VITAMIN D_3 ALLEVIATES CALCIUM AND PHOSPHORUS DEFICIENCY IN BROILERS

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SUMMARY

An experiment was carried out to examine effects of using extra dietary vitamin D3 along with low levels of calcium (Ca) and phosphorus (P) on performance, bone quality and mineral retention of broilers. Three starter diets were used; Control (C), Medium (M) and Low (L) which contain Ca: 1.00, 0.75 and 0.50%; non-phytate P (NPP): 0.50, 0.37 and 0.25%; D3: 3,000, 5,000 and 7,000 IU/kg, respectively. As well, three grower diets were used; (C), (M) and (L) contain Ca: 0.90, 0.65, and 0.40%; NPP: 0.45, 0.32 and 0.20%; D3: 3,000, 6,000 and 9,000 IU/kg, respectively. Six treatment groups were distributed according to diets fed in starter and grower periods consecutively; (C/C), (C/M), (C/L), (M/M), (M/L) and (L/L). Each group contained 40 birds in four replicates 10 chicks each. Body weight gain, feed efficiency, plasma concentration of Ca and P and plasma alkaline phosphatase activity, were not affected by dietary treatments compared to (C/C) except for (C/L) group. Similarly, tibia breaking strength, tibia ash and Ca and P percentage, were not affected by different dietary treatments except for (C/L) group which recorded lower bone density compared to (C/C) group. Birds of (C/L), (M/L) or (L/L) groups retained more Ca and P compared with those of other treatments. Based on results obtained, it could be concluded that extra vitamin D3 supplementations (9,000 IU/Kg) to low Ca and NPP (0.40 and 0.20%, respectively) diets could alleviate performance, bone quality and mineral retention, and decrease environmental pollution especially with P, as well as to minimize feed cost.

Keywords: *Calcium, phosphorus, vitamin D3, bone quality and mineral retention.*

INTRODUCTION

Plant feed ingredients contain P which is not completely available for chickens due to its complexity as phytate P (PP), and using these ingredients in chicken diets results in more excretion of phytate-bound P (Kornegay *et al.,* 1996). Recent estimates confirmed that the world releases amount of P that is substantially greater than pre-industrial emissions (Rockstrom *et al.,* 2009). Therefore improvements in freshwater quality and other ecosystems require reductions in P escape in these systems (Conley *et al.,* 2009). The adaptation of animals to deficient nutrient has been long eminent. In this regard, animals respond to nutrient limitation by increasing absorption and utilization, which in turn, decreases the excretion of restricted nutrient (Yan *et al.,* 2005). Moreover, excess levels of Ca in the diet reduce the utilization of PP in the chicken gut (Applegate et al., 2003). High intakes of vitamin D3 and low intakes of Ca independently increase PP utilization in the low P diets (Mohammed *et al.,* 1991) by increasing the activity of intestinal phytase (Shafey *et al.,* 1991). In addition, availability of PP from plant feed ingredients would be increased either by feeding diets deficient in P or with vitamin D3 supplementation (Onyango *et al.,* 2006) which in turn, reduces the use of costly inorganic P and minimizes P excretion (Rama Rao *et al.,* 2006). Decreasing dietary P, to concentrations that do not impair broiler performance, results in decreased litter P (Yan *et al.,* 2001; Yan *et al.,* 2003; Yan *et al.,* 2005). Vitamin D3 has been shown to improve body weight gain, feed efficiency, bone ash, and breast meat yield (McNutt and Haussler, 1973; McNaughton *et al.,* 1977) of broilers. Because of lower cost of synthetic vitamin D3 compared with that of supplemental P, reducing P and Ca concentrations with high levels of D3 might be beneficial for economic and *environmental* reasons (Rama Rao *et al.,* 2006). The current study was designed to examine effects of deficiency of Ca and NPP in broiler diets in the presence of extra levels of vitamin D3 and subsequent effects on performance and bone quality.

