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Calcium and phosphorus requirements of Japanese quail layers

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ABSTRACT
Objectives: To determine the dietary calcium and phosphorus requirements of Japanese quail layers
Methodology and Results: Two studies were conducted to determine the biological response of Japanese quail layers to diets containing different levels of calcium and phosphorus. A total of 540 (12 week old) and 270 (42 week old) were used. The birds were randomly assigned to six treatments consisting of three levels of Ca (2.5, 3.0 and 3.5%) and two levels of Pav (0.25 and 0.35%) following factorial completely randomized design. Each dietary treatment had three replications with 30 and 15 birds per replication for early and late production respectively. Diets were formulated using the User Friendly Feed Formulation (UFFF) software. Calcium source was 50% ground limestone and 50% oyster shell (1.5 mm), both in particulate form. Monodicalcium phosphate was the source of phosphorus. Quails in the early lay period attained optimal egg production, feed conversion, and egg mass on a diet containing 3.0% Ca with 0.25% Pav; Comparable values was attained in these parameters by the birds fed on a diet containing 3.5% Ca at both Pav levels. Quails on 3.5 percent Ca irrespective of Pav levels in the diet elicited higher tibia ash content. Eggshell weight was higher for diet containing 3.5% Ca with 0.25% Pav than the diet containing 3.0% Ca with 0.25Pav. In study two optimal egg production was attained with 3.5% Ca, irrespective of Pav level; birds on diet containing 2.5% Ca with 0.35% Pav was comparable with this group. The feed conversion ratio was low in diet containing 3.5% Ca with 0.35% Pav .
Conclusion and application: Findings in both studies indicate that the requirement of Japanese quail layers for calcium is higher than the 2.5 percent currently practiced in feed formulation when equal amount of limestone and oyster shell is used in the diet. A dietary Pav level of 0.35 percent is satisfactory for all periods, irrespective of Ca supplement. The emerging quail production in Uganda and Kenya calls all feed formulators and quail producers to use this formulation as a starting point in an attempt to find the right levels of calcium and phosphorus in the diet to maximize egg production.
Key Words: Available Phosphorus (Pav), Japanese Quails, oyster shell

INTRODUCTION

Quail occupy a small but special segment of the Philippine poultry industry. These birds are raised as source of specialty egg and meat. Raising quails provides livelihood and opportunity for income generation. Raymund, AL 2003). These birds are expected to increasing play a role in food security, necessitating means to improve their productivity. One of the areas that need particular attention is nutrition of the birds. The Japanese quail (*Commix coturnix japonica*) is the predominant breed being raised, largely for the production of table eggs. Shim 2005). The diets of these birds are usually formulated based on the recommendations of the NRC (1994). The recommended amounts of nutrients still lack experimental data to support or corroborate such or just an estimate based on values obtained from other ages or species (Bar 2002, Boitumelo 2004; Boitumelo, and Casartelli 2005;). Calcium and phosphorous are of particular interest since the recommended levels of these nutrient for breeding quails were based only from the work of Nelson *et al*. (1964). There have been continuous improvements in the genetic makeup, management and nutrition of the bird hence the need for new studies on their requirements for these minerals (Yakout 2003, Kadam 2006, Pizzolante 2006 and Bristol 2007). In addition, minimizing the amount of undigested or unabsorbed nutrients, particularly phosphorus, due to over supplementation or nutrient imbalance is also a concern for environmental welfare in (Sheikhlar A 2009). The present work examined calcium and phosphorous requirements of Japanese quails at two production stages.

MATERIALS AND METHODS

The experimental birds of Japanese quail layers were obtained from the Quail Project of the Central Luzon State University Philippines. A total of 570 birds (12 weeks of age) were used for the early production period and 270 birds (42 weeks old) for the post peak production period. The birds were randomly assigned to six dietary treatments following procedures for factorial completely randomized design. Each treatment was replicated thrice with 30 and 15 birds each, for quails in the early and post –peak production period, respectively. Diets were formulated using ground yellow corn, rice bran, coconut oil, and soybean meal. Limestone (fine) and oyster shell (granular), in equal amount, were used as Ca supplements in study 1 and 2 while phosphorus supplement was from monodicalcium phosphate (Table 1,2 and 3). These ingredients were analyzed for calcium and phosphorus contents at the Department of Agriculture, Bureau of Agriculture of Soils and Water Management, Diliman, Quezon City.

