}	1.66^{c}	1.64^{bc}	1.48^{a}	1.50^{ab}	0.07*
Yolk height.(cm)	0.94	0.95	0.93	0.93	0.92	0.05^{NS}
Yolk width (cm)	0.69	0.69	0.65	0.65	0.62	0.04^{NS}
Haugh unit (%)	68.09	67.80	67.92	68.08	67.68	0.37^{NS}
Yolk colour score	3.33	4.00	4.00	3.00	3.00	0.82^{NS}

Key: a, b, means with same superscripts letters within rows are not significantly (P > 0.05) different. SEM, standard error of mean. N.S = not significant, A, control (no sweet potato tuber meal); B, diet with 25% peeled cooked sweet potato tuber meal; C, diet with 50% peeled cooked sweet potato tuber meal; D, diet with 75% peeled cooked sweet potato tuber meal; E, diet with 96.45% peeled cooked sweet potato tuber meal.

Discussion

Values of 187.38 - 197.75g/bird obtained in this study were higher than the final body weight of 163-184.33g/bird reported by Edache *et al*. (2012), 187.55-192.67g/bird reported by Akinfenwa *et al*.(2011) and (180-186.50g/bird) reported by Akpa *et al*. (2008) and 141.30 - 154.00g/bird reported by Odunsi *et al*. (2007). Body weight change was not significantly affected by the diets. In the report of Ladokun *et al*. (2007) body weight changes was significantly higher in birds on the complete replacement with sweet potato than on other diets. The lack of significant effect of the diets on body weight change in the present report is in consonance with the report of Akinfenwa *et al*. (2011) for laying quail.

Feed intake ranged from 28.88g/bird/day (diet A) to 29.98g/bird/day (diet D) but was not significantly affected by the diets. This contradicts the report of Ladokun *et al*. (2007). In their report, feed intake decreased significantly as the levels of sweet potato increased. The report of Panigrahi *et al*.(1996) and Aina and Fanimo (1997), on the other hand, supports the present findings. They reported no significant differences between feed intake of chickens on maize –based diets and those on sweet potato diets. Shanaway (1994) had reported that at ambient temperatures of 20, 28 and 35^0 C, feed intake of laying Japanese quail was 20.8, 21.20 and 20.90g/bird/day but this was not observed in this study. Values reported in his work seem lower than reported in the present study. As reported earlier, the energy level of the diets decreased as the level of sweet potato increased. Since birds eat to satisfy energy requirement (NRC, 1994), the increased effort at feed intake by birds on the various sweet potato meal diets must have led to the similarity in feed intake between the test diets and the control. Previous report by Vasco de Basilio *et al.*, (1997) showed that feed intake was not affected as maize was replaced by sweet potato meal for laying Japanese quails up to 100% of the diet. This is in agreement with this study.

Hen –day egg production decreased from 78.11 (diet A) to 73.09 % (diet E) but did not differ significantly between the diets. The values reported in this study are higher than those (77.02 - 62.71%) reported for laying Japanese quail fed toasted mucuna seed meal (Tuleun and Dashe, 2010) and higher than 66.80-59.40% reported by Aggoor *et al.* (2006) for laying quail fed rice bran or broken rice at two different energy levels and higher than that (75.78-68.60%) reported by Akinfenwa *et al*.(2011) for laying Coturnix quail and higher than the 59.00 - 49.80% reported by Odunsi *et al*. (2007) for laying Japanese quail. As a result of the adequacy of dietary protein and metabolizable energy of the diet used (Aina and Fanimo, 1997), egg production did not differ significantly between birds fed maize and sweet potato diets. This agrees with the result of this study.

Water intake of birds on the test diets was significantly higher than those on the control (42.60ml/bird). Significant differences also exist between water intake of birds on diets C and D (51.93ml/bird) only. Ezieshi *et al*. (2003) reported that water intake for chicken increased as egg production increased to peak production which is similar to what was observed in the present study. They reported that average water intake per bird was about 300ml/day in the tropics which was much higher than earlier report (Savory,1978) for laying birds in temperate countries. Water to feed ratio for chicken was about 2.5 but a lack of published data from tropical zones could not allow for comparison (Ezieshi *et al*., 2003). According to Rajput (2006), daily feed and water consumption for young quail was observed to be 16.25g/bird and 33.07ml/bird respectively as compared to 29.98g/bird and 51.93ml/bird in the present study. This variation may be due to differences in the age of birds and climate where the studies were carried out since birds under higher environmental temperatures must consume more water to maintain body temperature.