MATERIALS AND METHODS

Birds and Management:

All procedures used during the study were approved by the University of Ain Shams Animal Care Committee. Two hundred forty unsexed one-day-old Hubbard broiler chicks were randomly distributed into six treatments. Each treatment comprised of 40 chicks divided into four replicates of 10 chicks each. The chicks were reared up to five weeks of age in wire-floored batteries. Each pen was fitted with individual feeder, waterer, and excreta collection tray and housing two birds. Birds were provided ad libitum access to feed and water during the study, with light provided with UV-filtered incandescent bulbs. All chicks were reared under similar managerial and hygienic conditions and were vaccinated by drinking-water-based vaccinations against Newcastle and Gumboro diseases. Chicks were brought from Hatcheries of Cairo Poultry Company Ltd., 10th of Ramadan City, Egypt. Vaccinations from Veterinary Serum and Vaccine Research Institute VSVRI, Cairo, Egypt.

Diets

Three different starter diets (fed from one to 14 days); Control (C) 1.00% Ca, 0.50% NPP supplemented with D3 3,000 IU/kg; Medium (M) 0.75% Ca, 0.37% NPP supplemented with D3 5,000 IU/kg and Low (L) 0.50% Ca, 0.25% NPP supplemented with D3 7,000 IU/kg. Three different grower diets (fed from 15 to 35 days); Control (C) 0.90% Ca, 0.45% NPP supplemented with D3 3,000 IU/kg; Medium (M) 0.65% Ca, 0.32% NPP supplemented with D3 6,000 IU/kg and Low (L) 0.40% Ca, 0.20% NPP supplemented with D3 9,000 IU/kg. Six dietary treatments (Table 1) were distributed according to diets fed to birds consecutively during starter and grower phases as; (C/C); (C/M); (C/L); (M/M); (M/L) and (L/L). Birds of (C/C) group were considered as control group according to requirements of birds (listed in Hubbard Broiler Management Guide) during starter and grower phases. Diets were formulated ensuring sufficient supply of nutrients to be isocaloric and isonitrogenous according to (NRC, 1994) and were offered in an age-relative mash form. Samples of mixed feeds were retained for analysis of calcium and phosphorus at Poultry Nutrition Laboratory, Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

Chemical and Biochemical Analyses:

Total excreta were collected two days prior to the end of the experiment to determine Ca and P retention, feed consumption during digestive trial period was recorded. Samples of diets, tibia and excreta were analyzed for Ca (AOAC, 1990a) and P (AOAC, 1990b). Each nutrient was analyzed in quadruplicate. Blood sampling was done simultaneously with slaughtering at the end grower and starter, and then blood was immediately centrifuged at 3,000 rpm for 10 minutes to separate plasma. Blood plasma samples were analyzed spectrophotometrically for Ca (Young, 2000), inorganic P (iP) (Tietz, 1995), and alkaline phosphatase (ALP) activity (Young, 1995) using Cromatest diagnostic kits, Linear Chemicals s.l., Joaquim Costa, 18 - 2a planta, 08390 Montgat. Spain.

Parameters Measured:

Mean body weights of treatment were taken weekly and recorded at 14 and 35 d of age. Feed consumption was determined at the same ages. Body weight gain (BWG) and feed conversion ratio (FCR; weight gain/feed intake) were calculated for both starter and grower. At 35 d, six birds per treatment were killed, and tibia was removed for ash determination on dry fat-free bones as described by (AOAC, 1990c). Seedor index (SI) values expressing bone mineral density were obtained by dividing tibia dry weight (g) by its length (cm), as proposed by (Seedor *et al.*, 1991). Tibia breaking strength (TBS) was determined on tibiae at wet-basis following the method of (Crenshaw *et al.*, 1981) by applying the simple three-point bending concept at Research Center of Properties and Testing of Materials and Quality Control, Engineering Consulting Center, Faculty of Engineering, Ain Shams University, with an Instron Universal Testing Machine, which was set at a maximum load of 50 Kg and a crosshead speed of 1 m/ min.

Statistical Analysis:

Data were subjected to one way analysis of variance General Linear Model (GLM) procedure of (SAS, 2003) user's guide according to the following model:

$Yij = \mu + Ti + eij$

Where; μ = overall mean, Ti = dietary treatment, eij = experimental error. Individual effects of dietary treatments were compared using Duncan's multiple range tests (Duncan, 1955) at α level equal to 0.05 or 0.01.