The nutrient content of the diet were in accordance with the recommendations for breeding quails by the NRC (1994). The PHILSAN (2003) was referenced for the Pav content of the feed ingredient. The birds were housed in triple-deck battery type laying cages and were provided 18 hours of light period per day. Ad libitum feeding was practiced. Strict sanitation, disease prevention and control were followed by introducing medication in the drinking water and vaccinating birds throughout the duration of the study. The performance of the birds was evaluated for 8 weeks (14^{th} – 21^{st} week) for pre-peak and (42^{nd} to 49^{th} week) for post-peak birds. The following data was collected hen-day egg production rate, daily feed intake, feed conversion ratio (FCR), egg mass and tibia ash (Table 3 and 4) . Summarized data was done on a weekly basis but only the means for all the periods were presented in this report. Eggshell weight was obtained from five egg samples per replicate per week for the entire measurement period. Incidence of soft-shelled eggs was also recorded (Table 3 and 4). At the end of the feeding period, two birds from each replicate were sacrificed and their tibias were obtained for tibia ash determination. Analysis of variance was used to determine significance among treatment means. Least Significant Difference was employed to compare means of parameters found significantly different. Analyses was done using SARS version 10.01 for windows '97.

Table 1: Composition (%), calculated analysis and cost of diets for pre-peak and post peak Japanese quail layers with varying levels of calcium (Ca) and available phosphorus (Pac)[1]

Ingredients	2.50%Ca 0.25% Pav	2.50%Ca 0.35% Pav	3.00%Ca 0.25% Pav	3.00%Ca 0.35% Pav	3.50%Ca 0.25% Pav	3.50%Ca 0.35% Pav
Ground yellow corn	50.32	49.68	47.52	47.25	45.07	44.43
Rice bran, Di	9.56	9.56	9.56	9.22	9.24	9.22
Coconut oil	2.87	3.05	3.80	3.93	4.68	4.86
Soybean meal, USHP	27.56	27.66	28.06	28.18	28.58	28.68
Fish meal, US	2.56	2.56	2.56	2.56	2.56	2.56
Limestone	2.97	2.86	3.65	3.54	4.33	4.24
Oyster shell	2.97	2.86	3.65	3.54	4.33	4.23
Monodicaltium phosphate	0.32	0.80	0.33	0.81	0.34	0.81
Iodized salt	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin premix [1]	0.12	0.12	0.12	0.12	0.12	0.12
Mineral premix [2]	0.10	0.10	0.10	0.10	0.10	0.10
Chlorine chloride	0.10	0.10	0.10	0.10	0.10	0.10
Toxin binder	0.10	0.10	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis (as is basis)						
ME, kcal/kg	2900	2900	2900	2900	2900	2900
Crude fat,%	6.23	6.45	7.13	7.20	7.89	8.04
Crude fiber, %	2.96	2.95	2.90	2.89	2.84	2.83
Calcium %	2.50	2.50	3.00	3.00	3.50	3.50
Available phosphorus %	0.25	0.35	0.25	0.35	0.25	0.35
Crude protein %	20.00	20.00	20.00	20.00	20.00	20.00
Methionine, %	0.35	0.34	0.35	0.35	0.35	0.35
Methoionine + Cystine, %	0.70	0.70	0.70	0.70	0.70	0.70
Lysine, %	1.00	1.04	1.05	1.05	1.06	1.05
Threonine, %	0.77	0.78	0.78	0.78	0.78	0.78
Sodium, %	0.13	0.14	0.13	0.14	0.14	0.14
Chlorine, %	0.21	021	0.21	0.21	0.20	0.20
Linoleic acid, %	1.54	1.54	1.52	1.50	1.48	1.48

[1]Vit. Premix (1 kg) contains vit. A 35 MIU, vit. D_3 9 MIU, vit. K_3 6 g, vit. B1 7 g, vit. B_2 22 g, vit. B_6 12 g, vit. B12 70 G, Niacin 120 g, Pantothenic acid 35 g, Folic acid 3 g, Biotin 0.30, carrier q.s. ad 1 kg, anticake 20 g, antioxidant 0.20 g.
[2]Mineral Premix (1kg) contains chlorine chloride 150,000 mg, iron 40,000 mg, manganese 30,000 mg, zinc 50,000 mg, copper 20,000 mg, iodine 2,500 mg, selenium 20 mg, cobalt 500mg.
[3]Toxin binder as Co-bind a-z contain dried molasses, fermentation soluble and dried brewer's yeast.