Feed per dozen eggs increased linearly from control (0.45kg; diet A) to 0.49kg (diet D) but did not differ significantly. This is similar to the report by Aina and Fanimo (1997) for laying chickens. They reported that there were no significant differences either in feed per dozen eggs or feed per kilogram egg between maize –based diets and sweet potato diets. Similar results have been reported by Ladokun *et al*. (2007) for laying birds and Vasco de Basilio *et al.* (1997) for laying Japanese quails fed sweet potato meal diets and by Kaya and Yildirim (2011) for laying chickens fed sweet potato vines.

Egg weight varied slightly between 11.15 grams (diet D) and 10.91 grams (diet E) but differences were not significant. Similar results have been published by Aina and Fanimo (1997), Vasco de Basilio *et al*. (1997), Akinfenwa *et al*. (2011) and Tuleun and Dashe (2010). Mean egg weight compared favourably with the range of 10.31- 10.46 grams reported by Akinfenwa *et al*. (2011) and 10.28-10.50 grams by Aggoor *et al*., (2006) but was higher than the range of 8.65-9.54 grams reported by Tuleun and Dashe (2010) and the range (9.33-10.10grams) reported by Odunsi *et al*. (2007) but was lower than the 13.71g reported by Kumar *et al*. (2008) and may be due to variations in species, weather and diets employed.

Egg length varied between 1.62 cm (diet A) and 1.46cm (diet C) but the differences were not significant. Similar results have been reported by Odunsi *et al*. (2007), Akinfenwa *et al*. (2011) for quail eggs and by Aina and Fanimo (1997) for chicken eggs. However, the range reported in this study is less than the range (3.47-3.49cm) reported by Genchev (2012) for quail eggs and the range (2.97-3.04cm) reported by Odunsi *et al*. (2007) for quail eggs. The differences in egg length between the current work and that reported by Genchev (2012) may be due to variations in species or subspecies of the quail used and diets employed.

Egg diameter as reported in the current study ranged from 0.93cm (diet B) to 0.78cm (diet E) but the variations were not significant (P> 0.05). Similar results have been reported elsewhere (Akinfenwa *et al*., 2011; Odunsi *et al*., 2007) for quail eggs and Aina and Fanimo (1997) for chicken eggs. However, the egg diameter or short axis (2.67-2.70 cm) reported by Genchev (2012) and the 2.56-2.60 cm by Akinfenwa *et al*. (2011) and 2.34-2.46cm by Odunsi *et al*. (2007) for quail eggs were higher and can be related to the diets used.

Egg shape index varied between 0.61 (diet B) and 0.51 (diet E) but the differences were not significant. Similar results have been observed by Odunsi *et al*. (2007). The range in the present study is lower than (0.78-0.80) values reported by Odunsi *et al*. (2007) and lower than the 0.79 reported by Kumar *et al*. (2008).

Shell thickness of quail eggs varied between 0.25 mm (diet C) and 0.22 mm (diet D) but did not differ significantly. This is in consonance with the report of Aggoor *et al*., (2006), Akinfenwa *et al*. (2011) for laying quail and Aina and Fanimo (1997) for laying chickens. Moreover, the egg shell thickness recorded in the present study seem to fall in the range (0.20-0.24mm) reported by Akinfenwa *et al*. (2011), 0.22-0.22 mm by Aggoor *et al*. (2006), close to the 0.21mm reported by Kumar *et al*. (2008) and 22-23 mm reported by Odunsi *et al*. (2007) for Japanese quail eggs. However, in the work of Ladokun *et al*. (2007) egg shell thickness increased significantly from the control which was not noticed in the current work.

Albumen height varied between 0.41 (diet A) and 0.39 cm (diet E) but did not differ significantly across the diets from the control. Similar results have been reported elsewhere (Akinfenwa *et al*., 2011; Vasco de Basilio *et al*., 1997). The albumen height (3.29-3.36 mm) reported by Akinfenwa *et al*. (2011) was a little lower than that reported in the present study. However, the levels reported in the present study was lower than the 0.49 cm reported by Kumar *et al*. (2008) and (0.46 - 0.47 cm) reported by Genchev (2012) probably due to larger size of the eggs in their study.

Albumen width showed variations between 1.48 cm (diet D) and 1.66 cm (diet B) and these variations differed significantly. Actual significant differences exist between diet D and diets A (1.64 cm), B (1.66 cm) and C (1.64cm) only. Diet E (1.50 cm) did not differ significantly from diets A, C and D. This is not comparable to the record of albumen weight reported by Akinfenwa *et al*. (2011) and the record of albumen percentage published by Aggoor *et al*. (2006) but is similar to the record of albumen width reported by Tuleun and Dashe (2010). These variations in albumen width may be due to the type of records collected of the albumen. While the albumen width decreased significantly as the level of toasted mucuna seed meal increased in the diet from the report of Tuleun and Dashe, (2010) for laying quail, which is similar to the pattern observed in the present study, Ladokun *et al*. (2007) reported that albumen weight varied significantly but inconsistently with increasing content of sweet potato meal for laying chickens.