RESULTS AND DISCUSSION

Growth performance:

Overall results of BWG and FCR (Table 2) indicated that supplementations of vitamin D3 have conquered Ca and P deficiency. These performance traits represents an obvious effect of high D3 levels (6,000 or 9,000 IU/Kg) which make chicks of (M/M), (M/L) or (L/L) treatments to be significantly similar to those of (C/C) treatment. These results agreed with findings of other studies (Rama Rao *et al.*, 2008) and (Thabet, 2010) which indicated that deficient Ca and NPP diets supplemented with vitamin D3 improved body weight as well as body weight gain. Surplus D3 levels (6,000 or 9,000 IU/Kg) have no effect on feed consumption and a positive effect on FCR as recently reported (Thabet, 2010) and (Yan *et al.*, 2005); in regard to these parameters, birds of (M/M), (M/L) or (L/L) treatments showed significantly similar values compared with those of (C/C) treatment. The fact that (L/L) group presented productive performance similar to those of (C/C) could be explained by broilers' ability to adapt to Ca & NPP deficiency (Yan *et al.*, 2005).

Blood parameters:

Values of blood plasma Ca, P concentrations and ALP activity are presented in Table (3). Data of starter showed no significant difference between (C), (M) or (L) treatments for both Ca and P, while ALP was high with (M) and (L) than (C). During grower, values of Ca for birds fed lower Ca with higher levels of D3 as of (M/M), (M/L) or (L/L) treatments were similar to those of (C/C) treatment, which in turn is in conformity with the rule of D3 in Ca metabolism. On the other hand, birds of (C/L) treatment showed significantly lower plasma Ca compared with those of (L/L) treatment which were well adapted to Ca deficiency and exhibited better Ca retention. The same trend was observed in plasma P concentrations. ALP activity values in birds fed deficient Ca and P diets were higher than those fed optimal Ca and P levels. Higher dietary D3 levels (9,000 IU/Kg) have seemingly helped birds fed deficient Ca and P to uphold this deficiency which finally presented no significant differences between (L/L) and (C/C) groups. These results were in agreement with those of other studies (Rama Rao et al., 2006) and (Thabet, 2010) which stated that decreasing dietary Ca and NPP did not affect plasma Ca, P concentration while using diets containing extra levels of vitamin D3. On the other hand, ALP activity for (M/M) and (M/L) was significantly higher compared to other treatments, while P of (M/M) was lower than that of (C/C). Increased concentrations of Ca and iP in serum of broilers fed low Ca and NPP with extra D3 might suggest beneficial effect of higher D3 on utilization of dietary Ca and NPP (Rama Rao *et al.*, 2006). These results clearly show that diets containing both low levels of Ca and elevated levels of vitamin D3 permit greater utilization of PP and reduce NPP needs (Mohammed et al., 1991) which was obvious when birds were seemingly adapted to lower levels of Ca and P (Yan *et al.*, 2005).

Bone composition and measurements:

Data in Table (4) showed no significant effect of dietary treatments on values of toe ash, wet and dry tibia weight, meaning that increasing dietary vitamin D3 (9,000 IU/Kg) had significantly overcome negative effects of Ca and P deficiency on bone composition. In this regard, it was clearly noticed that birds of (L/L) group gave values notably similar to those of (C/C) treatment. These results apply for tibia ash and tibia P. In addition, similar tibia Ca values were observed between birds of (C/M), (L/L) or (C/C) treatments. In the same way, it was observed that addition high levels of D3 (6,000 or 9,000 IU/Kg) imposed a positive effect on tibia length and width indicating no significant differences between birds of (M/M), (M/L), (L/L) or (C/C) treatments at five weeks of age. The same trend was observed in tibia breaking strength when birds fed high levels of D3 at either (M/M), (M/L) or (L/L) treatments, showed significantly similar values as those of (C/C) treatment. These results were in harmony with those found by (Edwards *et al.*, 2002) who found that supplemental D3 appeared to prevent incidence of rickets and improves the bone ash contents, and (Baker *et al.*, 1998) who found that bone ash was increased with high D3 concentrations. Large increases in percentage of bone ash suggest large increases in the utilization of Ca, P, and PP by the chicks receiving very high vitamin D3 levels in the diet (Edwards *et al.*, 2002). These results were also in harmony with those observed by (Thabet, 2010) who indicated that tibia breaking strength was in accordance with tibia ash content and bones were stronger with birds fed in high vitamin D3 diets when compared to those fed control diet.