Table 2: Composition (%), calculated analysis and cost of diets for post-peak Japanese quail layers with varying levels of calcium (Ca) and available phosphorus (Pav) containing oyster shell as the only calcium supplement[1]

INGREDIENTS	2.5% Ca		3.0% Ca		3.5% Ca	
	0.25 Pav	0.35 Pav	0.25 Pav	0.35 Pav	0.25 Pav	0.35 Pav
Ground yellow corn	50.24	49.45	47.44	46.58	44.41	45.04
Rice bran, D1	9.35	9.58	9.24	9.54	9.34	8.28
Coconut oil	3.00	3.23	3.97	4.20	4.96	4.97
Soybean meal, US high CP	27.69	27.77	28.22	28.29	28.73	28.89
Fish meal Menhaden	2.56	2.56	2.56	2.56	2.56	2.56
Limestone	0.00	0.00	0.00	0.00	0.00	0.00
Oyster shell	6.21	5.99	7.62	7.40	9.04	8.82
Mono-dicalcium	0.33	0.80	0.33	0.81	0.34	0.82
Iodized Salt	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin Premix1	0.12	0.12	0.12	0.12	0.12	0.12
Mineral premix [2]	0.10	0.10	0.10	0.10	0.10	0.10
Chlorine chloride	0.10	0.10	0.10	0.10	0.10	0.10
Toxin binder	0.10	0.10	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis ("As fed basis")						
ME, Kcal/kg, %	29000	2900	2900	2900	2900	2900
Crude fat, %	6.38	6.60	7.23	7.47	8.14	8.02
Crude fiber, %	2.95	2.94	2.86	2.88	2.83	2.80
Calcium, %	2.50	2.50	3.00	3.00	3.50	3.50
Available phosphorus, %	0.25	0.35	0.25	0.35	0.25	0.35
Crude protein, %	20.00	20.00	20.00	20.00	20.00	20.00
Methionine, %	0.35	0.35	0.35	0.35	0.35	0.35
Methionine + cystine, %	0.70	0.70	0.70	0.70	0.70	0.70
Lysine, %	1.04	1.04	1.05	1.05	1.05	1.05
Tryptophan, %	0.24	0.24	0.24	0.24	0.25	0.25
Valine, %	0.99	0.99	0.99	0.99	0.99	0.99
Arginine, %	1.34	1.34	1.34	1.35	1.35	1.35
Threonine, %	0.78	0.78	0.78	0.78	0.78	0.78
Leucine, %	1.73	1.73	1.72	1.72	1.71	1.71
Isoleucine, %	0.89	0.89	0.89	0.89	0.89	0.89
Phenylalanine, %	1.06	1.06	1.06	1.06	1.06	1.06
Histidine, %	0.55	0.55	0.55	0.55	0.55	0.55
Sodium, %	0.14	0.14	0.14	0.14	0.14	0.15
Chlorine chloride, %	0.21	0.21	0.21	0.21	0.20	0.20
Linoleic Acid, %	1.53	1.54	1.50	1.51	1.48	1.44
Cost/kg, (pesos)	12.54	12.64	12.69	12.79	12.82	12.91

[1]Vit. Premix (1 kg) contains vit. A 35 MIU, vit. D_3 9 MIU, vit. K_3 6 g, vit. B1 7 g, vit. B_2 22 g, vit. B_6 12 g, vit. B12 70 G, Niacin 120 g, Pantothenic acid 35 g, Folic acid 3 g, Biotin 0.30, carrier q.s. ad 1 kg, anticake 20 g, antioxidant 0.20 g.
[2]Mineral Premix (1kg) contains chlorine chloride 150,000 mg, iron 40,000 mg, manganese 30,000 mg, zinc 50,000 mg, copper 20,000 mg, iodine 2,500 mg, selenium 20 mg, cobalt 500mg.
[3]Toxin binder as Co-bind a-z contain dried molasses, fermentation soluble and dried brewer's yeast.