Records of albumen index (0.25, 0.24, 0.24, 0.27, 0.26) and yolk index (1.39, 1.41, 1.46, 1.46, 1.50) obtained from the present study showed that albumen index differed significantly between diet C and diet D only. Other differences were not significant. Albumen index values were slightly higher than values (0.105-0.106) reported by Genchev (2012) and the 0.13 by Kumar *et al*. (2008) and may be due to the bigger egg weight (13.25-13.71g) used.

Yolk height recorded in the present study showed some slight reduction from control (0.94 cm) to 0.92 cm (diet E) but these differences were not significant across the diets from the control. Similar result has been reported also for laying quail (Akinfenwa *et al*., 2011; Tuleun and Dashe, 2010). Ladokun *et al*. (2007) reported significant variations in yolk weight as the levels of sweet potato meal increased in the diets for laying chickens. It is most likely that record of egg yolk weight (not collected) in the present study may have followed the same pattern with virtually other internal egg parameters. The yolk height reported in the present study is a little lower than the 1.13cm reported by Kumar *et al*. (2008) and may be responsible to the larger size (13.71g) of eggs used.

Yolk width records from the current study ranged from 0.69 cm (diet A) to 0.62 cm (diet E) but the differences were not significant. Similar results have been obtained elsewhere for the coturnix quail (Tuleun and Dashe, 2010, Akinfenwa *et al*., 2011)

Records of yolk index did not differ significantly from the control to the 100 % replacement of maize with cooked sweet potato meal. Similar results have been reported for yolk index for coturnix quail fed dietary lysine (Akinfenwa *et al*., 2011) and comparable to yolk percentage of Japanese quail fed rice bran or broken rice at two energy levels (Aggoor *et al*., 2006). Values obtained in this study are higher than the 0.45 obtained by Kumar *et al*. (2008) and 0.51-0.67 obtained by Akinfenwa *et al*. (2011) for quail eggs. Tuleun and Dashe (2010) have also reported a non-significant effect of the diets used on yolk index of Japanese quail eggs. Similar results have been indicated elsewhere by Vasco de Basilio *et al*., (1997).

Haugh unit scores were similar across the dietary treatments. The non-significant difference (P> 0.05) in the present study was at variance with earlier report for laying chickens (Ladokun *et al*., 2007) fed sweet potato meal diets but in consonance with haugh unit scores obtained for laying chickens fed sweet potato diet (Aina and Fanimo, 1997). Results of haugh units measured in earlier reports (Tuleun and Dashe, 2010; Akinfenwa *et al*., 2011; Vasco de Basilio *et al*., 1997) also agree with the report of the present study. While the haugh unit values recorded in the present study are lower than that (85%) reported by Akinfenwa *et al*., (2011) and 88.99-89.01 reported by Genchev (2012) and 78.6-82.0 % reported by Aggoor *et al*., (2006), and the 89.9-92.9 % reported by

Odunsi *et al*. (2007) for quail eggs, the values recorded in this work are higher than the 58.27 % reported by Kumar *et al*. (2008) for quail eggs. However, the values in this current work are fairly similar to that (71.30-70.20%) reported by Aina and Fanimo, (1997) but lower than (72.50-80.40%) reported by Ladokun *et al*. (2007) for chicken eggs and could be due to differences in diets and avian species employed in the various studies.

Yolk colour fan score recorded in the present work varied between 3.00 (diet E) and 4.00 (diet B). However, such differences were not significant. Similar results of yolk colour have been observed for laying Japanese quail (Aggoor *et al*., 2006; Tuleun and Dashe, 2010; Odunsi *et al*., 2007). However, the report of Ladokun *et al*. (2007) indicated significant reduction in yolk colour with increasing content of sweet potato meal for laying chickens and this variation between the result of this study and that of Ladokun *et al*. (2007) may be responsible for differences in species response to sweet potato diets. According to Baker and Gunther (2004), egg yolk yellow pigmentations are affected by many factors such as animal health and physiology, dietary factors, feed production and product characteristics with the ability to store xanthophylls which seems to support this study.

Moreover, Kaya and Yildirim (2011) opined that for the yolk colour to reach the desirable yellow/red colour, the layer diet should be enriched by a more powerful natural pigment such as red pepper. While the figures for yolk colour fan score in the present work was similar to that (3.30) reported by Aggoor *et al*., (2006), the report (1.00) of Tuleun and Dashe, (2010) and that (1.2-1.5) of Odunsi *et al*. (2007) for quail eggs were much lower.

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