Mineral retention:

As anticipated, NPP and Ca consumption were directly related to dietary NPP and Ca levels (Table 5). Mineral retention values shown in Table (6) showed noticeable effect of adding higher D3 levels (9,000 IU/Kg), where birds of (C/L), (M/L) or (L/L) groups retained relatively more Ca and P compared with

those of (C/C) treatment. As D3 in high levels (9,000 IU/Kg) had positively affected Ca retention, the same trend was observed in P retention but it was less noticeable than that of Ca which might be related to the fact that D3 improve Ca digestibility in the first place (Scott *et al.*, 1982). These results were in harmony with those found by (Steenbock and Herting, 1955) and (Thabet, 2010) who stated that dietary vitamin D3 has long been known to increase PP digestibility and reduce the rachitogenic nature of low-Ca, high phytate diets. Generally, improvement of PP utilization upon large vitamin D3 supplementations (9,000 IU/Kg) might be accredited to increased biosynthesis and/or activity of intestinal phytase (Shafey *et al.*, 1990), increased phytate hydrolysis by stimulation Ca absorption making phytate more sensitive to hydrolysis and utilization (Mohammed *et al.*, 1991) or increased P absorption (Tanaka and Deluca, 1974). Reduced levels of NPP and Ca can improve the utilization of PP probably due to lower pH media brought about by lower Ca and P which in turn satisfies growth and activity of phytase-producing bacteria and in the same way, the acidic pH also encourage better activity for natural phytase found in feedstuffs (Dhandu and Angel, 2003). These effects might also be augmented by the effect of gradual adaptation to deficiency of both Ca and P (Yan *et al.*, 2005). Additionally it was found (Chou *et al.*, 2009), that 25-OH D3 consistently resulted in longer villus length of the duodenum and jejunum in birds which might in part justify better absorption of minerals.

In conclusion, under conditions of this experiment, it is clear that feeding extra levels of vitamin D3 (6,000 or 9,000 IU/Kg) present beneficial effects on performance of broilers fed low Ca and P diets till the end of growing period.

CONCLUSIONS

1. Body weight gain, feed conversion, Ca, and iP concentrations in plasma and tibia ash content in broilers fed lower concentrations of Ca and NPP appeared significantly similar to those fed recommended concentrations of these minerals, when birds were fed extra levels of vitamin D3.
2. Most of bone mineralization features in broilers fed lower concentrations of Ca and NPP with high concentrations of D3 (6,000 or 9,000 IU/kg) were similar to those fed the recommended levels of Ca, NPP, and D3.
3. Retention of Ca and P increased significantly with increased concentrations of D3 in diets containing lower concentrations of Ca and NPP, except for (M/M) group.
4. Reducing the concentrations of supplemental NPP from 0.50% and 0.45% to 0.25% and 0.20%; and Ca from 1.0% and 0.90% to 0.50% and 0.40% during starter and grower phases, respectively, with higher supplemental concentrations of D3 reduced feed cost by about $0.05/bird up to 35 d of age.
5. Based on results achieved, it is concluded that performance and bone mineralization in broilers, except for (M/L) group, could be normally maintained when feeding suboptimal concentrations of Ca and NPP with higher level of D3 (9,000 IU/kg).

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Table (1). Feed ingredients and chemical composition of experimental diets.