Table 3: Mean production performance of Japanese quails in the early production period as influenced by dietary levels of calcium (Ca) and available phosphorus (Pav)[1]

Ca (%)	Pav (%)	Egg Prod'n (%)	Feed intake (g/day)	Feed Conversion Ratio (g/g)	Egg Mass (g)	Tibia Ash (%)”
2.5	0.25	87.97^{a}	23.05^{ab}	2.17^{0}	9.22^{ab}	58.59^{abc}
	0.35	87.26^{a}	23.47^{a}	2.14^{bc}	9.61^{ab}	57.69^{c}
3.0	0.25	88.04^{a}	21.74^{c}	1.97^{a}	9.43^{ab}	59.52^{ab}
	0.35	84.00^{b}	22.22^{bc}	2.04^{ab}	8.89^{b}	58.42^{bc}
3.5	0.25	87.81^{a}	21.46^{c}	2.00^{a}	9.59^{ab}	60.21^{a}
	0.35	89.76^{a}	22.14^{bc}	1.99^{a}	9.86^{a}	60.20^{a}
LSD (P=0.05)		2.95	1.23	0.12	0.78	1.73
Significance of main effects						
Ca		NS	**	**	NS	*
2.5		87.61	23.26^{a}	2.15^{b}	9.41	58.15^{b}
3.0		86.02	21.98^{b}	2.01^{a}	9.16	58.97^{b}
3.5		88.79	21.80^{b}	1.99^{a}	9.73	60.21^{a}
LSD (P=0.05)		2.57	0.79	0.08	0.58	1.17
Pav		NS	NS	NS	NS	NS
0.25		87.94	22.08	2.04	9.41	59.44
0.35		87.01	22.61	2.06	9.45	58.77
LSD (P=0.05)		2.10	0.65	0.06	0.47	0.95
CaxPav		**	*	**	*	*

NS – Not Significant *Significant (P<0.05) **Highly Significant (P<0.01)
‘Column means, in a particular factor, with different superscript differ significantly.

Table 4: Mean production performance of Japanese quails in the post production period as influenced by dietary levels of calcium (Ca) and available phosphorus (Pav)[1]

Ca (%)	Pav (%)	Egg Prod'n (%)	Feed intake (g/day)	Feed Conversion Ratio (g/g)	Egg Mass (g)
2.5	0.25	77.17^{bc}	24.96^{a}	2.16^{b}	7.23
	0.35	81.56^{a}	23.86^{bc}	2.07^{b}	7.62
3.0	0.25	77.93^{b}	22.49^{d}	1.95^{a}	7.24
	0.35	74.80^{c}	24.65^{ab}	2.11^{b}	7.15
3.5	0.25	81.75^{a}	23.43^{c}	2.10^{b}	7.18
	0.35	82.59^{a}	22.46^{d}	1.97^{a}	7.51
LSD (P=0.05)		3.00	0.91	0.09	0.67
Significance of Main Effect					
Ca		**NS**	*	**NS**	**NS**
2.5		79.37	24.41^{a}	2.11	7.42
3.0		76.37	23.57^{ab}	2.03	7.19
3.5		82.17	22.95^{b}	2.03	7.34
LSD (P=0.05)		2.90	1.21	0.11	0.46
Pav		**NS**	**NS**	**NS**	**NS**
0.25		78.95	23.62	2.07	7.21
0.35		79.65	23.66	2.05	7.42
LSD (P=0.05)		2.37	0.99	0.09	0.37
CaxPav		**	**	**	NS

NS – Not Significant *Significant (P<0.05) **Highly Significant (P<0.01)
‘Column means, in a particular factor, with different superscript differ significantly.

RESULTS AND DISCUSSION

Early Production: A significant decrease of feed intake was evident with increasing calcium content but not with Pav. Significant (P 0.05) interaction of Pav and calcium was also observed. Birds on 2.5% Ca had higher feed intake than their counterparts. Comparable feed intake was observed with birds on the higher group of diets (3.0 and 3.5% Ca). The significant interaction between Ca and Pav indicated that the reduction in feed intake with diet containing 3.5% Ca tended to accentuate when such diet contained 0.25% Pav. The result showed a negative impact on increasing dietary Ca on birds' intake which was most profound with 3.5% Ca at 0.25% Pav. Excess Ca has a neutralizing effect in the intestines that caused a rise of intestinal pH (Bristol, 2007). This caused deficiency by formation of insoluble Ca phosphate in the digestive tract (Keshavars, 2000) and impairs metabolic functions (Kheiri and Rahmani, (2006) that caused the birds to refrain from eating.

Neither Ca nor Pav significantly ($P>0.05$) affected egg production; however, significant ($P<0.01$) interaction between the two dietary factors was evident. Analysis of the significant Ca and Pav interaction revealed that egg production was markedly reduced with 0.35% Pav but only in diet containing 3.0% Ca. The present findings indicated that quails in early production period tolerated well levels of 2.5% and 3.5% Ca with the two levels of Pav except when 3.0% Ca and 0.35% Pav was used when production decreased. The higher Ca level (3.5%) inclusion in the diet did not affect laying performance of the birds in this study. Rather, the combinations of small to large particulate oyster shell with fine limestone were able to provide the daily Ca and Pav requirements for both maintenance and optimal egg production (Bristol, 2007) Significant effect ($P<0.05$) of Ca levels were noted but not for the Pav levels. Significant Interaction ($P<0.01$) between Ca and Pav was evident. FCR was poorer for diets containing 2.5% Ca compared with diets containing 3.0 and 3.5% Ca., . Significant Ca and Pav interaction indicate that birds on 3.0% with 0.25% Pav diet elicited tendency for better FCR than when 0.35% Pav was provided. FCR value for diet containing 3.0% Ca and 0.25% Pav. showed no significant differences($P>0.05$) with the groups fed on diet with 3.5% Ca, irrespective of Pav levels. Improved FCR with increased dietary Ca was associated with the capacity of the birds to maintain optimal egg production despite the decrease in their feed intake. The decrease in their feed intake for Ca did not translate into fewer nutrients for egg production nor did high Ca intake. A dietary level of 3.5% Ca, irrespective of Pav level was optimal. Yakourt (2003) and Kadam (2006) observed in their studies that Ca level maintained at 3.0% with 0.35% Pav effected optimal feed conversion. .

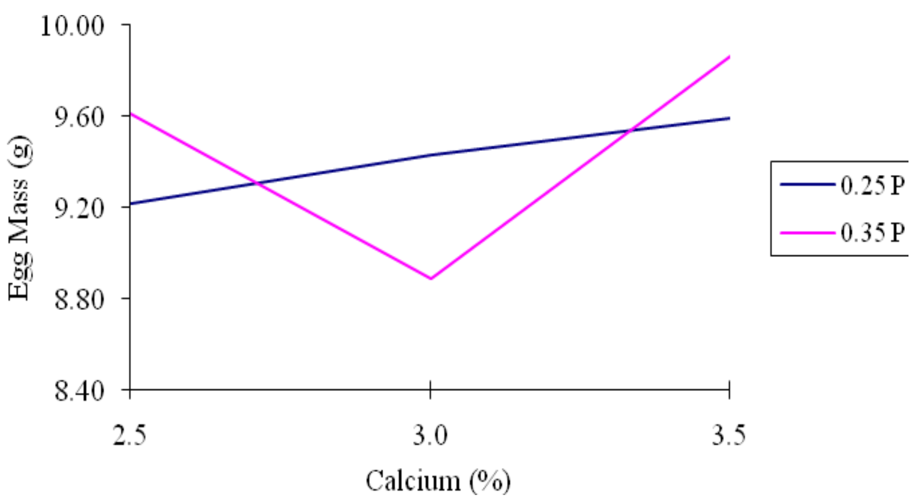

Figure 1: The details of significant interaction of calcium and phosphorus on mean daily egg mass