Ingredients	Dietary Treatments					
Starter	Control (C)			Medium (M)		Low (L)
Yellow Corn	56.01			57.75		59.49
SBM 44 %	28.83			28.85		28.84
Corn Gluten 60%	8.97			8.71		8.48
Soybean Oil	1.50			1.00		0.50
Ca Carbonate ($CaCO_3$)	1.60			1.22		0.80
MCP	1.85			1.23		0.65
HCI-LYS	0.39			0.39		0.39
METH (MHA)	0.25			0.25		0.25
Salt (NaCl)	0.30			0.30		0.30
Premix[1]	0.30			0.30		0.30
Total	100			100		100
Chemical Composition (Calculated)						
CP%	23.00			23.00		23.00
ME Kcal/Kg	3,000			3,000		3,000
Ca%	1.000			0.750		0.500
NPP%	0.500			0.375		0.250
Vitamin D_3 IU/Kg[2]	3,000			5,000		7,000
Price (L.E.)/ Ton	3292			3235		3179
Grower	C/C	C/M	C/L	M/M	M/L	L/L
Yellow Corn	59.90	61.66	63.39	61.66	63.39	63.39
SBM 44 %	26.39	26.45	26.40	26.45	26.40	26.40
Corn Gluten 60%	6.94	6.66	6.46	6.66	6.46	6.46
Soybean Oil	2.50	2.00	1.50	2.00	1.50	1.50
Ca Carbonate ($CaCO_3$)	1.46	1.05	0.64	1.05	0.64	0.64
MCP	1.64	1.02	0.45	1.02	0.45	0.45
HCl-LYS	0.32	0.31	0.31	0.31	0.31	0.31
METH (MHA)	0.25	0.25	0.25	0.25	0.25	0.25
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30
Premix[1]	0.30	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100	100
Chemical Composition (Calculated)						
CP%	21.00	21.00	21.00	21.00	21.00	21.00
ME Kcal/Kg	3100	3100	3100	3100	3100	3100
Ca%	0.900	0.650	0.400	0.650	0.400	0.400
NPP%	0.450	0.325	0.200	0.325	0.200	0.200
Vitamin D_3 IU/Kg[2]	3,000	6,000	9,000	6,000	9,000	9,000
Price (L.E.)/ Ton	3163	3107	3059	3107	3059	3059

1 The premix is totally free of Vitamin D_3 and each 3 kg contains: Vitamins: A: 12,000,000 IU; E: 10,000 mg; K_3: 2,000 mg; B_1:1,000 mg; B_2: 5,000 mg; B_6:1,500 mg; B_{12}: 10 mg; Biotin: 50 mg; Coline chloride: 250,000 mg; Pantothenic acid: 10,000 mg; Nicotinic acid: 30,000 mg; Folic acid: 1,000 mg; Minerals: Mn: 60,000 mg; Zn: 50,000 mg; Fe: 30,000 mg; Cu: 10,000 mg; I: 1,000 mg; Se: 100 mg and Co: 100 mg.

2 Crystalline vitamin D_3, Lutavit® D3 500 [500,000 IU/Kg] BASF, GmbH - Germany, MCP: Mono-Ca-Phosphate; MHA: Methionine Hydroxy Analogue; HCl-LYS: HCl –Lysine; L.E.: Egyptian Pound

Table (2). Effect of different dietary treatments on productive performance during different experimental periods.

Items	Dietary Treatments						
	C/C	C/M	C/L	M/M	M/L	L/L	Sig.
Live body weight (g)							
14 days		388.42±3.97		379.55±5.50		378.25±9.77	NS
35 days	1900.70^{ab}±49.24	1939.25^{a}±26.18	1791.30^{b}±20.45	1819.80^{ab}±38.76	1830.43^{ab}±44.57	1856.28^{ab}±46.98	*
Daily weight gain (g)							
0-14 days		24.37±0.29		23.70±0.39		23.57±0.72	NS
15-35 days	71.74^{ab}±2.08	75.05^{a}±1.22	67.00^{b}±0.89	68.91^{b}±1.77	68.75^{b}±1.71	70.38^{ab}±1.84	*
0-35 days	52.95^{ab}±1.40	54.06^{a}±0.75	49.82^{b}±0.58	50.62^{ab}±1.09	50.93^{ab}±1.26	51.66^{ab}±1.34	*
Daily feed consumption (g)							
0-14 days		32.33±0.32		31.79±0.48		32.13±0.55	NS
15-35 days	118.03^{ab}±2.81	122.73^{a}±2.38	114.17^{b}±2.18	113.24^{b}±1.66	114.28^{b}±3.17	116.10^{ab}±1.96	*
0-35 days	83.93^{ab}± 1.86	86.47^{a}±1.66	81.36^{ab}±1.45	80.43^{b}±1.08	81.52^{ab}±2.20	82.51^{ab}±1.31	*
Feed conversion ratio (g feed/ g gain)							
0-14 days		1.32±0.01		1.33±0.01		1.36±0.01	NS
15-35 days	1.64^{b}±0.01	1.63^{b}±0.01	1.70^{a}±0.01	1.64^{b}±0.02	1.66^{ab}±0.01	1.65^{b}±0.01	*
0-35 days	1.58^{b}±0.01	1.58^{b}±0.01	1.63^{a}±0.01	1.59^{ab}±0.02	1.60^{ab}±0.01	1.59^{ab}±0.01	*

*a, b Means within the same row with different superscripts are significant1y different. Sig. = Significance ** (P≤0.01), * (P≤0.05). NS = Non-Significant.*

Table (3). Effect of different dietary treatments on plasma Ca, P and ALP of broiler chicks at 14 and 35 days of age.

Items	Dietary Treatments						
Starter	Control			Medium		Low	Sig.
Calcium (mg/dl)	7.97±0.25			7.70±0.31		7.49±0.41	NS
Phosphorus (mg/dl)	4.55±0.17			4.24±0.17		3.96±0.26	NS
ALP Activity (U/dl)	1.39^{c}±0.02			2.24^{b}±0.04		3.04^{a}±0.08	**
Grower	C/C	C/M	C/L	M/M	M/L	L/L	Sig.
Calcium (mg/dl)	10.53^{a}±0.44	10.38^{a}±0.51	8.93^{b}±0.33	9.31^{ab}±0.31	9.70^{ab}±0.44	10.03^{ab}±0.41	*
Phosphorus (mg/dl)	6.76^{a}±0.28	6.63^{ab}±0.27	5.55^{c}±0.25	5.91^{bc}±0.24	6.05^{abc}±0.20	6.37^{ab}±0.24	**
ALP Activity (U/dl)	2.77^{c}±0.08	2.99^{c}±0.10	5.26^{a}±0.19	4.17^{b}±0.18	4.28^{b}±0.19	3.07^{c}±0.14	**

*a, b, c Means within the same row with different superscripts are significant1y different. Sig. = Significance ** (P≤0.01), * (P≤0.05). NS = Non-Significant.*

Table (4). Effect of different dietary treatments on some aspects of bone composition and measurements at 35 days of age.

Items	Dietary Treatments						
	C/C	C/M	C/L	M/M	M/L	L/L	Sig.
Toe Ash %	11.34±0.61	11.31±0.24	10.24±0.37	11.16±0.22	10.75±0.38	11.21±0.42	NS
Wet Tibia Weight %	0.54±0.01	0.55±0.01	0.53±0.02	0.53±0.01	0.55±0.01	0.55±0.02	NS
Dry Tibia Weight %	0.26±0.01	0.26±0.01	0.24±0.01	0.25±0.01	0.26±0.01	0.25±0.01	NS
Tibia Ash %	42.04^{a}±0.50	41.29^{a}±0.36	38.32^{b}±0.52	40.54^{ab}±0.66	39.24^{ab}±1.08	41.00^{ab}±1.61	*
Tibia Ca %	13.65^{a}±0.19	13.51^{a}±0.11	11.48^{c}±0.16	12.32^{bc}±0.23	12.10^{c}±0.41	13.13^{ab}±0.16	**
Tibia P %	7.79^{a}±0.90	7.63^{ab}±0.08	7.07^{b}±0.11	7.51^{ab}±0.18	7.27^{ab}±0.25	7.58^{ab}±0.11	*
Tibia Length (mm)	90.11^{ab}±0.85	92.35^{a}±0.46	88.88^{b}±0.85	90.66^{ab}±0.73	92.28^{a}±0.83	91.93^{a}±1.02	*
Tibia Width (mm)	7.30^{ab}±0.15	7.35^{ab}±0.17	6.96^{b}±0.17	7.08^{ab}±0.26	7.28^{ab}±0.13	7.69^{a}±0.29	*
Tibia Breaking Strength (Kg/cm^2)	20.10^{a}±0.44	19.56^{a}±0.41	13.06^{c}±0.79	18.36^{ab}±0.76	17.53^{b}±0.79	18.16^{ab}±0.30	**

*a, b, c Means within the same row with different superscripts are significant1y different. Sig. = Significance ** (P≤0.01), * (P≤0.05). NS = Non-Significant.*

Table (5). Effect of different dietary treatments on Ca, NPP and vitamin D_3 intake during different experimental phases.