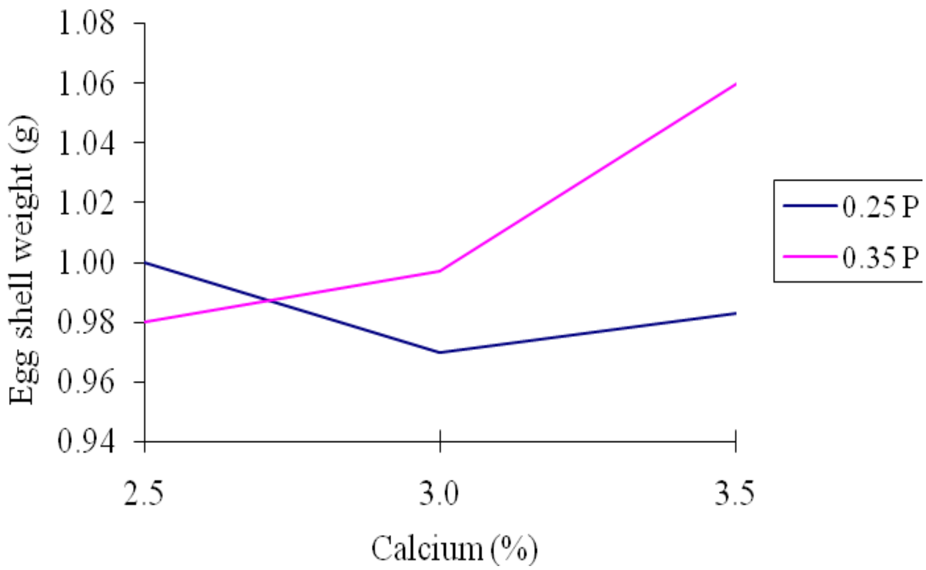

Figure 2: The details of significant interaction of calcium and phosphorus on mean eggshell weight

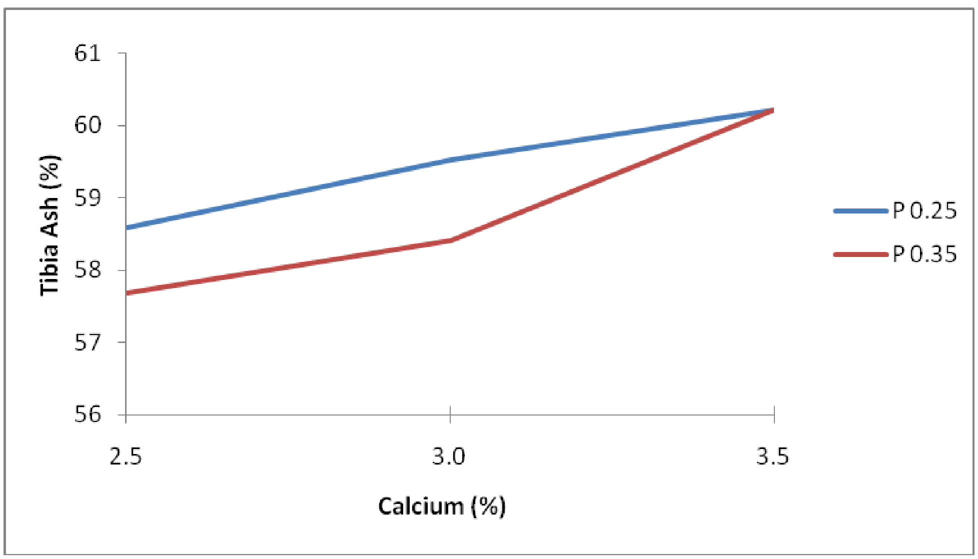

Figure 3: The details of significant interaction of calcium and phosphorus on tibia ash weight

Mean egg mass was not significantly P>0.05) influenced by Ca nor Pav. However, significant P<0.05) interaction of these dietary factors was observed. The details for this interaction (Figure 1) showed that mean egg mass of Japanese quail layers fed diet with 3.0 percent Ca tended to decease significantly with 0.35 percent Pav. Egg mass value from this group was significantly (P<0.05) lower than that for the group with 3.5 percent Ca and 0.35 percent Pav. This was mainly due to lower egg production. . Egg mass is a function of both weight and quantity of egg produced by the birds. It was apparent that nutrient intake including Ca and Pav could not have been compromised as to adversely affect egg mass. In a related study, Kadam (2006) observed improvement in egg mass with increased in calcium level from 2.5 to 3.25 percent Ca with 0.35 percent Pav, which was not the case in this present work. Significant (P<0.05) interaction of Ca and Pav was noted for eggshell weight. The analysis of the significant (P 0.05) - interaction (Figure 2) showed that egg shell weight was higher when 0.35 percent Pav was used instead of 0.25 percent Pav 3.5 percent Ca diet; however egg shell weight value for such group was comparable to that achieved with 3.0 percent Ca with 0.35 percent Pav and diet with 2.5 percent Ca with 0.25 percent Pav. With 3.5 percent Ca and 0.35 Pav, shell synthesis could have been enhanced. Yakout (2003) observed maximum egg shell weight with higher levels of Ca (3.0 %) and Pav (0.35 and 0.45%) which agrees with this present study. Significant P<0.05) effect of Ca levels on relative tibia ash weight was noted but not with the Pav levels. Significant (P<0.05) interaction of Ca and Pav was also noted. Birds fed on diet with 3.5 percent Ca had significantly (P<0.05 higher percentage tibia ash than those fed with 2.5 and 3.0 percent Ca levels. Analysis of the significant interaction (Figure3) showed that superior relative ash values were attained with 3.5 percent Ca, irrespective of Pav level. However, comparable percentage ash values with this group was noted for diet with 2.5 percent Ca and 0.35 percent Pav and diet with 3.0 percent Ca and 0.25 percent Pav. Result showed that increasing amount of Ca resulted to higher amount of tibia ash. With 3.5 percent Ca, values was optimal, irrespective of Pav level in the diet suggesting that Ca and Pav ratio was not critical for bone material synthesis at such level. The fact that ash value increased with increased amount of dietary Ca means that the birds were able to deposit Ca rather than having it used for shell formation and other Ca needs. When sufficient Ca is obtained from the diet, Ca from the medullary bone is not released for eggshell formation (Hofacre, 2002).

Post-Peak Production: Significant interaction between Ca and Pav were noted for egg production, daily feed intake and FCR. The hen day egg production rate was higher by 4.79% and lower by 3.13% with 0.25% Pav compared with 0.35% Pav in diet containing 2.5% Ca and 3.0% Ca, respectively. There was no apparent effect of Pav level in the diet with 3.5% Ca but production was highest with only the diet containing 2.5% and 0.35% Pav reaching comparable production. Evident effect of Pav level on feed intake at all Ca levels was noted although this was not consistent. Both diet containing 2.5 and 3.5% Ca elicited a decrease in feed intake by 4.0% with Pav level of 0.25% compared with 0.35%. On the contrary, feed intake increased by 10% in the diet containing 3.0% Ca with 0.25% Pav than 0.35% Pav. Overall, daily feed intake of the birds decreased as Ca level decrease with profoundest decrease with 3.5% Ca. For FCR, significant decrease of 8.0% and increase of 7.0% was noted with the higher Pav level in diets with 3.0 and 3.5% Ca, respectively. Eggshell weight and incidence of soft-shelled eggs were not influenced by Ca or Pav. The results indicate definitive response to high level of Ca by the birds in the post peak period than that observed in quails in the early stage of production. This was manifested in terms of satisfactory response in both egg production and FCR with the diet containing 3.5% Ca with 0.35% Pav. Such level of Ca with 0.35% Pav was also satisfactory for eggshell quality.

CONCLUSIONS

The results showed that Japanese quails require at least 3.0% Ca with 0.25% Pav during the early stage of production for optimal egg production, egg shell weight and tibia ash which were also achieved with the diet containing 3.5% Ca with 0.25% or 0.35%. For quails in the post peak production period, Ca level of 3.5% and Pav of 0.35% was optimal based on egg production and feed conversion. These findings indicated that improvement in performance of quails in both early and post peak production period can be achieved with dietary calcium level higher than the 2.5% recommended by the NRC (1994). The current Pav level of 0.35% used in practical dietary formulations for quails remains satisfactory. Quail production is emerging in some countries in Eastern African region (Kenya and Uganda). Formulating quail layers feeds, both locally and commercially, is a challenge especially the inclusion level of calcium and phosphorus. Formulators and poultry farmers are encouraged to use the formulation in this research outcome as a beginning point in their effort to obtain optimal egg production with good quality eggshells that enhance egg preservation and lead to optimal profit making.

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