Items	Dietary Treatments						
Starter (0-14 days)		Control		Medium		Low	Sig.
Ca intake (g)		4.52^{a}±0.04		3.33^{b}±0.05		2.25^{c}±0.04	**
NPP intake (g)		2.26^{a}±0.02		1.67^{b}±0.02		1.12^{c}±0.01	**
D_3 intake (IU)		1358.17^{c} ±13.83		2226.00^{b} ±34.17		3149.50^{a} ±54.55	**
Grower (15-35 days)	C/C	C/M	C/L	M/M	M/L	L/L	Sig.
Ca intake (g)	22.31^{a}±0.53	16.10^{b}±0.31	9.59^{d}±0.18	14.86^{c}±0.21	9.60^{d}±0.26	9.75^{d}±0.16	**
NPP intake (g)	11.15^{a}±0.26	8.38^{b}±0.16	4.79^{d}±0.09	7.73^{c}±0.11	4.80^{d}±0.13	4.87^{d}±0.08	**
D_3 intake (IU)	7436.00^{d} ±177.04	15464.50^{b} ±299.78	21579.25^{a} ±413.63	14268.25^{c} ±209.73	21600.00^{a} ±599.49	21943.00^{a} ±370.57	**
Overall (0-35 days)	C/C	C/M	C/L	M/M	M/L	L/L	Sig.
Ca intake (g)	26.89^{a}±0.59	20.60^{b}±0.39	14.09^{d}±0.23	18.14^{c}±0.24	13.00^{e}±0.34	12.00^{e}±0.19	**
NPP intake (g)	13.45^{a}±0.29	10.62^{b}±0.20	7.04^{d}±0.11	9.36^{c}±0.12	6.50^{e}±0.17	6.00^{e}±0.09	**
D_3 intake (IU)	8812.75^{d} ±195.81	16811.75^{c} ±323.74	22929.50^{b} ±428.19	16453.75^{c} ±225.19	23866.50^{b} ±651.94	25092.25^{a} ±404.39	**

*a, b, c, d, e Means within the same row with different superscripts are significant1y different, Sig. =Significance ** (P<0.01), * (P<0.05). NS= Non Significant*

Table (6). Effect of different dietary treatments on calcium and phosphorus retention at 35 days of age.

Items	Dietary Treatments						
	C/C	C/M	C/L	M/M	M/L	L/L	Sig.
				Calcium			
Intake (g)	3.35^{a}±0.16	2.49^{b}±0.18	1.56^{c}±0.16	2.37^{b}±0.14	1.57^{c}±0.06	1.65^{c}±0.05	**
Excretion (g)	1.92^{a}±0.12	1.28^{b}±0.12	0.73^{c}±0.07	1.19^{b}±0.16	0.70^{c}±0.04	0.72^{c}±0.06	**
Retention (g)	1.43^{a}±0.13	1.21^{a}±0.07	0.83^{b}±0.09	1.18^{a}±0.06	0.87^{b}±0.04	0.93^{b}±0.04	**
Retention %	42.69^{b}±2.97	48.59^{ab}±1.35	53.21^{a}±0.86	49.79^{ab}±4.69	55.41^{a}±2.18	56.36^{a}±2.86	*
Relative Retention	100.00 %	113.82 %	124.64 %	116.63 %	129.80 %	132.02 %	-
				Phosphorus			
Intake (g)	2.55^{a}±0.12	2.14^{b}±0.16	1.78^{b}±0.18	2.04^{b}±0.12	1.79^{b}±0.07	1.87^{b}±0.06	**
Excretion (g)	0.98^{a}±0.05	0.79^{ab}±0.08	0.61^{b}±0.04	0.74^{b}±0.06	0.59^{b}±0.06	0.57^{b}±0.09	**
Retention (g)	1.57^{a}±0.07	1.35^{ab}±0.10	1.17^{b}±0.14	1.30^{ab}±0.08	1.20^{b}±0.09	1.30^{ab}±0.07	*
Retention %	61.57^{b}±0.80	63.08^{ab}±2.20	65.73^{a}±1.16	63.73^{ab}±2.51	67.04^{a}±3.68	69.52^{a}±4.22	*
Relative Retention	100.00 %	102.45 %	106.76 %	103.51 %	108.88 %	112.91 %	-

*a, b, c Means within the same row with different superscripts are significant1y different. Sig. = Significance ** (P≤0.01), * (P≤0.05). NS = Non Significant.*

فيتامين د٣ يعالج تأثير نقص الكالسيوم والفوسفور على دجاج التسمين

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تم استخدام 240 كتكوت تسمين غير مجنس عمر يوم لمدة 5 أسابيع لدراسة تأثير المستويات المرتفعة من فيتامين د٣ مع نقص عنصرى الكالسيوم والفوسفور على الاداء الانتاجي ومقاييس العظام والمحتجز من العناصر موضع الدراسة لبداري التسمين. استخدمت ثلاث علائق بادىء فى الفترة من 1 وحتى 14 يوم: مقارنة (C)، متوسطة (M) و منخفضة (L) تحتوى على كالسيوم: 1.00 ، 0.75 و 0.50%; فوسفور متاح: 0.50، 0.37 و 0.25%; فيتامين د3 3000، 5000 و 7000 وحدة دولية /كجم علف، على الترتيب. كذلك تم استخدام ثلاث علائق نامى فى الفترة من 15 وحتى 35 يوم: مقارنة (C)، متوسطة (M) و منخفضة (L) تحتوى على كالسيوم: 0.90، 0.65 و 0.40%; فوسفور متاح: 0.45، 0.32 و 0.20%; فيتامين د3 3000، 6000 و 9000 وحدة دولية /كجم علف، على الترتيب. تم توزيع ستة معاملات غذائية على أساس ما يغذى عليه الطيور فى مرحلتى البادىء والنامى بالتتابع لتكون: (CC) مغذاة على بادىء مقارنة ثم نامى مقارنة، (CM) مغذاة على بادىء مقارنة ثم نامى متوسطة، (CL) مغذاة على بادىء مقارنة ثم نامى منخفضة، (MM) مغذاة على بادىء متوسطة ثم نامى متوسطة، (ML) مغذاة على بادىء متوسطة ثم نامى منخفضة و (LL) مغذاة على بادىء منخفضة ثم نامى منخفضة. احتوت كل معاملة على ٤٠ طائر مقسمة الى ٤ تكرارات بكل منهم ١٠ طيور. أوضحت النتائج أن الاداء الانتاجي للطيور (وزن الجسم – وزن الجسم المكتسب – الاستهلاك الغذائي – معامل التحويل الغذائي) لم يتأثر معنويا بالتغذية على علائق منخفضة في الكالسيوم والفوسفور مدعمة بمستويات مرتفعة من فيتامين د3 بإستثناء مجموعة (CL). كذلك لم يتأثر مستوى كلا من الكالسيوم والفوسفور بالإضافة الى نشاط إنزيم الألكالاين فوسفاتيز في بلازما الدم معنويا بخفض الكالسيوم والفوسفور وزيادة فيتامين د3 بإستثناء مجموعة (CL). قيم وزن عظمة الساق ونسبة الرماد بها وكذلك نسبة الكالسيوم والفوسفور بها لم تتأثر معنويا بخفض الكالسيوم والفوسفور وزيادة مستوى فيتامين د3 بإستثناء مجموعة (CL) عند مقارنتها بمجموعة (CC). بنفس الإتجاه، لم تتأثر قيم طول وسمك عظمة الساق وكذلك قوة الكسر لها بتأثير المعاملات الغذائية. كانت النسبة المئوية للمحتجز من الكالسيوم والفوسفور للطيور المغذاة على علائق (CL)، (ML) أو (LL) أعلى معنويا من مثيلاتها المغذاة على العلائق الأخرى.

ويستنتج من هذه الدراسة أن استخدام مستويات مرتفعة من فيتامين د3 (9000 وحدة دولية / كجم علف). لعلائق منخفضة في كلاً من الكالسيوم والفوسفور (0.40 و 0.20%، على الترتيب) يمكن أن يحسن من الاداء الانتاجي ومقاييس جودة العظام والمحتجز من الكالسيوم والفوسفور بغرض تقليل التلوث البيئى وبخاصة من عنصر الفوسفور بالاضافة الى تقليل تكلفة الغذاء.